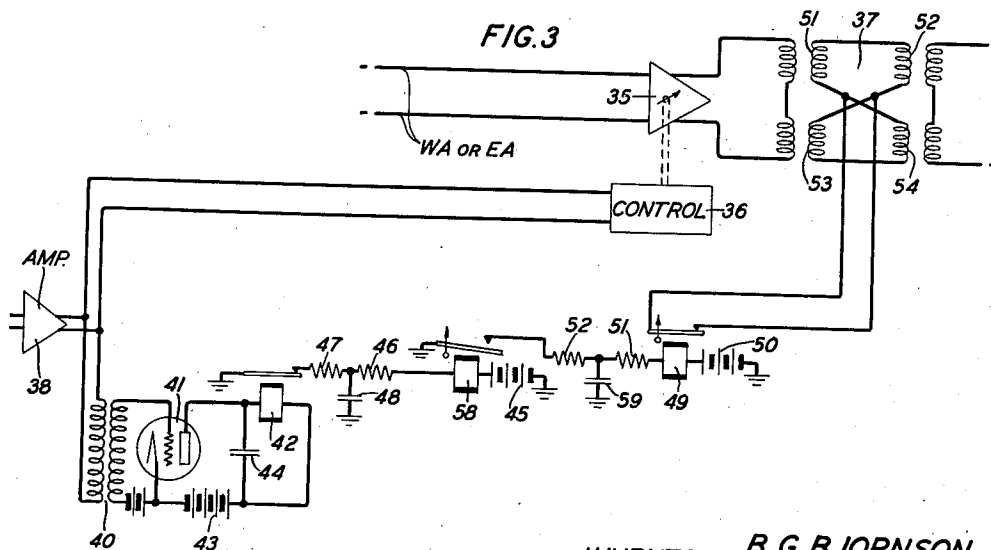


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TRANSMISSION CONTROL IN TWO-WAY
SIGNALING SYSTEM

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The invention relates to two-way signaling systems and particularly to the signal-controlled switching circuits employed for directionally controlling signal transmission in such systems.

An object of the invention is to improve the operation of such circuits.

To obtain proper operation of long two-way signaling systems, such as four-wire toll telephone systems, it has been found necessary in the past to make use of voice-operated switching apparatus, so-called echo suppressors or anti-singing devices, for inserting a suitable loss in the signal path for one direction when signal transmission is taking place in the opposite direction so as to prevent echoes or reflected current from being transmitted back to the transmitting end of the system in sufficient volume to cause a disturbance or singing. Such a suppressor usually comprises an amplifier-rectifier circuit connected to the two-wire path for each direction and responsive to signal transmission therein to control the operation of mechanical relays to short-circuit or open-circuit the signal transmission path for the opposite direction, or to suitably control the operation characteristics of an amplifier therein.

In one type of circuit, the suppressor units are located at or near the terminals of the four-wire circuit. When such a suppressor is controlled from the output of the talking path, it is known as a "receiver" terminal echo suppressor; and when operated from the input of the talking path it is known as a "sender" terminal echo suppressor. In both cases, it is desirable to provide auxiliary means, the so-called hang-over circuit, for prolonging the operation of each suppressor unit the proper interval of time after the supply of controlling speech waves thereto ceases in order to completely suppress all echoes of these speech waves and to prevent false operation of the other suppressor unit. With a receiver terminal type suppressor it has been necessary in the past to use artificial delay networks in the transmission path to prevent the transmission of the initial part of the signal preceding the application of the suppression loss to the other transmission path, which would cause false operation of the suppressor associated therewith. Since this short impulse would apply full hang-over serious mutilation of the speech signal would result. Such electrical delay networks are relatively costly and often necessitate additional amplification to compensate for the loss they insert in the transmission path.

