Aug. 29, 1939. K. H. DAVIS **2,170,941**

TRANSMISSION CONTROL IN SIGNALING SYSTEMS

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FIG. 1

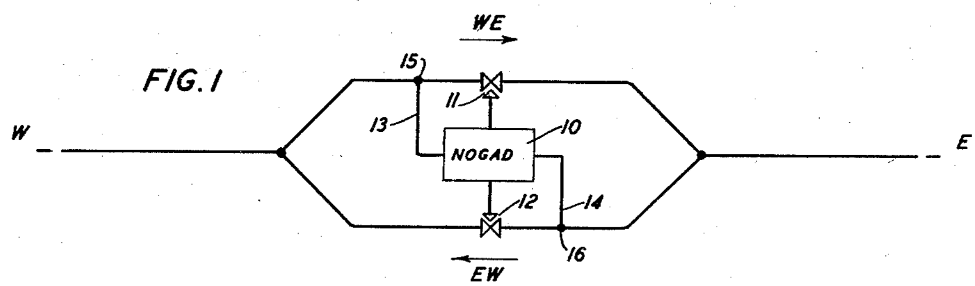

FIG. 2

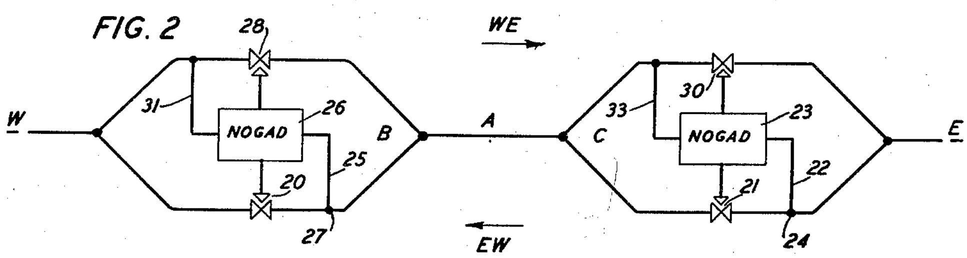

FIG. 3

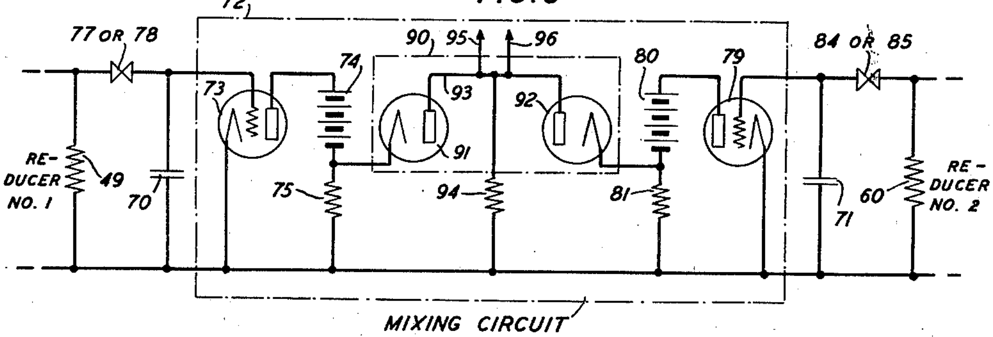

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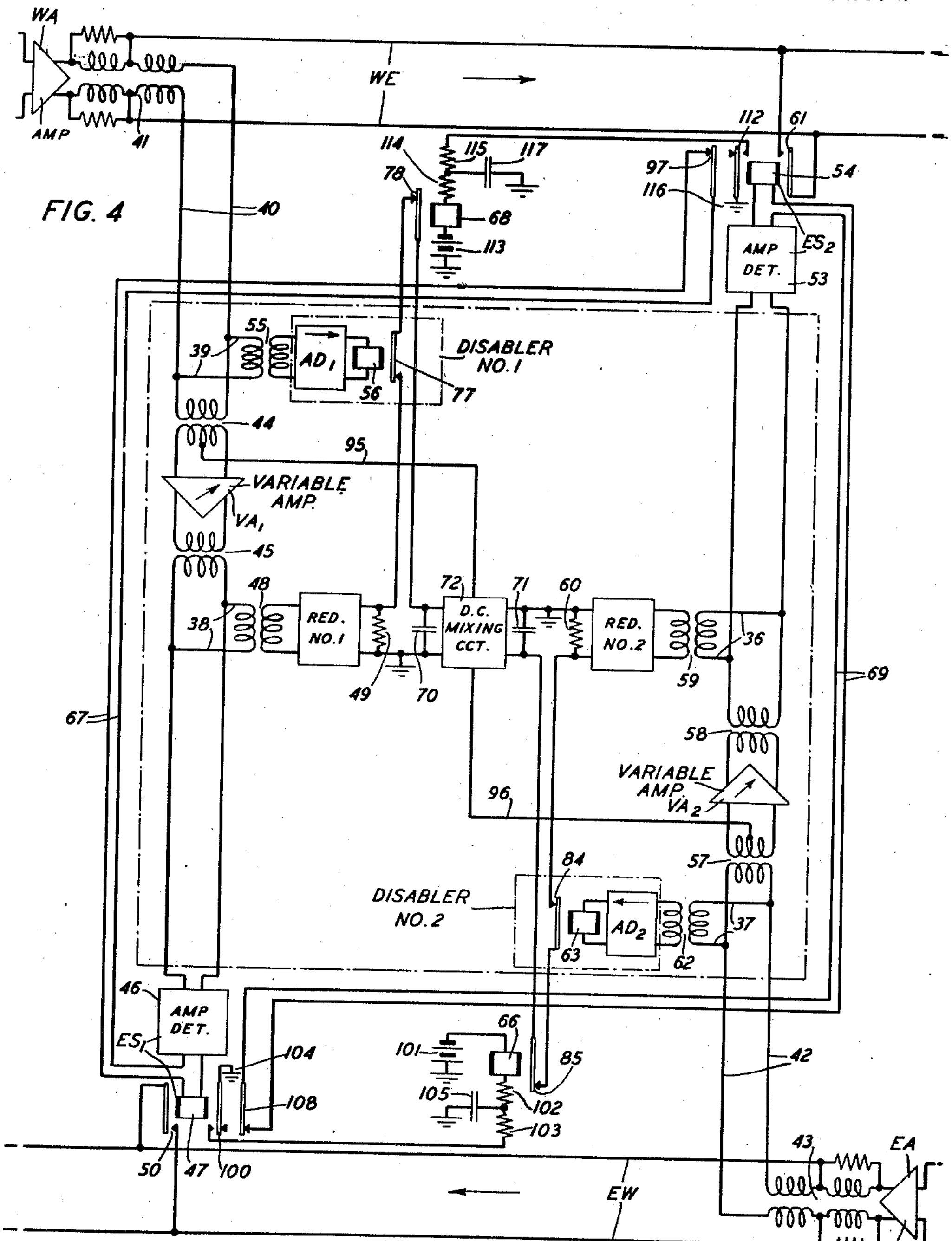
FIG. 4



