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TRANSMISSION CONTROL IN TWO-WAY SIGNALING SYSTEMS

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FIG. 1

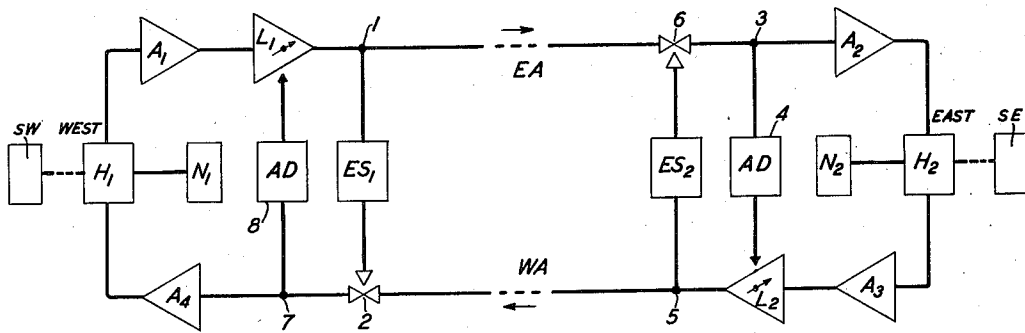


FIG. 2

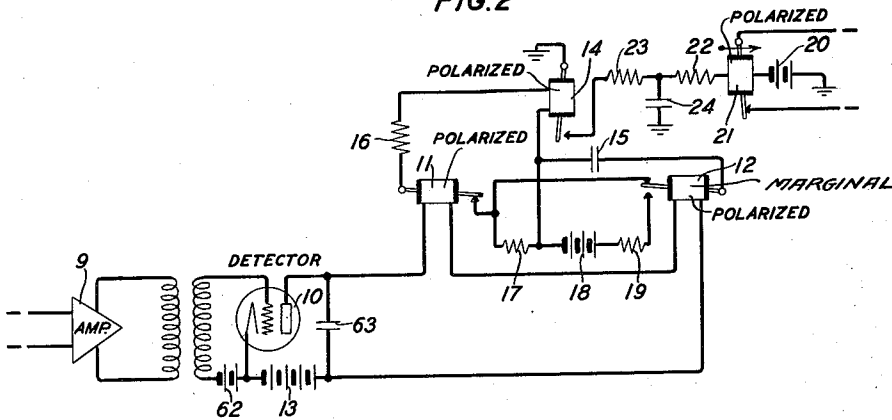
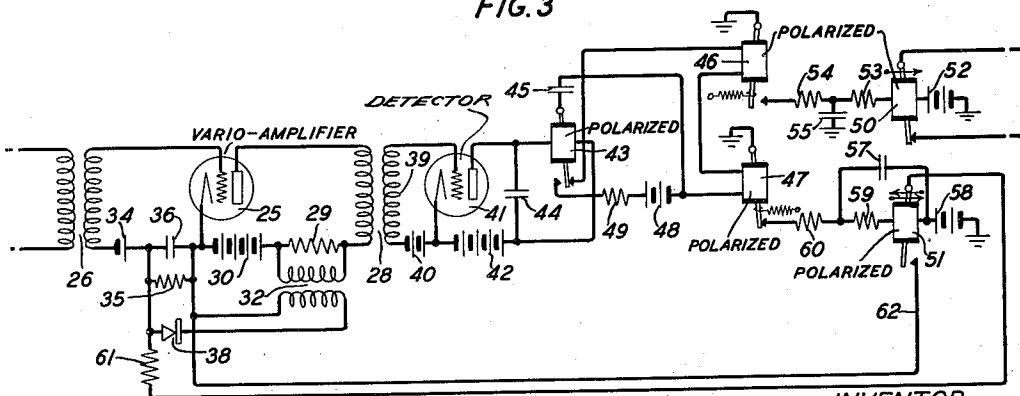


FIG. 3



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TRANSMISSION CONTROL IN TWO-WAY
SIGNALING SYSTEMSBjorn G. Bjornson, New York, N. Y., assignor to
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This invention relates to two-way signaling systems and particularly to the signal-controlled switching circuits employed for directionally controlling signal transmission in such systems.