Experiments on terminal echo suppressors

have shown that, due to side tone and air transmission, the talker's ear is highly desensitized during the utterance of a syllable and recovers its normal sensitivity gradually thereafter. The echo suppressor circuits of the present invention take advantage of this desensitization of the ear in such a way as to improve the operation under noise conditions. The circuits operate to insert a low loss in the echo path during the passage of the echo due to the initial part of a speech syllable and a larger loss thereafter in order that the effective echo may be maintained low when the ear recovers its sensitivity. No hang-over is made effective until the high loss is inserted. In one embodiment, the large loss is inserted in the echo path and the hang-over is applied only when the amplitude level of the transmitted signals exceeds a predetermined value. In another embodiment, a small loss proportional in value to the amplitude level of the transmitted signal is initially inserted in the echo path, and, if the input signal persists for a given interval of time, a large disabling loss is then inserted and hang-over applied. These circuits can be operated satisfactorily without electrical delay circuits in the signal transmission paths.

The objects and advantages of the invention will be better understood from the following detailed description thereof when read in connection with the accompanying drawing in which:

Fig. 1 shows diagrammatically a four-wire toll telephone circuit equipped with transmission control circuits in accordance with this invention; and

Fig. 2 and Fig. 3 show in greater detail different constructions of the transmission control circuits utilized in the system of Fig. 1.

The diagram of Fig. 1 is not an actual circuit diagram but rather a single line layout, each line indicating a transmission path. A normal make in a path is indicated by contacting arrow heads. An arrow directed at a make point indicates that the path will be disabled at that point by an associated voice-operated device.

The four-wire telephone circuit of Fig. 1 comprises a one-way transmission path EA including the one-way amplifying devices A1 and A2, for repeating telephone currents in the direction from west to east between a two-way circuit terminated by the west station SW and a two-way circuit terminated by the east station SE, and the one-way transmission path WA including the one-way amplifying devices A3 and A4, for repeating telephonic currents in the direction from east to west between the same two-way circuits.

The oppositely directed one-way transmission paths EA and WA may be connected at their terminal in substantially conjugate relation with each other and in energy transmitting relation with the two-way circuits, respectively, leading to the west and east stations in any suitable manner, for example, as indicated by hybrid coil transformers H₁ and H₂ and associated balancing networks N₁ and N₂.

Connected to the path EA near its output is the input of a voice-operated switching device or receiver terminal echo suppressor unit ES₁ which operates in response to signal waves transmitted over the path EA to first insert a small transmission loss in the input of path WA for example, as indicated, by removing the normal short circuit around the resistance 1, and subsequently, as indicated by the delay means 2 in one output branch of the suppressor ES₁, to disable the path WA or to insert a large loss therein at a point 3 near the east terminal of the four-wire circuit. Similarly, connected to the path WA near its output is the input of a voice-operated switching device ES₂ which operates in response to signal waves transmitted over the path WA to first insert a small loss in the input of the path EA, as by removing the normal short circuit around the resistance 4, and subsequently, as indicated by the delay means 5 in one output branch of the suppressor ES₂, to disable the path EA or to insert a large loss therein at a point 6 near the west terminal of the four-wire circuit.

A preferred construction of the echo suppressor units ES₁ and ES₂ is shown in Fig. 2. As indicated, each echo suppressor unit ES₁ or ES₂ comprises an amplifier 7, the input circuit of which in the system of Fig. 1 for the case of ES₁ would be connected to the one-way path EA at some point 8 near its output and for the case of ES₂ would be connected to the one-way path WA at some point 9 near its output. The output of the amplifier 7 is coupled to the input of a three-electrode electric discharge detector tube 10, the plate circuit of which includes in series the winding of relay 11, an operating winding 12 of relay 13 and plate battery 14. A condenser 15 is connected directly between the plate of the tube 10 and the positive terminal of plate battery 14, for the purpose of diverting the alternating current components of the detected signals from the winding of relay 11 and the winding 12 of relay 13.

The winding of a third relay 16 is connected in a closed circuit through ground in series with resistances 17 and 18 and a battery 19. The battery 19 is normally short-circuited through the resistance 18, the normally closed back contact and armature of relay 11 and ground, so that relay 16 is normally deenergized. The normally open front contact of relay 11 is connected in series with the winding of a fourth relay 23, battery 24 and ground so that when relay 11 operates and shifts its armature from its back to its front contact the winding of relay 23 is energized by battery 24 over a circuit extending from the positive terminal thereof through the relay winding, the resistance 25, front contact and armature of relay 11 and ground to the negative terminal of battery 24.