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TRANSMISSION CONTROL IN SIGNALING SYSTEMS

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6 Claims. (Cl. 178—44)

This invention relates to control of transmission in signaling systems, and more particularly to arrangements for minimizing the effects of interfering waves in such systems.

Long distance telephone systems are often subject to noise waves of varying amplitudes, including ordinary line noise introduced into the system by the operation of line apparatus and the noise induced into the system from extraneous sources, particularly neighboring power lines. In these systems it is frequently the practice to employ voice-operated, switching devices such, for example, as voice-operated echo suppressors or anti-singing devices. The noise waves in the system may materially interfere with the proper operation of the switching devices on speech energy in a manner such that noise waves of high amplitude may cause either false operation of the switching devices or necessitate reducing the sensitivity of the latter to such degree as to prevent proper operation on speech waves of low amplitude.

Certain circuits of the prior art attain proper discrimination against noise by utilizing the noise energy to automatically produce a continuous reduction in sensitivity in the voice-operated switching device proportional to the increase in amplitude of the line noise in the associated line so as to prevent operation of the device by the noise while maintaining the maximum effective sensitivity thereof to operation by speech for the amount of noise present. In one circuit of this type, disclosed in the patent of H. L. Barney No. 2,020,452 issued November 12, 1935, the sensitivity of the voice-operated switching device is controlled by utilizing the input energy to the device from the line or other circuit subject to the noise to control the gain of an amplifier in the input of the device in such manner as to cause very slow decrease in its gain when the input energy increases suddenly, i. e., when speech comes on the line, and a very rapid increase in gain when the input energy is reduced, i. e., when speech transmission and noise are removed from the line. To prevent excessive reduction in the gain of the amplifier by speech during strong parts of the received speech syllables, a marginal control device connected to the input of the vario-amplifier is arranged to respond to the peaks of the received speech impulses to disable the gain-controlling circuit.

A device of the type disclosed in the patent of H. L. Barney, supra, will be hereinafter referred to as a nogad, i. e., noise-operated-gain-adjusting-device. Nogads are designed for use on long distance telephone circuits in which it is imperative from the standpoint of most efficient operation that as much sensitivity of the echo suppressors be provided as noise in the circuit will allow. In addition, nogads are arranged to vary the sensitivity of the echo suppressors inversely relative to the amount of noise on the circuit, always maintaining the echo suppressors as sensitive as possible without permitting uncommercial amounts of operation thereof on noise.

Another circuit of the prior art improved the system disclosed in the above patent to H. L. Barney by associating with the latter a device which is unresponsive to noise but is responsive to weak as well as to strong speech impulses to disable the gain-controlling circuit. This improved nogad disclosed in the patent of B. G. Bjornson No. 2,081,422 issued May 25, 1937, includes, in addition to the marginal device connected across the input of the vario-amplifier and operated on strong parts of speech to disable the gain-controlling circuit as disclosed in the above patent of H. L. Barney, another device comprising a very sensitive syllabic amplifier-detector connected across the output of the vario-amplifier and arranged to respond to the lower range of speech voltages to disable the gain-controlling circuit.

It has been found that the combination of the two disabling circuits embodied in the nogad according to the above patents of H. L. Barney and B. G. Bjornson prevent any change in the gain of the vario-amplifier during a very large part of any speech syllable and therefore materially reduce the amount of speech desensitization of the nogad. In addition to the aforementioned feature, this combination of two disabling circuits serves, when a second long distance telephone link equipped with echo suppressors is connected in tandem with a link having the speech desensitized nogad, to prevent false adjustments of the gain of the vario-amplifier due to noise being cut off by the operation of the echo suppressor in the other link of the system.

Without the two disabling circuits mentioned above, the gain of the vario-amplifier might increase to a maximum during the short interval after speech operated the desensitized echo suppressor associated with the nogad in the one link while the echo suppressor in the other link would cut off noise therefrom thereby causing a rapid gain in the sensitivity of the nogad. Then, when the latter released and noise could reach the nogad, the echo suppressor associated therewith would be falsely operated, thus causing mutilation of the speech which was continuing on the same branch of the system. The combination of the two disabling circuits illustrated in the patent of B. G. Bjornson, supra, prevents such false operations by operating a disabler master relay and applying a comparatively long hangover thereto so that no false adjustment in the gain of the vario-amplifiers is made while noise is cut off by operation of the remote echo suppressor on speech in a tandem transmission system.