5 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 10 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 over the signal path for the 15 opposite direction so as to prevent echoes or reflected currents from being transmitted back to the transmitting end of the system and causing a disturbance or singing. Such suppressors usually include an amplifier-rectifier circuit connected to the signal path for each direction, which 20 is responsive to signal transmission therein to insert a suitable amount of loss in the signal path for the opposite direction.

Certain suppressors of the prior art are of the 25 type which operate to completely disable the echo path or to insert a large loss of fixed value therein. Another type of suppressor in the prior art when operated inserts a loss in the echo path which, above the operate point, is directly proportional to the amplitude level of the waves in the other path at the input to the suppressor. 30 With this suppressor, the echo path is never completely blocked. Loss is inserted in the echo path to reduce the echo below a certain predetermined level. Among the advantages of this type of 35 suppressor may be mentioned easier break-ins; the avoidance of complete blocking of the circuit when the noise is above the minimum operate point of the suppressor; and the prevention 40 of intermittent blocking of the circuit by the echo suppressor when the gain is raised beyond the singing point. The disadvantage for the lossier type of circuit is that if the above advantages are retained, the echoes from the final 45 parts of the syllables are objectionable.

In accordance with the present invention, the two above-described types of echo suppressors are combined in such manner as to realize the advantages of both while minimizing their disadvantages. 50 The circuits of the invention are arranged to take advantage of the fact that the part of the echo which is returned to the talker before the end of his speech syllable, or just after, requires less attenuation than the final part of 55 the echo, due to the desensitization of the ear of

the talker by speech during the initial time interval.

In one embodiment of the invention, a control circuit at or near each terminal of the four-wire circuit is responsive to incoming waves above the 5 operate level to insert a small loss in the outgoing repeating path thereat, the value of which is directly proportional to the control circuit input power, and a second control circuit at or near 10 each terminal is responsive to outgoing speech waves to insert a large loss in the incoming path. The circuits are arranged so that the small loss attenuates the echo of the initial part of each speech syllable and the large loss suppresses the 15 echo of the final part of each syllable.

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 20 telephone system equipped with wave-operated transmission control apparatus which may be arranged in accordance with this invention; and

Figs. 2 and 3 show schematically echo suppressor circuits representing different embodiments of 25 the invention which may be utilized in connection with 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. The triangular shaped boxes in the diagram represent 30 one-way transmission elements, such as amplifiers, the vertex of the triangle pointing in the direction of transmission. An arrow within the triangular box indicates that the transmission element is variable, and to show that the loss or gain of such a variable transmission element is to be varied in response to the level of waves impressed on an associated wave-operated control 35 device (amplifier-detector), an arrowhead points from the control device towards the variable element. A normal make in a transmission path is indicated by contacting arrowheads. An arrow directed at a make point indicates that the path will be disabled at that point by the associated 40 wave-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 45 repeating telephonic currents in the direction from west to east between the two-way circuit leading to a west station SW and the two-way circuit leading to the east station SE, and the one-way transmission path WA including the one-way 50 amplifying devices A₃ and A₄, for repeating tele-

phonic currents in the direction from east to west between the two-way circuit associated with the east station SE and the two-way circuit associated with the west station SW. In any suitable manner, the oppositely directed one-way transmission paths EA and WA may be connected in substantially conjugate relation with each other and in energy transmitting relation with the two-way circuits leading to stations SW and SE, respectively, for example as indicated, by hybrid coil transformers H₁ and H₂ and associated balancing networks N₁ and N₂.

Connected to the path EA at some point 1 near its input is the input of a voice-operated device or echo suppressor ES₁ which operates in response to impressed voice signal waves from the path EA to disable the path WA at some point 2 near its output. Connected to the path EA at some point 3 near its output is the input of a "proportional loss" consisting of a wave-operated control device (amplifier-detector) 4 and a loss device L₂, such as a variable gain amplifier, controlled thereby, which operates in response to impressed waves from the path EA above a certain critical amplitude to insert a proportional transmission loss in the input of the path WA. Connected to the path WA at a point 5 near its input but in the output of the loss device L₂ is the input of the voice-operated control device or echo suppressor ES₂, which operates in response to impressed voice signal waves from the path WA to disable the path EA at a point 6 near the output thereof but in front of the point of connection 3 of the proportional losser thereto. Similarly, connected to the path WA at a point 7 near its output but beyond the disabling point 2 therein is the input of another proportional losser circuit comprising the wave-operated control device (amplifier-detector) 8 and the loss device L₁ controlled thereby, which operates in response to impressed waves from the path WA above a certain critical amplitude to insert a proportional transmission loss in the path EA in front of the point of connection 1 of the echo suppressor ES₁ thereto.