The normally open contact of relay 23 is connected through series resistances 28 and 29, winding 26 of relay 13 and battery 27 to ground, and the junction point of series resistances 28 and 29 is connected through the condenser 30 to ground. When relay 23 operates the winding 26 of relay

13 is energized by current from battery 27 over a circuit extending from its positive terminal through the relay winding, resistances 28 and 29, closed contact and armature of relay 23 and ground to the negative terminal of battery 27.

A loss network comprising the two tandem transformers 20 and 21, is connected in each one-way path WA or EA near its input, for example, at the point 3 in the former and at the point 6 in the latter path in the system of Fig. 1. The transformer 20 has two secondary windings 31 and 32, and the transformer 21 has two primary windings 33 and 34. The upper terminals of windings 31 and 33 are connected together and likewise the lower terminals of windings 32 and 34. The lower terminal of winding 33 is connected to the upper terminal of winding 32, and the upper terminal of winding 34 is connected to the lower terminal of winding 31. These connections taken by themselves are such that the windings 31, 32, 33, and 34 would effectively oppose each other so as to prevent transmission through the network over the transmission path in which it is connected. However, as indicated, a normal cross-connection made through the closed armature and contact of relay 16 and the closed armature and contact of relay 13 in series ties together the lower terminals of the windings 31, 33 and the upper terminals of windings 32 and 34, so that, in effect, two series aiding circuits are established through transformers 20, 21 and transmission through the transformer network with little attenuation is normally permitted.

A resistance 22 of small value, which corresponds to the resistance 1 or 4 in the system of Fig. 1, is connected between the lower terminals of windings 31 and 33 and between the upper terminals of windings 32 and 34, in series with the normally closed contact and armature of relay 13, but this resistance is normally short-circuited by the normally closed armature and contact of relay 16. Thus, when relay 16 operates to break this short-circuiting connection and relay 13 remains unoperated, the resistance 22 is in series with the path WA or EA between the transformers 20 and 21 and introduces a corresponding small loss in the path. The subsequent operation of relay 13 in response to the detected currents in the output of the detector tube 10, opens its normally closed contact and armature so as to break the connection between windings 31 and 33 and between windings 32 and 34 through the resistance 22. The windings 31, 32, 33, and 34 of transformers 20, 21 are then connected in opposing relation so that the transformer network provides a large loss in the path WA or EA in which it is connected.

A more complete description of the operation of the elements of the circuit of the invention shown in Fig. 2 when used as the echo suppressor units ES₁ and ES₂ in the system of Fig. 1 follows:

It will be assumed that the speech waves of a west subscriber at station SW are received over the two-way circuit associated therewith and are impressed by the hybrid coil transformer H₁ on the input of the path EA, and, at that time, no speech waves in the direction from east to west are being received by the four-wire circuit over the two-way circuit associated with the east station SE. Both echo suppressor units ES₁ and ES₂ are normally in the unoperated condition indicated in Fig. 2 so that the loss network comprising transformers 20 and 21 in the

input of each transmission path EA and WA off-ers little or no loss to the transmission of signals. Therefore, the speech waves in the path EA after amplification by the amplifier A1 are transmitted out over the path EA towards the east end of the four-wire circuit.

At the east end of the four-wire circuit, the main portion of the incoming speech waves will be amplified by the amplifier A2 and the amplified waves impressed by hybrid coil H2 on the associated two-way circuit over which it will be transmitted to the listening subscriber at the east station SE.

A small portion of the incoming speech waves, however, will be diverted from the path EA into the input of the suppressor unit ES1 at the point 8, and (see Fig. 2) will be amplified by the amplifier 7 and detected by the detector tube 10 therein. The resultant flow of current in the plate circuit of the detector tube 10 will pass through the winding of the relay 11 and the winding 12 of relay 13 in series. Relay 11 is designed to be operated immediately by this initial flow of current, to shift its armature from the back to the front contact. As soon as the armature of relay 11 leaves the back contact the short-circuiting connection around battery 19 is removed and energizing current is supplied thereby to the winding of relay 16 which operates immediately to attract its armature, removing the short-circuiting connection around the resistance 22. Resistance 22 is then effective to insert a small amount of loss corresponding to its value in the input of the path WA due to its connection to the windings of transformers 20 and 21, in the manner which has been described previously. No hang-over is applied to the relay 16 so that it releases immediately at the termination of each signal impulse, reapplying the short circuit around resistance 22.