When the circuits disclosed in the patent of B. G. Bjornson, supra, are incorporated in a tandem system comprising at least two links each of which includes two oppositely directed one-way paths, an echo suppressor is usually connected to each of the one-way paths and functions in the well-known manner to disable the opposite of the two paths associated therewith. Also, in such system each echo suppressor is equipped with a nogad arranged so that the energy taken from the outputs of the two vario-amplifiers is combined and introduced into a common reducer circuit and the energy supplied to the inputs of the two vario-amplifiers is taken off the one-way paths ahead of the echo suppressors so that noise in each link can reach each nogad regardless of the operation of the suppressors associated therewith. The common reducer, as seen in the above patents of H. L. Barney and B. G. Bjornson, builds up a direct current voltage whose magnitude depends on the amount of noise present in the system. This direct current voltage is then applied simultaneously to both vario-amplifiers to adjust the gain thereof in such way that the noise is substantially constant in the output of the vario-amplifiers.

Although there may be substantially no false adjustments of the nogad and operations of the echo suppressors in the tandem telephone system mentioned above, it does happen in such systems using a common reducer for each link thereon that the east and west sides of the nogad are both disabled for relatively long periods of time, necessitating, of course, the disabling of the nogad a large part of the time. This period of time would be the interval while speech waves are being transmitted in either direction. Because of the insensitivity of the disabling combination it would still be possible to cut off noise from a nogad without disabling it, if the speech waves were to have such amplitude as to operate the echo suppressors without operating the disablers. Cutting off noise from and rendering ineffective the nogad for intervals of time may result in rapid increases in the gain of the vario-amplifiers thereby causing false operations of the echo suppressors. Such occurrences would obviously defeat the purpose for which the nogad was designed.

It is an object of the invention to discriminate between electrical waves of different characteristics, for example, between useful signals and interfering noise waves.

It is another object of the invention to improve the operation of a signal-controlled device for controlling transmission in a signaling system subject to interfering waves, such as line noises.

It is another and more specific object of the invention to provide that interfering noise waves can always reach each nogad embodied in a tandem telephone system.

It is a further and more specific object of the invention to control substantially at all times the effectiveness of each nogad in a tandem telephone system.

It is a still further and more specific object of the invention to control the gain of vario-repeaters in such manner that the possibility of false operations of the echo suppressors is substantially reduced.

The present invention contemplates an improved operation of a tandem two-way telephone system comprising two or more four-wire links each of which embodies two oppositely directed one-way paths equipped with echo suppressors and a nogad. The latter includes means for producing two voltages corresponding to waves in the one-way paths and applied to the amplifiers in such manner that the gain thereof is automatically controlled in accordance with the larger of the two. Associated operably with each echo suppressor is an arrangement for disabling the voltage producing means whose input comes from the one-way path which is opposite to the one-way path whose waves caused the operation of the echo suppressor. Thus, one side of the nogad is substantially always connected to the one-way path transmitting both noise and voice waves while the other side thereof is disconnected from the one-way path transmitting noise waves alone.

As a result high-sensitivity disabling of the voltage producing means is obtained without cutting off the nogad from noise for long periods of conversation. Furthermore, this arrangement provides such control of the gain of the amplifiers that false operations of the echo suppressors associated therewith are substantially reduced, or eliminated entirely, after noise is returned to the voltage producing means that was disabled.

The invention will be more readily understood from the following description taken together with the accompanying drawings in which:

Fig. 1 is a schematic diagram showing an echo suppressor associated with a nogad in a single-link telephone system;

Fig. 2 is a schematic diagram illustrating a tandem telephone system comprising two links each of which is of the type shown in Fig. 1;

Fig. 3 is a diagrammatic circuit of a mixing circuit; and

Fig. 4 is a partial schematic and a partial diagrammatic circuit illustrating a single link including the preferred embodiment of the invention.

In the following description, the same reference numerals are employed to designate the same elements appearing in the several figures.

Fig. 1 is a schematic diagram of a commonly used single-link four-wire transmission circuit comprising WE and EW one-way paths connecting west and east two-way transmission paths. The arrows in parallel with the one-way paths indicate the direction of transmission. Embodied in the four-wire circuit is a nogad 10 with which is preferably associated a central-type echo suppressor represented by the arrowheaded lines and designed to be applied to the circuit at a point intermediate and some distance from the ends of the four-wire circuit. As is well understood, the arrowheaded lines indicate control paths such that speech waves arriving at the points 11 or 12 cause the operation of mechanisms that produce controlling effects, preferably short circuits across the respective one-way paths. A more detailed description of echo suppressors may be had by referring to an article by A. B. Clark and R. C. Mathes, entitled "Echo Suppressors for Long Telephone Circuits" which was published in the Journal of the American Institute of Electrical Engineers, Vol. XLIV, pages 618–626, for June 1925. Control circuits 13 and 14 connect the nogad 10 to the paths WE and EW, respectively.

As shown in Fig. 1 the control circuit 13 is connected to the path WE at a point 15 which lies between the west terminal and the echo-suppression point 11. Therefore, the operation of the echo suppressor in the path WE cannot prevent noise energy originating at the west terminal from reaching control circuit 13 of nogad 10, assuming speech waves originating at the east terminal to cause the operation of the echo suppressor. Likewise, control circuit 14 is connected to the path EW at a point 16 which lies between the east terminal and the echo-suppression point 12. Consequently, the operation of the echo suppressor in the path EW due to speech waves originating in the west terminal cannot prevent noise energy produced in the east terminal from arriving at the nogad 10. In both cases, then, noise can always reach the control circuits of the nogad 10 to adjust sensitivity thereof to a sensitivity depending on the noise at the west or east terminals.