The details of a suitable proportional losser which may be used in the system of Fig. 1 are illustrated in Fig. 2 of my Patent 1,840,015 issued January 5, 1932, in which the proportional loss is inserted in one repeating path by suitably controlling the bias on the grid of a vacuum tube amplifier in that path in accordance with the amplitude level of waves in the other path, under control of an amplifier-detector circuit connected thereto. Other arrangements of proportional lossers which may be used in the system of Fig. 2 are illustrated in A. B. Clark Patent No. 1,821,928, issued September 8, 1931, and in H. C. Silent Patent No. 1,745,457, issued February 4, 1930.

A preferred construction of the echo suppressors ES₁ and ES₂ employed in the system of Fig. 1 is shown in Fig. 2 as indicated. The suppressor includes an amplifier 9, the output of which is coupled by a transformer to the input of a three-electrode detector tube 10, the plate circuit of which includes in series with plate battery 13, the windings of mechanical relays 11 and 12, which windings are shunted by a condenser 63. The terminals of the winding of a third relay 14 are connected through the normally closed armature and contact of relay 11 in series with the resistances 16 and 17. A condenser 15 is connected in shunt with resistance 17 through the normally closed armature and back contact of relay 12. When the relay 12 operates to shift its

armature from the back to the front contact, the condenser 15 is disconnected from in shunt of resistance 17, and the battery 18 is connected across condenser 15 in series with resistance 19. The armature and contact of relay 14 are normally open and when closed by operation of that relay complete an energizing circuit for the winding of a fourth relay 21 from battery 20 through series resistances 22 and 23 and ground, causing the operation of relay 21 to open its normally closed armature and contact. The junction of series resistances 22 and 23 is connected to ground through condenser 24 for a purpose which will be brought out later.

The operation of the system illustrated by Fig. 1 will now be described using the circuit shown in Fig. 2 for the echo suppressor ES₁ and for the echo suppressor ES₂.

When the circuit of Fig. 2 is used as the echo suppressor ES₁ in the system of Fig. 1, the input 20 of the amplifier 9 is connected across the path EA at the point 1 and the normally closed armature and contact of relay 21 are arranged in any suitable manner to render the path WA operative at the point 2, and when the armature and contact are separated by operation of the relay, to disable that path or to insert a large disabling loss therein at the point 2. Similarly, when the circuit of Fig. 2 is used for the echo suppressor ES₂ in the system of Fig. 1, the input of the amplifier 9 would be connected across the path WA at the point 5, and the armature and contact of relay 21 would be arranged normally to render the path EA operative at the point 6 and to insert a large disabling loss at that point in the path when relay 21 operates to separate its armature and contact.

It will be assumed that speech waves for transmission from west to east are received by the four-wire repeating circuit over the two-way line connected to the west station SW from a west subscriber and, at that time no speech waves have as yet been received at the east terminal of the four-wire circuit over the two-way line connected to the east station SE.

The received speech waves in the path EA will be amplified by the amplifier A₁ and will pass through the loss device L₁ of the proportional losser circuit arrangement located near the west terminal of the four-wire circuit. If the noise level at the point 7 in the path WA at that instant is sufficiently high to cause operation of the amplifier-detector device 8, the loss device L₁ is inserting in the path EA a small amount of loss which is directly proportional to the level of the noise currents impressed upon the amplifier-detector 8. The circuits are arranged so that the amount of this small amount of loss at any instant is just sufficient to prevent operation of the echo suppressor ES₁ connected to the path EA at the point 1 by the noise waves alone in the latter path. The main portion of west's speech waves slightly attenuated by the loss device L₁ will be transmitted out over the path EA towards the east terminal of the four-wire circuit; a small portion, however, will be diverted to the suppressor ES₁ at the point 1 and will cause its operation to disable the path WA at the point 2 in a manner which will be later described in detail in connection with Fig. 2.