The small loss momentarily inserted in the input of the path WA by resistance 22 by each speech impulse will attenuate slightly the initial echoes thereof impressed by hybrid coil H2 on the path WA and passing through the transformer network 20, 21 during this interval. The attenuated echo currents will be transmitted to the west end of the path WA and after amplification by amplifier A4 will be impressed on hybrid coil H2. The portion of the echo returned to the talker at station SW over the associated two-way circuit although of fairly high amplitude will not be troublesome because it is returned during the initial time interval, t_0 , when the talker's ear is highly desensitized by speech.

Should the portion of the echo currents over the path WA be of sufficient magnitude to cause false operation of the echo suppressor unit ES2 connected to path WA, in the manner which has just been described for the corresponding echo suppressor unit ES1 at the east end of the circuit, so that a small loss is inserted in the input of the path EA, this will cause only an inappreciable degradation in the quality of speech transmission over the line EA. This is because the condition can exist only momentarily due to the short time that the relay of the suppressor ES2, corresponding to the relay 16 of the suppressor ES1 at the east end of the circuit, which inserts the loss remains operated before operation of the relay corresponding to relay 13 of suppressor ES1 to remove the loss, and the echo currents thereafter received by ES2 will be of too low amplitude to cause false operation because of the large loss inserted in the echo path

at the east end of the circuit by the suppressor ES1 after the initial time interval, as will be described.

Returning to the echo suppressor ES1 at the east end of the four-wire system, the same speech impulse which causes the energization of the winding of relay 11 also causes the energization of the winding 12 of relay 13 in series therewith. The latter relay is a marginal relay designed to operate immediately whenever the level of the detected signal builds up, say L_2 decibels, above the marginal level required to operate relay 11, so that the relay 13 will operate after relay 11, but within the initial time interval, and only if the applied signal reaches the required level. The operation of relay 13 opens its armature and contact breaking the cross connection through the resistance 22 between the windings 31, 32, 33, and 34 of the transformers 20 and 21, producing in the manner which has been described a differential connection of these windings and therefore the insertion of a large loss in the input of the path WA at the point 3.

If the relays in echo suppressor ES2 at the west end of the four-wire circuit, corresponding to the relays 11 and 16 of the echo suppressor ES1 at the east end, had previously been falsely operated in response to the initially transmitted slightly attenuated echo currents, because of the insertion of the large loss in the path WA at the east end of the circuit cutting off subsequently the transmission of echo currents of appreciable amplitude, they will quickly release.

When the relay 11 in the echo suppressor ES1 at the east end of the four-wire circuit is completely operated in response to the initial speech impulse, that is, when its armature closes through the front contact of the relay, the winding of relay 23 is energized by battery 24 over a circuit extending from the positive terminal of the battery, through the winding of relay 23, resistance 25, front contact and armature of relay 11 and ground to the negative terminal of the battery. The winding of relay 23 is shunted by a condenser 57, the charging of which by current from the battery 24 slows up the operation of relay 23. When relay 23 operates, it closes through its armature and contact an energizing circuit for the hang-over winding 26 of relay 13 from battery 27 which may be traced from the positive terminal of the battery through winding 26, resistances 28 and 29 in series, closed armature and contact of relay 23 and ground to the negative terminal of battery 27. If relay 13 has operated in response to the initial impulse through its winding 12, the energization of winding 26 maintains the relay 13 operated, for winding 26 is wound so as to assist the action of winding 12. However, if the amplitude level of the detected speech pulse applied to winding 12 is not sufficiently high to cause its complete energization, the energization of winding 26 will effect the operation of relay 13. Hang-over is applied to relay 13 when the winding 26 is energized but does not become effective unless and until relay 13 is operated. Relay 13 when operated, as explained above, breaks the connection of resistance 22 to the windings of transformers 20 and 21 located at the point 3 in the path WA thereby inserting a large loss in that path.