Fig. 2 is a schematic diagram of two four-wire links of the type shown in Fig. 1 connected in tandem and extending through a two-wire circuit in station A between the west and east terminals. Assuming speech waves to originate at the west terminal, these would immediately cause the operation of the echo suppressor at point 20 in the path EW of link B, and eventually the operation of echo suppressor at point 21 in path EW of link C. In link C it is noted that control circuit 22 of nogad 23 is connected to the path EW at a point 24 which is intermediate the east terminal and echo-suppression point 21. Consequently, nogad 23 will always be exposed to noise originating in the east terminal, and because of this condition will adjust itself to a satisfactory sensitivity, regardless of the operation of echo-suppression point 21.

However, in link B it is observed that control circuit 25 of nogad 26 is joined to the path EW at a point 27 which lies intermediate the echo-suppression points 20 and 21. Because of the operation of echo-suppression point 21 as hereinbefore explained, noise from the east terminal will be cut off from control circuit 25 associated with nogad 26. This will cause a sudden increase in the sensitivity of nogad 26 such that when noise is returned thereto due to a release of echo-suppression point 21, the echo-suppression point 28 in link C of the path WE will be falsely operated during the interval required for nogad 26 to adjust itself to the prevailing noise condition at the east terminal.

When speech waves originate at the east terminal, an entirely analogous situation exists in the case of nogads 23 and 26 but in this case it is evident that noise from the west terminal is cut off from control circuit 33 of nogad 23. This will cause a sudden increase in the sensitivity of nogad 23 so that when noise is returned to the latter due to the release of echo-suppression point 28, the echo-suppression point 21 in link C will be falsely operated during the period required for nogad 23 to adjust itself to the prevailing noise condition at the west terminal. It is obvious that frequent false operations of the respective echo-suppressing points in the manner aforementioned would interrupt a talker, thereby impairing the efficiency of speech transmission.

While Fig. 2 shows each of the two links equipped with a nogad, it is understood that this showing is only for the purpose of this description and the important circuit requirement to be remembered is that the explanation applies to a signal transmission system comprising at least two four-wire links each of which has an echo suppressor and at least one of the four-wire links also includes a nogad associated with its echo suppressor. Therefore, in either link B or C the nogad could be eliminated without interfering with the operation of the invention which will now be explained in detail.

This invention therefore contemplates a tandem telephone system of the type described in Fig. 2 in which the sensitivity of the nogads is so maintained that false operations of the echo suppressors associated therewith are substantially reduced, and will now be described.

Fig. 4 shows a four-wire link comprising a one-way transmission path WE including a one-way amplifying device WA and a one-way transmission path EW embodying a one-way amplifying device EA, the respective amplifying devices serving to transmit waves in the directions indicated by the arrows. The one-way paths WE and EW may be coupled at their terminals in conjugate relation with each other and in energy-transmitting relation with the two-way lines or circuits between which signal transmission is desired by the usual transformers and associated balancing networks (not shown) or by other suitable means.

The incoming portion of the path WE and the input of transmission control circuit 40 are connected by a network 41 in substantially conjugate relation with each other and in energy-transmitting relation with output of the amplifying device WA. This is to prevent the short-circuiting of the outgoing portion of path WE by echo suppressor ES_2 associated therewith from affecting the input of control circuit 40. Likewise, the incoming portion of the path EW and the input of transmission control circuit 42 are connected by a network 43 in substantially conjugate relation with each other and in energy-transmitting relation with the output of the amplifying device EA so as to preclude the short-circuiting of the outgoing portion of path EW by echo suppressor ES_1 from affecting the input of control circuit 42. The networks 41 and 43 are preferably of the type disclosed in the patent of G. Crisson No. 1,755,243, issued April 22, 1930.

The control circuit 40 comprises vario-amplifier VA_1 and an echo suppressor ES_1. The input of vario-amplifier VA_1 is coupled to the network 41 by a transformer 44. The vario-amplifier VA_1 may include any suitable variable gain thermionic amplifying device which, for the purpose of this description, may be of the type disclosed in the patent of B. G. Bjornson, supra. Output transformer 45 couples the output of vario-amplifier VA_1 to the input of the echo suppressor ES_1 which may be of any suitable type to disable the path EW in response to voice energy impressed on its input and, for the purpose of this description, comprises an amplifier-detector 46 in whose output is a mechanical relay 47 responsive to detected current to close short-circuiting connection 50 across the one-way path EW.

Across the output of the vario-amplifier VA_1 is also connected a transformer 48 coupling the former to reducer No. 1 whose function it is together with reducer No. 2, as will be hereinafter explained, to automatically regulate the gain of the vario-amplifier VA_1 so that the noise input to the echo suppressor ES_1 is always below that level of amplitude at which the operation of the echo suppressor ES_1 is effected. Reducer No. 1 includes rectifying and direct-current amplifying means, and may be preferably of the type disclosed in the patent of B. G. Bjornson, supra. In the output of reducer No. 1 is connected a resistance 49 through which flows direct current whose magnitude depends on the amplitude of the waves in the output of the vario-amplifier VA_1. The potentials developed across the resistance 49 by this flow of current serve to control the gain of the vario-amplifier VA_1 in a manner that will be subsequently explained.

The time constants of reducer No. 1 are such that an impulse of high amplitude applied suddenly to the input thereof requires a comparatively long time to decrease the gain of vario-amplifier VA_1 and when this impulse is suddenly removed, requires a relatively short time to increase the gain of vario-amplifier VA_1.

Across the input of vario-amplifier VA_1 is a transformer 55 coupling the former to disabler No. 1 whose function is to prevent strong parts of applied speech syllables in one-way path WE from causing reducer No. 1 to make false gain adjustments of vario-amplifier VA_1. Disabler No. 1 also serves an additional purpose that will be hereinafter explained, and comprises a thermionic amplifier-detector AD_1 in the output of which is a relay 56 whose operations are controlled by the amplifier-detector AD_1.