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 impressed by the hybrid coil H₂ on the associated two-way line over which it will be transmitted to the listening

subscriber at the east station SE. A small portion of the incoming speech waves (west's) will be diverted from the path EA into the proportional loss circuit connected at the point 3. Since the amplitudes of these waves will exceed the critical value which will cause operation of the control device 4 of the proportional loss circuit, that device will be operated and will control the device L₂ in the input of the path WA so that it inserts therein a loss which is proportional in value to the amplitude of the waves impressed on the control device 4. By suitable design of the proportional loss circuit, the value of this loss is made sufficient to so attenuate the initial part of the echo of each speech syllable of west's speech entering the input of the path WA through the hybrid coil H₂ and transmitted westward thereover to the two-way circuit associated with the west station SW so that it will not be heard by the speaker at that station. The amount of this loss may be made quite small inasmuch as experiments have shown that during the initial portion of each spoken syllable, the speaker's ear is highly desensitized and only regains its normal sensitivity gradually. The loss inserted by the loss device L₂ near the input of the path WA is also such as to prevent false operation of the echo suppressor ES₂ connected at the point 5 in the path by the echo, which suppressor if operated falsely would disable the path EA at the point 6 in its output and thus thereafter prevent west's speech currents from being transmitted to the east subscriber associated with station SE. Because of the amount of additional attenuation undergone by the echo currents in transmission over the path WA from the output of the loss device L₂ to the point 7 near the west terminal of the four-wire circuit, the echo waves impressed on the control device 3 of the proportional loss circuit connected at that point will be of such low level that they will either not operate that control device or, if they do operate it, the amount of loss inserted in the input of the path EA by the loss device L₁ and the time for which it is inserted will be so small as not to degrade the subsequent speech transmission over the path EA appreciably.

The above description explains how the arrangement of Fig. 1 functions to prevent undesirable echo effects due to the initial portion of each syllable. The operation of the circuits of Fig. 2 in suppressing echoes of speech due to the final portion of each syllable which arrive at the transmitting station after the reduction in hearing sensitivity caused by the syllable has been reduced, will now be described.

As stated previously, a small portion of west's speech waves at the west terminal of the four-wire circuit is diverted at the point 1 into the echo suppressor ES₁. Referring to Fig. 2, this portion will be amplified by the amplifier 9 and impressed on the input circuit of the tube 10 which is biased by a grid battery 62 to act as a detector. The impressed speech impulse will overcome the normal negative grid bias on the tube and cause plate current to flow in the plate circuit thereof from battery 13 through the windings of relays 11 and 12 in series and the plate-filament space path of the tube. The alternating current components of this plate current will be kept out of the relay windings by condenser 63.

Relay 11 is designed to operate in response to the detected speech syllable above a given amplitude to open its armature and contact, breaking the connection around the winding of relay 14

through resistances 16 and 17. The relay 12, however, is designed to operate when, and if, the amplitude of the detected speech syllable rises a given amount, say 3 decibels, above the amplitude which will cause operation of relay 11. If the amplitude of the detected speech impulse remains below this critical value, the relay will not operate and the path WA will not be disabled at the point 2. If, however, the level of the detected speech currents is sufficiently high to supply the proper energizing current to the winding of relay 12, that relay will operate and shift its armature from the back contact to the front contact, thus disconnecting condenser 15 from resistance 17 and closing a circuit for that condenser from battery 18 through series resistance 19 and the back contact and armature of relay 12.

If the detected speech impulse is very short, relay 12 is operated for such a short time that the charge accumulated on condenser 15 from battery 18 will be insufficient to operate relay 14 through resistance 16 and the closed armatures and contacts of relays 11 and 12 when these relays release. Therefore, on short impulses relay 21 will not be operated to disable the path WA. On longer speech impulses, however, the condenser 15 will store up a sufficient charge to operate relay 14.

When relay 12 releases, the charge accumulated on condenser 15 begins to immediately dissipate itself in resistance 17. If relay 11 releases a short time after relay 12, there will be a large enough charge on condenser 15 to cause relay 14 to operate. If the signal impulse decays slowly enough to cause a substantial time interval between the release of relays 12 and 11, most of the charge on condenser 15 will have been dissipated in resistance 17 and relay 14 will not operate. The time constant of the circuit just described by suitable selection of the values of the circuit elements is made such as to provide for the operation of relay 14 if the received speech signal impulse is of a predetermined magnitude and duration and decays with a predetermined rapidity.