When the winding 12 of relay 13 is deenergized at the end of the speech impulse causing its operation, relay 13 will not immediately release but will be maintained operated for an additional hang-over time interval while condenser

30, which was discharged to ground when relay 23 operated, is being charged by current from battery 27 through the winding 26 and resistance 28. When condenser 30 is completely charged by battery 27, the flow of current through winding 26 will cease due to the previous release of relay 23 and the armature and contact of relay 13 will return to their normally closed condition. At this time relay 16 has also released and resistance 22 is short-circuited through its armature and contact so that the windings of transformers 20 and 21 in the path WA are connected as described above in such manner that the loss inserted in the path WA is very low. The next received speech syllable repeats the operation which has just been described.

The values of the elements in the hang-over circuit for relay 13 above described are made such as to insure that relay 13 remains operated for a sufficient time after the end of the controlling speech syllable to maintain the high loss in the input of the path WA until all echoes thereof have been substantially dissipated by that loss. The high loss inserted in the path WA also serves to block the transmission of subsequently received east subscriber's speech currents over that path while the west subscriber continues to talk and thus prevents false operation of the echo suppressor unit ES₂ at the west end of the circuit to reverse control of the circuit during this time interval.

The operation of the system for the case where the east subscriber is the first to start talking is similar to that described above for the case where the west subscriber starts talking first. The east subscriber's voice currents are impressed by hybrid coil H₂ upon the path WA and transmitted thereover with a certain amount of amplification produced by amplifiers A₃ and A₄ to station SW. A portion of each syllable of the east subscriber's speech current is diverted from the path WA at the point 9 near the west end of the circuit and causes operation of the echo suppressor ES₂, connected thereat to insert a small loss in the inputs of the path EA during the initial interval while the speaker's ear is greatly desensitized and a larger loss in that path thereafter, the latter loss being maintained in the path EA for a sufficient time to completely suppress the echo currents due to each syllable of the east subscriber's speech currents. As in the case of the echo suppressor ES₁ at the east terminal just described, the relay circuits of the suppressor ES₂ act to prevent the larger loss being inserted in the path EA and the hang-over from becoming effective for a definite period unless the input signal reaches the required level.

Somewhat different operation may be attained with the circuit of Fig. 2, if the windings 12 of relay 13 are omitted, the windings of relay 11 and condenser 15 alone being connected in the plate circuit of tube 10, as indicated by the dotted line X in the figure, and relay 13 is designed to be operated to insert the large loss in the echo path when the winding 26 of the relay is energized by current from battery 27 in response to the operation of relay 11 and subsequent operation of relay 23. The operation of the modified circuit differs from that of the circuit of Fig. 2 in that, if the detected impulse in the output of detector 10 does not persist above the marginal or just operate level for at least a time t_1 , the time required to complete the energization of the winding 26 of relay 13, the relay 13 does not operate and no hang-over is applied. If the input signal

persists for the required time, the relay 13 operates, inserting the large loss and the associated hang-over. This time interval may be made of any desired length by proper design of the relays 11, 23, and 13 and the associated resistances and condensers. The time is made such that the relay 13 will be operated by a speech syllable but will be unoperated by the usual noise impulses.

Fig. 3 shows a modified construction in accordance with the invention which may be used for the echo suppressor units ES₁ and ES₂ in the system of Fig. 1. This modification makes use of the so-called "proportional loss" suppressor, illustrated conventionally as the variable gain amplifier 35 and a circuit 36 for reducing its gain in proportion to the increase in amplitude level of the waves in the output of the amplifier 38. One example of such a proportional loss circuit which might be used is illustrated in detail in Fig. 2 of the Patent 1,840,015 issued to B. G. Bjornson on January 5, 1932, wherein the gain of a vacuum tube amplifier in one amplifying path of a four-wire circuit is continuously reduced in proportion to the rise in amplitude level of the waves in the other amplifying path after a certain threshold value is reached, by a control circuit employing no movable elements. Other types of proportional lossers which may be used are disclosed in A. B. Clark Patent 1,829,928 issued December 8, 1931, and Silent Patent 1,745,457 issued February 4, 1930.