The control circuit 42 comprises vario-amplifier VA_2 and echo suppressor ES_2. The input of vario-amplifier VA_2 is coupled by a transformer 57 to the network 43. Output transformer 58 couples the output of vario-amplifier VA_2 to the input of echo suppressor ES_2 which comprises amplifier-detector 53 in whose output is a relay 54 responsive to detected current to close short-circuiting connection 61 across the one-way path WE. The vario-amplifier VA_2 is identical with vario-amplifier VA_1.

Across the output of vario-amplifier VA_2 is bridged a transformer 59 coupling the former to reducer No. 2 whose function it is together with reducer No. 1, as will be hereinafter explained, to automatically regulate the gain of the vario-amplifier VA_2 so that the noise input to the echo suppressor ES_2 is always below that level of amplitude at which the operation of the echo suppressor ES_2 is accomplished. Reducer No. 2 is of a type the same as previously mentioned reducer No. 1. In the output of reducer No. 2 is connected a resistance 60 through which flows direct current whose magnitude depends on the amplitude of the waves in the output of the waves in the vario-amplifier VA_2. The potentials developed across the resistance 60 by this flow of current serve to control the gain of the vario-amplifier VA_2 in a manner that will be hereinafter described. The time constants of reducer No. 2 are preselected such that the operation thereof is similar to that of reducer No. 1 with respect to the abrupt application of an impulse of high amplitude to associated vario-amplifier VA_2 and the sudden removal of this impulse therefrom for controlling the gain thereof.

In bridge of the input of vario-amplifier VA_2 is a transformer 62 coupling the former to disabler No. 2 whose function is to prevent strong parts of applied speech syllables in one-way path EW from causing reducer No. 2 to make false gain adjustments of vario-amplifier VA_2. Disabler No. 2 also serves an additional purpose that will be subsequently explained, and comprises a thermionic amplifier-detector AD_2 in the output of which is a relay 63, the operation of which is controlled by the amplifier-detector AD_2.

Associated with the relay 47 of echo suppressor ES_1 is a relay 66 which is connected with relay 63 included in the disabler No. 2. Output circuit 67 of the amplifier-detector 46 in echo suppressor ES_1 is connected to relay 54 of echo suppressor ES_2. Associated with the relay 54 of echo suppressor ES_2 is a relay 68 which is connected with relay 56 embodied in the disabler No. 1. Output circuit 69 of the amplifier-detector 53 in echo suppressor ES_2 including the operating circuit of relay 54 is connected to relay 47 in echo suppressor ES_1.

Bridging the resistance 49 and 60 of the respective reducers Nos. 1 and 2 are condensers 70 and 71 charged by the voltages built up across the respective resistances 49 and 60 and whose charges are applied through mixing circuit 72, Fig. 3, to the vario-amplifiers VA_1 and VA_2 to control the gain thereof in a manner that will be subsequently explained.

The mixing circuit 72 shown in Fig. 3 comprises, looking from reducer No. 1, a thermionic tube 73 whose input is connected across condenser 70 and whose output includes anode battery 74 and resistance 75. The condenser 70 bridges resistance 49 with disabling points 77 or 78 therebetween. The mixing circuit 72 also comprises, looking from reducer No. 2, a thermionic tube 79 whose input is bridged by condenser 71 and whose output embodies anode battery 80 and resistance 81. The condenser 71 is also applied across resistance 60 with disabling points 84 or 85 interposed therebetween.

Also included in the mixing circuit 72 is a rectifier 90 comprising thermionic rectifiers 91 and 92. The input of rectifier 91 is connected to resistance 75 while the input of rectifier 92 is connected to the resistance 81. The anodes of the rectifiers 91 and 92 are joined by a strap 93 so that the outputs are applied across resistance 94. The voltage developed across 94 is applied through leads 95 and 96 to vario-amplifiers VA_1 and VA_2 to control the gain thereof in a manner that will be hereinafter explained.

The operation of the system will now be described.

When neither noise nor speech is present in the path WE, reducers Nos. 1 and 2 produce no output voltages, the biases applied to the grids of the vario-amplifiers VA_1 and VA_2 are such that both of the latter are at maximum gain, and the echo suppressors ES_1 and ES_2 are effectively at maximum sensitivity.

Now, let it be assumed that there are no speech waves being transmitted over the system, but that noise of a fairly steady character is present therein. Referring to Fig. 4, a portion of the noise in path WE is diverted through network 41 into control circuit 40. The portion of the noise transmitted through control circuit 39 and transformer 55 into disabler No. 1 will be dissipated therein due to the fact that the detector thereof is set so as not to be operated on the maximum noise anticipated in the path WE. The remaining portion of the noise directed into control circuit 40 will be impressed by transformer 44 on vario-amplifier VA_1 to be amplified thereby. The amplified noise will be divided between the input of control circuit 38 for reducer No. 1 and the input of echo suppressor ES_1.

The first portion of the noise impressed on echo suppressor ES_1, due to the initial high gain of vario-amplifier VA_1 before the reducers have commenced to function as will be hereinafter explained, may be of an amplitude that will cause momentary operation of echo suppressor ES_1 to disable the path EW. However, as soon as the reducer No. 1 has built up an output voltage as will be subsequently described, the gain of vario-repeater VA_1 will be reduced to the proper point to cut down the level of the noise applied to the echo suppressor ES_1 so that such level of noise will be inadequate to effect the operation thereof. The remaining portion of the amplified noise in the output of VA_1 will be impressed on control circuit 38 and applied through transformer 48 on reducer No. 1 in whose output is a resistance 49 across which is built up a voltage that serves to charge condenser 70.