When relay 14 operates, an energizing circuit is closed for relay 21, from battery 20 through the closed armature and contact of relay 14, series resistances 23 and 22 and the winding of relay 21. Relay 21 then operates to open its normally closed armature and contact so as to disable the path WA or to insert a large transmission loss therein at the point 2.

When relay 14 releases after the discharge current from condenser 15 ceases to flow through its winding, the energizing circuit for relay 21 from battery 20 through the closed armature and contact of relay 14 is broken, but the relay 21 does not release immediately but will remain operated to maintain the path WA disabled for the additional time which it takes condenser 24 to be charged up from battery 20 through the winding of relay 21 and resistance 22. This "hang-over" time interval is made long enough by suitable selection of the time constants of the circuit to insure that the loss inserted at point 2 in path WA will be maintained until all echo waves of the controlling speech waves have reached point 2 and have been dissipated in the disabling loss thereat.

Since practically all speech syllables retain a substantially constant amplitude for a short time, and since their rate of decay falls within definite limits, the proper time constants of the circuit may be determined experimentally which will result in the operation of relay 21 and the con-

sequent insertion of a disabling loss in the path WA on practically every speech syllable, which loss will be effective to so attenuate echoes due to the final part of each syllable returned to the talker at station SW during the period when his ear has recovered its normal sensitivity, that they will not be troublesome. Narrow peaks of noise and slow variation in the noise just reaching above the operate point of the suppressor, because of the time relation just described, will not cause operation of the disabling relay 21. The requirements for operation (1) that the length of the speech impulse must exceed a given value and (2) that the amplitude near the operating point must fall off a definite amount in a given time, can be eliminated by omitting resistance 17 and making resistance 19 very small.

Now, if the east subscriber associated with the station SE starts to talk while the west subscriber associated with the station SW is still talking, the former's speech currents will be impressed by hybrid coil H₂ on the input of the path WA and after amplification in the amplifier A₃ will pass through the loss device L₂ to the input of the suppressor ES₂ connected at the point 5. As the loss device L₂ is controlled by west's speech currents to insert a proportional loss in the path, east's speech currents will be considerably attenuated thereby. However, if east talks loudly enough, his speech currents will operate the echo suppressor ES₂ to disable the path EA at the point 6.

A portion of these speech currents with the attenuation undergone in passing through the loss device L₂ will be transmitted out over the path WA to the west terminal of the four-wire circuit. At any pause by west long enough to permit release of the echo suppressor ES₁ to render the path WA operative at the point 2, east's speech currents will get through and after being amplified by the amplifier A₄ will be impressed by the hybrid coil H₁ on the two-wave line leading to the west station SW over which it will be transmitted to the west subscriber indicating to him that east wishes to break in. If both parties then continue to talk, neither will be able to hear the other because of the simultaneous operation of the echo suppressors ES₁ and ES₂ by the voice currents of west and east, respectively. It is to be noted that since echo suppressors ES₁ and ES₂ do not stay continuously operated during the transmission of each syllable, the total time they are held operated is much shorter than with other types of echo suppressors. However, if he wishes, the west subscriber may cease talking and allow the east subscriber to obtain control of the switching circuit in a manner similar to that which has been described for west's speech currents for the opposite direction of transmission.

As the echo suppressors ES₁ and ES₂ are assumed to be identical, the detailed operation of the system for the case where the east subscriber is talking and the west subscriber is silent need not be given here.

In the above discussion it has been assumed that the east subscriber talked loudly enough to operate ES₂. However, it is more probable to expect that east will not be able to operate ES₂ if the west subscriber talks continuously. But, part of east's speech, in spite of the loss in L₂, can be heard by west if the suppressor at 2 is lifted. Since ES₁ is not continuously operated during speech syllables this condition is frequently satisfied, and, therefore, east has been sup-

plied with extra facility for letting west know that he (east) is trying to break in.

Fig. 3 shows an alternative circuit which may be used for the echo suppressors ES₁ and ES₂ in the system of Fig. 1.