As indicated, the variable gain amplifier 35 would be connected in the input of the path WA or EA in front of the transformer network 37 employed for producing the large disabling loss in the path and which is similar to the transformer network 20, 21 described in connection with Fig. 2. The input of the control circuit 36 is connected to the output of an amplifier 38, the input of which in the system of Fig. 1 would be connected across the path EA at the point 8 in the case of the suppressor ES₁, or across the path WA at the point 9 in the case of suppressor ES₂.

A transformer 40 connects the circuit coupling the output of the amplifier 38 to the input of the control circuit 36 to the input of a three-electrode vacuum tube detector tube 41, the plate circuit of which includes the winding of a relay 42 in series with the plate battery 43. Condenser 44 is connected across the plate circuit of tube 41 in shunt with the winding of relay 42, and serves to keep the alternating current components of the detected currents out of the relay winding. The winding of a second relay 58 is normally energized by current from the battery 45 over a circuit extending from the positive terminal of the battery through the winding of relay 58, series resistances 46 and 47, normally closed contact and armature of relay 42, and ground to the negative terminal of battery 45, so as to maintain its armature and contact separated. A condenser 48 is connected between the junction of resistances 46 and 47, and ground.

The winding of a third relay 49 is adapted to be energized by current from the battery 50 when the normally operated relay 58 releases to close its contact and armature, over a circuit extending from the positive terminal of battery 50, through winding of relay 49, series resistances 51 and 52, closed contact and armature of relay 58 and ground to the negative terminal of battery 50. A condenser 59 is connected between the junction of the series resistances 51 and 52 and 75

ground. The armature and contact of relay 49 are normally closed and in the closed condition connect the windings 51, 52, 53, and 54 of loss network 37 in series aiding relation, as explained in connection with the similar network 20, 21 in the system of Fig. 2, so that normally the network 37 offers little or no transmission loss in the path WA or EA in which it is connected; and when relay 49 operates to open its contact and armature, the windings 51, 52, 53, and 54 of the transformer network are connected in opposing relation so that a large loss sufficient to prevent appreciable transmission through the network is inserted in the path WA or EA.

When used as an echo suppressor ES₁ or ES₂ in the system of Fig. 1, the circuit arrangement of Fig. 3 operates as follows: The wave impulses impressed on the input of the suppressor at the point 8 in the path EA in the case of the suppressor ES₁, or at the point 9 in the path WA in the case of the suppressor ES₂, are amplified by the amplifier 38 and the amplified waves in the output of amplifier 38 are divided between the input of the control circuit 36 and the input of the detector 41. The portion impressed on the input of the control circuit 36 after a certain threshold value of level is reached will cause the control circuit 36 to operate to reduce the amplification of the variable gain amplifier 35 in the path WA or EA in proportion to the amplitude of the waves impressed on the input of the suppressor, thus effectively inserting in the transmission path WA or EA a proportional loss in series with the network 37.

By suitable design of the proportional loss circuit, the value of this initial loss is made small but such that the echo wave due to the initial portion of each speech syllable inserting the loss transmitted to the talking subscriber at the other terminal of the system during the initial time interval while his ear is highly desensitized by speech, is of sufficiently low amplitude as not to be troublesome, and such as to prevent false operation of the echo suppressor at the transmitting terminal by the received echo wave. The noise waves in the path EA or WA during the time in which speech is not being transmitted will also insert a loss proportional to the noise level in the other path. By suitable design of the proportional loss circuit, this loss may be made at any instant just sufficient to prevent false operation of the associated suppressors by noise, thereby allowing the suppressors to be maintained at maximum sensitivity as regards operation by speech.

The portion of the output current of the amplifier 38 in the system of Fig. 3, impressed on the input circuit of detector tube 41 by transformer 40 will be detected thereby and supplied as energizing current to the winding of relay 42 which is the first relay in the chain which, when completely operated, causes a large disabling loss to be inserted in the echo path through the transformer network 37. It is desired that this relay chain insert the large disabling loss in the echo path and apply hang-over only if the input signal applied to the detector circuit persists above a given level for a predetermined time t_2 , corresponding to that which would obtain in the case of a speech syllable. Preferably, the large loss should be inserted in the echo path and the hang-over applied before the talker's ear has regained its normal sensitivity. This type of operation is obtained by suitable design of the resistance-condenser combinations 46, 47, 48 and 51, 52, 59

associated with the relays 58 and 49, respectively.