Similar operation occurs in the opposite side of the circuit with the result that amplified noise in the output of vario-amplifier VA_2 is applied to control circuit 36 and transformer 59 to reducer No. 2 in whose output is a resistance 60 across which is developed a voltage that serves to charge condenser 71.

Referring to Fig. 3, the charges on the condensers 70 and 71 are applied through tubes 73 and 79 to the respective resistances 75 and 81. The voltages developed across the latter resistances are applied through the rectifiers 91 and 92 to the resistance 94 in their combined output. Whichever one of resistances 75 and 81 produces the larger voltage at a given instant that one will cause current to flow in resistance 94. The voltage built up across resistance 94 will be substantially equal to the voltage across either resistance 75 or 81 that caused current to flow in resistance 94, as the latter is relatively large compared to either of the resistances 75 and 81.

The voltage produced across resistance 94 will be applied over leads 95 and 96 through the secondary windings of the transformers 44 and 57 to the grids of the respective vario-amplifiers VA_1 and VA_2 to control the gain thereof as described in the patent to B. G. Bjornson, supra. The smaller of the voltages developed across either resistance 75 or 81 will in no wise affect the voltage across the resistance 94, as the smaller voltage will be in the non-conducting direction of the respective rectifiers 91 and 92 associated therewith. Therefore, the voltage across the resistance 94 serves to automatically control the bias on both vario-amplifiers VA_1 and VA_2 such that the sensitivity thereof is constantly adjusted to the higher level of noise.

Now, let it be assumed, that while noise is still present in the path WE, a subscriber at the west terminal commences speaking thereby producing speech waves that are impressed on the WE path of link B in Fig. 2. As explained above, this will cause first, the operation of echo-suppression point 20 in link B and in due course the operation of echo-suppression point 21 in link C. Also, as previously described, the operation of echo-suppression point 21 serves to cut off from the control circuit 25 of nogad 26 such noise as originated at the east terminal. Also, as hereinbefore mentioned, the effect of this is such that in the absence of the invention the sensitivity of nogad 26 increases rapidly to cause false operation of echo-suppression point 28 during the interval required for nogad 26 to adjust its sensitivity after echo-suppression point 21 had been released to allow noise from the east terminal to reach control circuit 25.

It will now be explained how, in accordance with this invention, abrupt changes in the sensitivity of nogad 26 and the false operations of echo-suppression point 28 are substantially reduced. It is to be kept in mind that for the purpose of this description the circuit shown in Fig. 2 embodies in each of links B and C the circuit illustrated in Fig. 4, although the circuit in Fig. 2 may be further modified as hereinbefore explained. In Fig. 2 the nogads 23 and 26 represent circuits in accordance with Fig. 4. Therefore in Fig. 4 a portion of the speech waves together with noise in the path WE will be diverted by network 41 into control circuit 40. The diverted energy will be divided between circuit 39 for disabler No. 1 and the input of vario-amplifier VA_1.

The portion of speech energy diverted into vario-amplifier VA_1, whose gain has been adjusted by the reducers in accordance with the amount of noise in the system as above described, will be amplified therein. The main portion of the amplified speech in the output of vario-amplifier VA_1 will be applied to the amplifier-detector 46 of echo suppressor ES_1 to cause the energization of winding of relay 47. The latter operates to close across the path EW the short-circuiting contact 50 which, since the circuit according to Fig. 4 is embodied in both links B and C, is the equivalent of operating echo-suppression points 20 and 21 in Fig. 2.

The operation of relay 47 also shifts its armature 100 from its back contact to its front contact thereby causing the energization of the winding of relay 66 through a circuit comprising negative terminal of battery 101, winding of relay 66, series resistances 102 and 103, closed front contact of armature 100 of relay 47 and ground 104. Relay 66 operates to open contact 85 thereby disabling reducer No. 2. Now, condenser 105 charged normally by battery 101 through winding of relay 66 and resistance 102 is discharged to ground 104 through resistance 103 and closed front contact of armature 100 of relay 47. When relay 47 releases to return armature 100 to its back contact, the operating winding of relay 66 is not immediately broken, although ground 104 is removed therefrom. Relay 66 will not immediately release but will be held operated to keep contact 85 open for a hangover period of time while condenser 105 is being charged up to the potential of battery 101 by a flow of current therefrom through winding of relay 66 and resistance 102.

Since reducer No. 2 is connected through control circuit 36 vario-amplifier VA_2, circuit 42 and network 43 to the path EW, the disabling of reducer No. 2 by the operation of relay 66 has the effect that whatever noise prevails in the path EW such noise will be precluded from affecting the charge on the condenser 71 in each circuit according to Fig. 4 embodied in both links B and C in Fig. 2. Consequently, at least the amount of charge on condenser 71 will be rendered effective through the mixing circuit 72 in Fig. 3 to bias the grids of both vario-amplifiers to control the gain thereof in the manner hereinbefore explained.

Thus, when relay 66 operated to open its contact 85 in each of the circuits according to Fig. 4 embodied in both links B and C, it was thereafter unimportant whether the control circuits 22 and 25 of the respective nogads 23 and 26 in Fig. 2 were either exposed to or cut off from noise originating at the east terminal. As a matter of fact the control circuit 22 remained exposed to such noise while the control circuit 25 was cut off therefrom. The reason for this unimportance is that the disabling of the reducer No. 2 in Fig. 4 renders it impossible for further noise energy in the path EW to affect the charge on the condenser 71 in Fig. 4.