As indicated the system of Fig. 3 comprises in order a vario-amplifier, a detector and a relay circuit. The vario-amplifier comprises a three-electrode vacuum tube amplifier tube 25, the input circuit of which in the system of Fig. 1 for the case of the echo suppressor ES₁ would be connected across the path EA at the point 1 by the input transformer 26, and for the case of the echo suppressor ES₂ would be connected across the path WA at the point 5 by that transformer.

The grid-cathode circuit of the amplifier tube 25 comprises in series the secondary winding of input transformer 26, the negative grid biasing battery 34, and a circuit comprising the resistance 35 and the condenser 36 in parallel. The plate circuit of the vario-amplifier tube 25 comprises in series the battery 30, the resistance 29 and the primary winding of the transformer 28. The primary winding of a transformer 32 is connected across the resistance 29 in the plate circuit of amplifier tube 25, and the secondary winding of that transformer is connected across the resistance 35 in the grid circuit of the amplifier tube and the copper-oxide rectifier 38 in series.

The output of the amplifier tube 25 is coupled to the input of the three-electrode detector tube 41 by the transformer 28, the grid-cathode circuit of the detector tube including the negative grid-biasing battery 40. The plate circuit of the detector tube 41 includes in series between the filament and plate of the tube the plate battery 42 and the winding of a mechanical relay 49. The winding of the relay 43 is shunted by the condenser 44.

The windings of two other relays 46 and 47 are connected in series through the series condenser 45 and the normally closed armature and right-hand contact of relay 43. When relay 43 operates to shift its armature from the right-hand to the left-hand contact, the connection of the windings of relays 46 and 47 through condenser 45 is broken and the battery 48 is connected across the condenser 45 and series resistance 49.

The winding of a fourth mechanical relay 51 is normally energized by current from the battery 58 through series resistances 59 and 60, the normally closed armature and contact of relay 47 and ground. The armature and contact of relay 46 are normally open and when closed by operation of that relay complete an energization circuit for the winding of a fifth mechanical relay 50 from battery 52 through series resistances 53 and 54, the closed armature and contact of relay 46 and ground. The condenser 57 is connected across the winding of relay 51 and resistance 59 in series and serves to make that relay slow-operating and slow-releasing, and a condenser 55 is connected between the junction of series resistances 53 and 54 and ground for a purpose to be brought out later.

The normally closed armature and contact of relay 50 are arranged in any suitable manner to render, in the case of echo suppressor ES₁, the path WA normally operative at the point 2, and, in the case of the echo suppressor ES₂, to render the path EA normally operative at the point 6, and, when relay 50 operates to separate its armature and contact, to disable the path WA at the

point 2 in the case of the echo suppressor ES₁ and to disable the path EA at the point 6 in the case of the echo suppressor ES₂.

The armature and contacts of relay 51 are normally maintained open due to the normal energization of the winding of that relay by battery 58. When the relay 51 releases to close its armature and contact, a short-circuiting connection 62 including the series resistance 61 is connected across the parallel condenser 36 and resistance 35, and across the secondary winding of transformer 32 in series with copper-oxide rectifier 38.

The echo suppressor arrangement of Fig. 3 is designed to operate to disable the echo path when the syllabic amplitude of the impressed signal impulse has fallen a definite amount below its maximum value. This is easy to accomplish for a single signal impulse but when the signals follow each other closely or are run together as in ordinary conversation, complications develop, the effects of which are nullified in the circuit of Fig. 3. The circuit operates as follows:

In the normal condition of the circuit, that is, when no speech signal is being received, there is no charge on the condenser 36 in the grid circuit of the tube 25 and the vario-amplifier, therefore, is at maximum gain. The tube 25 is preferably a variable μ tube. Now, if a speech signal impulse is received from the associated repeating path, this signal is impressed by the transformer 26 on the grid circuit of the vario-amplifier tube 25 and will cause current to flow in the plate circuit of the tube through the resistance 29 causing a voltage drop corresponding to the value of the current across that resistance. This voltage is fed back into the grid circuit of tube 25 through the transformer 32, the copper-oxide rectifier 38 in series with its secondary winding, and the parallel condenser 36 and resistance 35 in the grid circuit of tube 25, producing on the condenser 36 a corresponding charge. This charge adds to the negative bias on the grid of the tube and thus effectively reduces the gain of the amplifier in proportion to the increase in the amplitude level of the applied signal impulse, so that its output level remains substantially constant.