Relay 42 is operated immediately by the detected currents, whether due to speech or noise, to break its armature and contact and thus break the energizing circuit for the winding of relay 58 for battery 45 through the resistances 46, 47 and ground. However, relay 58 will not release immediately but will be retained operated for a definite time thereafter while the condenser 48 is being charged up by current from battery 45 through the winding of relay 58 and resistance 46. When condenser 48 is charged up, the relay 58 will release closing its armature and contact thereby closing an energizing circuit for the winding of relay 49 from battery 50 through resistances 51 and 52, closed armature and contact of relay 58 and ground, and causing condenser 59 normally charged by current from battery 50 to be discharged. If the applied signal does not persist for the required interval of time, t_3 , the chain of operation will be broken at some point, the winding of relay 49 will not be completely energized, and hang-over will not be applied to that relay.

If the level of the applied signal persists for the required time interval, relay 49 is energized and operates to break its contact thereby connecting the windings 51, 52, 53 and 54 of the transformer network 37 in opposing relation so that the network inserts effectively in the echo path a large loss to supplement the small loss previously inserted in the echo path by the proportional loss circuit 36, 35. Any echoes transmitted to the talker at station SW after his ear recovers its normal sensitivity, due to this large loss, are of such amplitude as not to be troublesome.

At the end of each transmitted speech syllable, or when the talking subscriber ceases talking, the relay 42 will release but the last relay in the chain, relay 49, will be maintained operated for an additional "hang-over" interval while first condenser 48 is being discharged to ground through the resistance 47 and then while condenser 59 is being charged by current from battery 50 through the winding of relay 49 and resistance 51. By suitable design of the circuit elements, this hang-over interval is made sufficiently long to maintain relay 49 operated to maintain the large loss in the echo path through network 37 until all echoes of the talker's controlling speech currents are dissipated thereby. At the end of this interval, relay 49 will release and the network 37 will be returned to its normal low loss condition.

Tests of each of the above described echo suppressor circuits in connection with four-wire telephone circuits indicate that the optimum values of the small loss L_1 , inserted in the echo path during the initial period, t_0 , for proper suppression of echoes depends on the transmission time of the circuit and the suppressor sensitivity. For short transmission times, L_1 may be made small and t_0 quite large. It was found that when the round trip transmission time is quite small, it is possible to obtain proper suppression of echoes for $L_1 = \text{zero}$. In general, it may be said that when L_1 is made small, t_0 must be short, but if L_1 is made large, t_0 may be made long.

Each of the circuits of the invention which have been described above will permit noise having peaks above the marginal sensitivity of the suppressor of duration less than t_0 without serious degradation in the quality of transmission.

In the circuit of Fig. 2, noise spurts above the operate point, lasting less than time t_0 and never reaching an amplitude of L_2 decibels above the operate amplitude will put only the small loss L_1 in the transmission path. However, if the noise amplitude becomes greater than L_2 decibels above the marginal or operate amplitude, maximum loss is immediately inserted in the echo path. This function reduces the false operation of the other suppressor by echoes of speech.

In the modification of the circuit of Fig. 2 described above in which the winding 12 of the relay 13 is omitted and the winding 26 of the relay controls the insertion of the large loss in the transmission path, noise spurts above the operate point of the suppressor circuit and of duration less than t_0 will never insert a loss more than L_1 decibels in the transmission path regardless of the amplitude of the spurts. The number of times that the loss L_1 is inserted and the intervals of time it is inserted are equal to the number of times the noise spurts rise above the operate point and the lengths of time they remain above, respectively. These insertions of loss in the transmission path will degrade the transmitted speech somewhat, but tests indicate that the degradation will be practically negligible on some types of noise.

The operation of the circuit of Fig. 3 on noise is somewhat similar to that of the circuit of Fig. 2, but the small loss L_1 inserted in the transmission path is variable, its instantaneous magnitude depending on the instantaneous amplitude of the noise spurts. Any noise spurt lasting less than t_0 second will insert loss proportional to its amplitude. If it lasts longer than t_0 second, the large loss will be inserted and proper hang-over applied.