Therefore, the gain of both vario-amplifiers and thereby the sensitivity of the associated echo suppressors are adjusted at least to that level represented by the amount of the charge on condenser 71 regardless of the amount of the charge on condenser 70. As described above in connection with Fig. 3, the charge on either condenser 70 or condenser 71 is rendered effective through the mixing circuit 72 to control the gain of both vario-amplifiers, depending on which of the charges is the larger,

The remaining portion of the amplified energy in the output of vario-amplifier VA_1 is impressed through circuit 38 on reducer No. 1 which functions to varyingly charge condenser 70 whose charge together with that of condenser 71 serves to control the gain of both vario-amplifiers and thereby the sensitivity of both echo suppressors in the manner hereinbefore described. A more complete description of the functioning of reducer No. 1 may be had by referring to the patent of B. G. Bjornson, supra.

The portion of the energy diverted into circuit 39, when containing strong parts of speech, will cause the functioning of disabler No. 1 by energizing the relay 56 which operates to open normally closed contact 77 thereby disabling reducer No. 1. This serves to prevent change in the gain of the vario- amplifiers when the amplitude of the energy in the circuit 40 incoming from the path WE exceeds a predetermined value. Such predetermined value is the amplitude of the peaks of the loudest noise that can be tolerated on commercial circuits. A more complete description of disabler No. 1 may be had by referring to the patent of B. G. Bjornson, supra.

Finally, the operation of relay 47 opens normally closed contact 108 thereby interrupting the operating circuit of relay 54 in the output 69 of the amplifier-detector 53 included in the echo suppressor ES_2. The latter is therefore disabled so long as the subscriber at the west terminal continues to talk.

Now, let it be assumed that while noise is still present in the path EW a subscriber at the east terminal commences speaking thereby producing speech waves that are impressed on the EW path of link C in Fig. 2. As hereinbefore explained, this will cause, first, the operation of echo-suppression point 30 in link C and in due course thereafter the operation of echo-suppression point 28 in link B. Also, as previously described, the operation of echo-suppression point 28 serves to cut off from the control circuit 33 of nogad 23 such noise as originates in the west terminal. Also, as above explained, the effect of this is such that in the absence of the invention the sensitivity of nogad 23 increases rapidly to cause false operations of echo-suppressor point 30 during the interval required for nogad 26 to adjust its sensitivity after echo-suppression point 28 has been released to allow noise from the west terminal to reach control circuit 33. The rapid change in the sensitivity of nogad 23 together with the false operations of echo-suppression point 30 are substantially reduced in the manner similar to that set forth above in connection with the sensitivity of nogad 26 coupled with the false operations of echo-suppression point 20, and will now be explained.

When the speech arriving over circuit EW causes operation of suppressor ES_2, relay 68 is operated, opening contact 78 to cut condenser 70 off from circuit WE, leaving condenser 70 charged to a voltage dependent upon the noise present in path WE. Therefore, at least the amount of charge remaining on condenser 70 will be rendered effective through the mixing circuit 72 in Fig. 3 to bias the grids of both vario-amplifiers to control the gain thereof in the manner set forth above.

Thus, when relay 68 operated to open its contact 78 in each of the circuits according to Fig. 4 embodied in both links B and C, it was thereafter unimportant whether the control circuits 31 and 33 of the respective nogads 26 and 23 in Fig. 2 were either exposed or cut off from noise originating at the west terminal. As a matter of fact control circuit 31 remained exposed to such noise while the control circuit 33 was cut off therefrom. The reason for this unimportance is that the disabling of the reducer No. 1 in Fig. 4 renders it impossible for further noise energy in the path WE from affecting the charge on condenser 70 in Figs. 3 and 4.

Therefore, the gain of both vario-amplifiers and thereby the sensitivity of both echo suppressors are adjusted at least to that level represented by the amount of the charge on condenser 70 irrespective of the amount of the charge on condenser 71. As previously explained relative to Fig. 3, the charge on either condenser 70 or condenser 71 is rendered effective through the mixing circuit 72 to control the gain of both amplifiers, depending on which of the charges is the larger.

The remaining portion of the amplified energy in the output of vario-amplifier VA_2 is applied through circuit 36 on reducer No. 2 which functions to charge condenser 71 whose charge together with that of condenser 70 serves through the mixing circuit 72 to control the gain of both vario-amplifiers and thereby the sensitivity of both echo suppressors as hereinbefore set forth. A more complete description of the functioning of reducer No. 2 may be had by referring to the patent of B. G. Bjornson, supra.

The portion of the energy diverted into circuit 37, when containing strong parts of speech, will cause the operation of disabler No. 2 by energizing the relay 63 which then operates to open normally closed contact 84 thereby disabling reducer No. 2. This serves to prevent change in the gain of the vario-amplifiers when the amplitude of the energy in the circuit 42 incoming from the path EW exceeds a predetermined value. Such predetermined value is the amplitude of the peaks of the loudest noise that can be tolerated on a commercial circuit. A more complete description of disabler No. 2 may be had by referring to the patent of B. G. Bjornson, supra.

Finally the operation of relay 54 opens normally closed contact 97 thereby interrupting the operating circuit of relay 47 in the output 67 of the amplifier-detector 46 included in the echo suppressor ES_2. Consequently the latter is disabled so long as the subscriber at the east terminal continues to talk.

Thus, it is seen that when a nogad having two reducer circuits is embodied in each of at least two four-wire links in a transmission system the highly sensitive echo suppressors are utilized to disable that reducer whose input originates at a terminal opposite to that from which the input of the disabling echo suppressor comes. Accordingly, as previously described in detail, echo suppressor ES_1 operated by energy originating in the west terminal serves through the operation of relays 47 and 66 to disable reducer No. 1 whose input comes from the east terminal while echo suppressor ES_2 operated by energy originating in the east terminal serves through the operation of relays 54 and 68 to disable reducer No. 1 the input of which comes from the west terminal.