By suitable selection of the circuit constants of the amplifier and of the feed-back control circuit, the maximum output level of the vario-amplifier tube 25 is maintained a few decibels above the operate point of the detector tube 41.

The amplified signal impulse in the output of the amplifier 25 is impressed by transformer 28 on the input of the detector tube 41, overcomes the normal negative grid bias thereon supplied by grid battery 40, and causes plate current to flow in the plate circuit of the detector tube 41 through the winding of relay 43. The condenser 44 keeps the alternating current component of the detected signal impulse out of the relay winding and thus smooths out the energizing current in that winding. Relay 43 then operates to shift its armature from the right-hand contact to the left-hand contact, disconnecting the condenser 45 from in shunt of the windings of relays 46 and 47, and connecting it across the battery 48 in series with resistance 49 so that the condenser is charged up to the value of the battery 48.

When the signal impulse applied to the amplifier 25 begins to decay, that is, to fall off after reaching its maximum level, the gain of the vario-amplifier 25 is held practically fixed, since the resistance 35 in shunt with the condenser 36 in the grid circuit of the amplifier tube is made

large. At the end of the signal impulse, relay 43 will release and the armature thereof will leave the left-hand contact and return to the right-hand contact, thereby removing battery 48 from condenser 45 and reconnecting condenser 45 in shunt with the windings of relays 46 and 47 in series.

The condenser 45 will now discharge through the windings of relays 46 and 47 causing the operation of these relays. When relay 46 operates its armature and contact close completing an energization circuit for relay 50 from battery 52 through the series resistances 53 and 54 and ground. Relay 50 will then operate to open its normally closed armature and contact thus inserting a large disabling loss in the echo path WA or EA depending on whether the circuit is used in echo suppressor ES₁ or echo suppressor ES₂. Due to the delay in the operation of the suppressor until the syllabic amplitude has fallen a definite amount below its maximum value, the disabling loss is inserted into the echo path at the most effective time, that is, only in time to attenuate the last part of the echo of each speech syllable which will arrive at the talker's end of the system just about the time when the talker's ear has regained its normal sensitivity. Due to the insertion of this large loss the returning echo will be of such small amplitude as not to be troublesome. As previously described in connection with the system of Fig. 1, the initial part of the speech echo which arrives at the talker's end of the system while his ear is still in the highly desensitized condition due to his own speech is attenuated only just the amount necessary to prevent it being troublesome, by the proportional loss circuit at the receiving end of the four-wire circuit.

The relay 46 releases when the condenser 45 has been completely discharged through its winding to reopen its armature and contact breaking the normal energizing circuit for relay 50 from battery 52, but relay 50 does not immediately release being maintained energized for an additional hang-over interval while condenser 55, which was discharged when relay 46 operated, is being charged up from battery 52 through the winding of relay 50, resistance 53 and ground. By suitable selection of the circuits associated with relay 50, this hang-over time interval is made sufficient to insure that all echoes of the controlling speech syllable have reached the disabling point in the echo path and are dissipated thereat before relay 50 releases to remove the large loss.

As stated above, when the signal impulse begins to decay, the gain of the vario-repeater is held practically fixed, since the resistance 35 in shunt with the condenser 36 in its grid circuit is quite large. When the relay 43 releases, it is necessary to increase the gain of the vario-repeater so that the relay 46 can operate at least on the peak of the next signal impulse. The gain must not be returned to normal so quickly that the relay 43 will operate again on the tail end of the same signal impulse. The reset relay 51 under control of the relay 47 performs this function.

After relay 43 releases, the winding of relay 47 is energized by the discharge current of condenser 45 along with the winding of relay 46 as described above and will operate to break its armature and contact thus breaking the normal energization circuit for the winding of relay 51 from battery 58 through series resistances 59 and 60 and ground. The reset relay 51 is a slow-operate and slow-release relay due to the effect

of the condenser 57 in shunt with its winding and resistance 59. When the energization circuit for the winding of relay 51 from battery 58 is broken, condenser 59 will discharge through the relay winding and resistance 59 maintaining the relay operated for an additional interval of time after which the relay releases. When relay 51 releases, its armature and contact close the circuit 62 including the series resistance 61 across the condenser 36 and parallel resistance 30 causing the condenser 36 to discharge quickly, returning the vario-amplifier tube 25 to its condition of maximum gain so as to enable quick operation of relay 43 in the output of detector tube 41 on the succeeding speech syllable. This is insured by the fact that the reset relay 51 is a slow-operate relay, for when the armature and contact of relay 47 return to the normal-closed condition when condenser 45 has completely discharged through the winding of the relay, the contact and armature of the reset relay 51 will be maintained in the open condition for the time that it takes the condenser 57 to be charged up from battery 58.