Various modifications of the circuits of the invention which have been described and illustrated within the scope of the invention will occur to persons skilled in the art. The invention is only to be limited by the scope of the appended claims.

What is claimed is:

1. In a two-way telephone transmission system comprising at least near the terminals thereof two associated one-way transmission paths for transmitting the telephonic signals in opposite direction, switching means connected to one one-way path near one terminal and responsive to speech signal transmission in said one path to insert a loss of small value in the other one-way path sufficient to attenuate the echoes of the speech signals a relatively small amount during an initial time interval of a length corresponding to the time during which a talker's ear is relatively desensitized by the speech signals and to insert a loss of higher value sufficient to substantially suppress echoes of the speech signals in said other path at the end of such interval.
2. In a two-way telephone transmission system comprising two associated one-way transmission paths for repeating signals in opposite directions, a switching device connected to one one-way path and responsive to speech wave transmission therein to insert a loss of small value at a point in the other one-way path while an echo due to the initial part of a speech syllable is passing that point therein and to insert a larger loss in said other path thereafter, means for producing a hang-over in the operation of said switching device so that said larger loss will be maintained in said other path a desired interval

of time after cessation in the supply of controlling energy thereto, and means for preventing said hang-over from becoming effective until said larger loss is inserted in said other path.

3. In a two-way telephone system, a four-wire circuit comprising two oppositely-directed one-way circuits for repeating telephonic signals in opposite directions between two two-way lines, a voice-operated switching device connected to each one-way circuit near its output and responsive to incoming speech signals therein to insert a loss of small value at a point in the other one-way circuit while an echo due to the initial part of a syllable of said signal is passing that point in said other circuit, and to insert a disabling loss thereafter in said other circuit, means for producing hang-over in the operation of said switching device for a desired time interval after the supply of controlling energy thereto ceases, and means for preventing said hang-over from becoming effective until said disabling loss is inserted in said other one-way circuit.

4. In a two-way telephone system comprising two associated one-way paths for repeating telephone signals in opposite directions, a voice-operated switching device connected to one one-way path and immediately responsive to the initial low amplitude part of each syllable of the speech signal waves received therefrom to insert a loss of small value at a point in the other one-way path while an echo due to the initial part of said syllable is passing that point therein, said loss being sufficient to produce only a small amount of attenuation in said echo and responsive to the higher amplitude parts of each received speech syllable to insert a large disabling loss in said other one-way path, and means for maintaining said large loss in said other one path a given time after the end of the controlling speech syllable to insure that all echoes thereof are completely dissipated by said large loss.

5. In a two-way telephone transmission system, a four-wire circuit comprising two oppositely directed one-way paths for repeating telephonic signals in opposite directions between two two-way paths, a voice-operated switching device connected to each one-way path near its output and operatively responsive to incoming speech signals therein to insert a loss of small value at a point in the other one-way path near its input while an echo due to the initial part of a syllable of said signals is passing that point in said other path, and responsive to incoming speech signals of a level slightly higher than the marginal operating level of said device to insert a large disabling loss in said other path near its input, means for producing a hang-over in the operation of said switching device for a desired time interval after the end of the controlling speech syllable, and means responsive to operation of said device to prevent said hang-over from becoming effective unless and until said large disabling loss is inserted in said other path.

6. In a two-way telephone system, a four-wire circuit comprising two oppositely-directed one-way paths for repeating telephonic signals in opposite directions between two two-way transmission circuits, a wave-operated switching device connected to each one-way path near its output and immediately responsive to waves received therefrom of amplitude level above a certain threshold value to insert at a point near the input of said other one-way path a small loss of value which increases in direct proportion

5 to the increase in level of the controlling waves, and responsive to an impressed wave impulse of level above said threshold value only when it persists for a given length of time, to insert a large disabling loss in said other path near its output, means responsive to operation of said device for producing a hang-over in its operation

a definite time after the end of the controlling impulse, and means for preventing said hang-over in operation from becoming effective unless and until said large loss is inserted in said other path.

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