Therefore, one side of each nogad is always effective for adjustment due to noise in one one-way path of the transmission system and one side of each nogad is always disabled when a subscriber is talking. Obviously, this enables each nogad to function a much larger percentage of time since only one side thereof is disabled with a hangover during the interval when a subscriber is talking.

Moreover, it is seen that when a reducer is disabled the gain of both vario-amplifiers together with the sensitivity of the echo suppressors is held at least to a certain amount for the period of the disability. This is so for, as previously explained, the charge on either condenser 70 or 71, depending on which reducer is disabled, remains substantially constant and so long as the particular charge is rendered effective through the mixing circuit 72 for controlling the gain of both vario-amplifiers the latter will be held to a gain depending on the amount of such charge.

Consequently, when the disabled reducer is again rendered effective for controlling the charge on the condenser associated therewith, the change in the charge due to noise energy will be with respect to the previous amount of charge and in ordinary commercial circuits such change would be relatively small. Accordingly, the change in gain of both vario-amplifiers and the change in sensitivity of the echo suppressors associated therewith would also be correspondingly small thereby requiring a relatively short interval for accomplishing such changes. Hence, there is materially reduced, if not entirely eliminated, the possibilities for the echo suppressors to make a relatively large number of false operations of the echo-suppression points 20 and 30 during the interval required for the nogads to adjust their sensitivities after the release of the respective echo-suppression points 21 and 28 as hereinbefore explained.

What is claimed is:

1. In a two-way telephone system comprising a source of voice waves, two or more four-wire links connected in tandem, each of the links embodying two oppositely directed one-way paths subject to interfering noise waves, a wave device connected to the one-way paths in each link and responsive to waves therefrom to short-circuit the opposite one-way paths therein, a wave amplifier connected between each one-way path and the wave device operatively associated therewith, and means for maintaining for a substantial portion of time an automatic control of the gain of the amplifiers in each link in response to waves impressed thereon comprising means connected to the output of each amplifier for producing voltages representative of the amplitudes of the waves therein, a control circuit for combining the controlling effects of the produced voltages in such manner that a single control voltage is effectively applied to the amplifiers, and means operably connected to each wave device to disable the voltage producing means whose input comes from the one-way path which is opposite to the one-way path whose waves caused the operation of the wave device.

2. In a two-way telephone system comprising a source of voice waves, two or more four-wire links connected in tandem, each of the links embodying two oppositely directed one-way paths subject to interfering noise waves, a wave device connected to the one-way paths in each link and responsive to waves therefrom to short-circuit the opposite one-way paths therein, a wave amplifier connected between each one-way path and the wave device operatively associated therewith, and means in each link for automatically controlling the gain of the amplifier in response to the waves causing the operation of the wave device therein comprising means connected to the output of each amplifier for producing voltages corresponding to the amplitudes of the noise and voice waves flowing therein, means for combining the controlling effects of the produced voltages in such manner that the larger one is effectively applied to the amplifiers, and means operably connected to each wave device to disable the voltage producing means whose input comes from the one-way path which is opposite to the one-way path whose waves caused the operation of the wave device.

3. In a two-way telephone system comprising a source of voice waves, two or more four-wire links connected in tandem, each of the links embodying two oppositely directed one-way transmission paths subject to interfering noise waves, a wave device connected to the one-way paths in each link and responsive to waves therefrom to short-circuit the opposite one-way path therein, a wave amplifier connected between each one-way path and the wave device operatively associated therewith in at least one link, and means in the one link for maintaining for a substantial portion of time an automatically continuous control of the effects of noise waves on the wave devices embodied in the one link regardless of the operation of the wave devices in the other links while retaining the sensitivity of the amplifiers to voice waves comprising means connected to the output of each of the amplifiers and supplied with waves therefrom for producing voltages corresponding to the amplitudes of such waves, a control circuit for combining the controlling effects of the produced voltages in such manner that the larger of the two voltages controls the gain of the amplifiers, and means operably associated with the wave devices in the link embodying the amplifiers to disable the voltage producing means whose input comes from the one-way path which is opposite to the one-way path whose energy caused the operation of the wave device.

4. In a two-way telephone system comprising a source of voice waves, two or more four-wire links connected in tandem, each of the links embodying two oppositely directed one-way transmission paths subject to interfering noise waves, a wave device connected to the one-way paths in each line and responsive to waves therefrom to short-circuit the opposite one-way path therein, a wave amplifier connected between each one-way path and the wave device operatively associated therewith, and means for maintaining for a substantial portion of time an automatically continuous control of the effects of noise waves on the wave devices embodied in each link while retaining the sensitivity thereof to voice waves

comprising means connected to the output of each of the amplifiers and supplied with waves therefrom for producing voltages corresponding to the amplitudes of such waves, means for combining the controlling effects of the produced voltage in such manner that the larger thereof is effectively applied to the amplifiers to control the gain thereof, means operably connected to each wave device to disable the voltage producing means whose input comes from the one-way path which is opposite to the one-way path whose energy caused the operation of the wave device, and means connected to the input of each amplifier and unresponsive to noise waves but responsive to voice waves of at least a predetermined amplitude to disable the voltage producing means connected to the one-way path transmitting both noise and voice waves.

5. The two-way telephone system according to claim 4 in which each voltage producing means includes a condenser charged in an amount depending on the amplitudes of the waves in the respective outputs, and the combining means embodies means for rendering effective the larger of the two charges and rendering ineffective the smaller of the two charges.

6. The two-way telephone system according to claim 4 in which each voltage producing means includes a condenser charged to an amount depending on the amplitudes of the waves in the respective outputs and the charge on the condenser in the disabled voltage producing means remains substantially the same during the period of such disability.

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