This simple method of insuring operation of the suppressor on each speech syllable will operate satisfactorily in practice because in practically every case the longest decay period of a speech syllable is shorter than the shortest time interval from the beginning of the decay of syllable to the beginning of the decay of a following speech syllable.

In the systems which have just been described, the location of the proportional loss should be as near the receiving end of the four-wire circuit as possible so as not to insert loss before it is necessary. The echo suppressors should be located as near the transmitting end of the four-wire circuit as possible, so as not to insert high loss in the echo path until the talker has just finished saying a syllable. The proportional lossers should be made more sensitive than the echo suppressors in order to insure their operation first.

The echo suppressor circuits of the invention described above, have been found to be an improvement over the ordinary proportional loss type of suppressor in that the initial sensitivity is the same as for the type of suppressor operating to completely disable the echo path, for equivalent echo suppression, and in that no hang-over is associated with the loss circuit which tends to make the loss proportional to the noise peaks. They are an improvement over the type of suppressor only operating to entirely disable the echo path, in that (1) the system allows the listener to get some speech through to the talker more easily than the latter type of suppressor, and (2) in that transmission lock-outs characteristic of the latter type of suppressor when both subscribers start talking at about the same time, are prevented, for in the present systems the amplitude of singing current is limited and the circuit is never completely blocked.

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

What is claimed is:

1. In a two-way telephone system comprising at least near the terminals thereof two one-way

circuits for transmitting the speech signals in opposite directions, a control device connected to the incoming one-way circuit near one terminal of the system, responsive to the incoming signals to insert in the outgoing one-way circuit near that terminal a loss which is directly proportional to the amplitude level of the impressed signals above a certain minimum level, a second control device connected to the outgoing one-way circuit near the other terminal, which is operative at or near the end of each transmitted speech syllable to insert a loss of large value in the incoming one-way circuit near said other terminal.

2. The system of claim 1, in which said second control device operates to insert said loss of large value in the incoming one-way circuit near said other terminal when the syllabic amplitude of outgoing speech signals has fallen a definite amount below its maximum value.

3. The system of claim 1, in which said second device controls a wave detector having its input connected to the outgoing circuit, a chain of mechanical relays controlling the insertion of said large loss and being operated in sequence in response to the rectified signals in the output of said detector, the time constants of said relays being selected so that the last relay in the chain operates to insert said loss at the desired time.

4. The system of claim 1, in which said second control device comprises an amplifier for amplifying the signals received from the outgoing one-way circuit near said other terminal, a detector for rectifying the amplified signals, a chain of mechanical relays operating in sequence in response to the rectified energy, the last relay in the chain operating to insert said large loss, means also responsive to the rectified energy to so adjust the gain of said amplifier that all rectified speech syllables are reduced to the same energy level, the time constants of the relays in said chain being so selected that said large loss is inserted in the incoming one-way circuit at the proper time.

5. In a two-way telephone transmission system, a four-wire repeating circuit for repeating speech signals in opposite directions between two two-way lines, a voice-operated switching device connected to each side of the four-wire circuit near its output and responsive to incoming speech signals to insert in the input of the other side of the circuit a loss which is directly proportional to the power input to said device above the operate value, and a second voice-operative device connected to each side of said four-wire circuit near its input beyond the point where the loss is inserted by said first device connected to the other side of the four-wire circuit, said second device operating at or near the end of each transmitted speech syllable to insert a loss of large value in the output of said other side in front of the point where said first device is connected.

6. The system of claim 1, in which the first-mentioned control device operates to insert said proportional loss in the outgoing one-way circuit near said one terminal quickly in response to the initial portion of each syllable of the impressed speech signals, and the maximum value of said proportional loss is small in comparison with the value of said large loss inserted in the incoming one-way circuit at said other terminal by said second control device.

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