

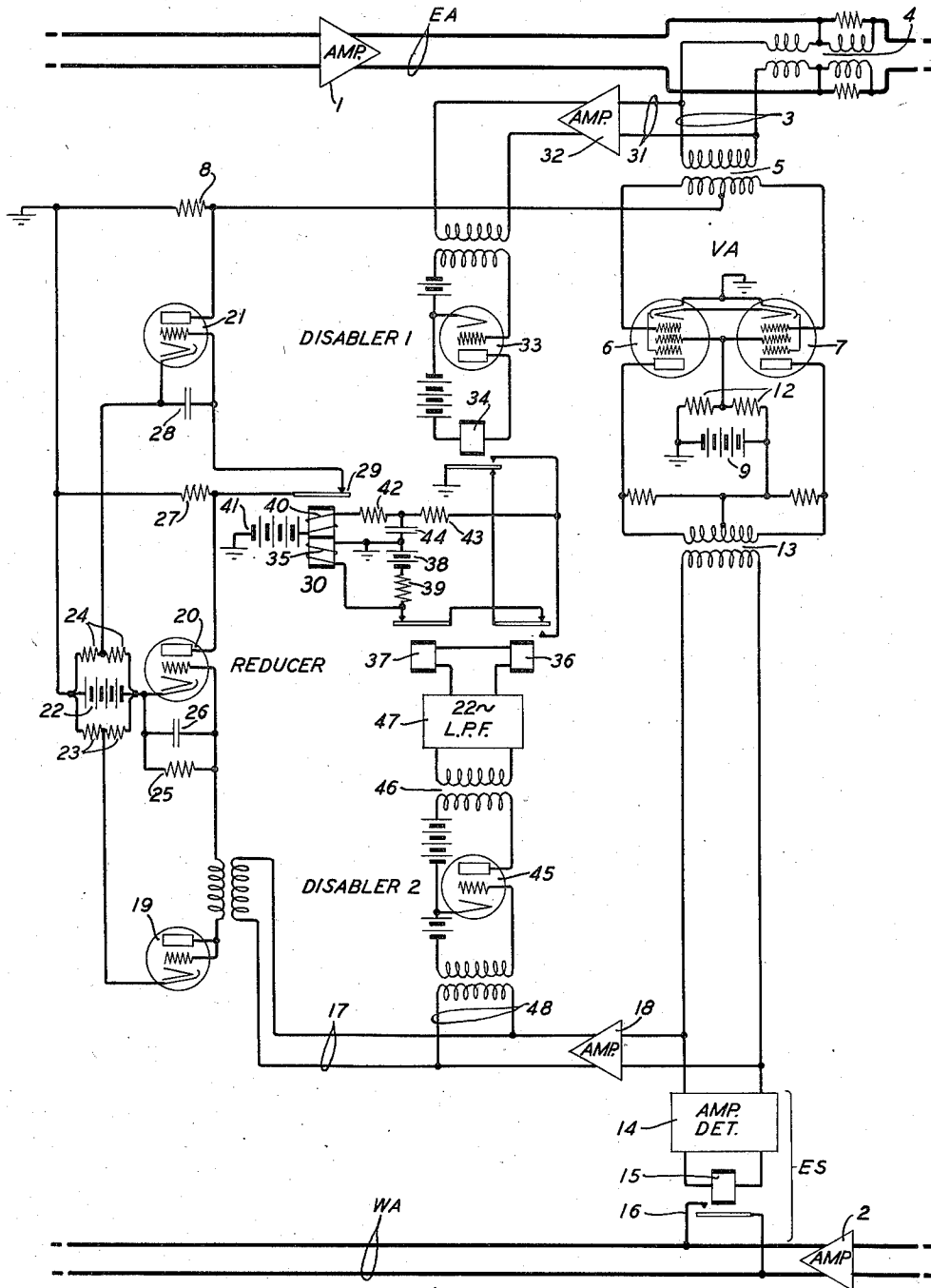
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TRANSMISSION CONTROL IN SIGNALING SYSTEMS

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TRANSMISSION CONTROL IN SIGNALING
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The invention relates to transmission control in signaling systems and particularly to circuits for reducing the effects of interfering waves in such systems.

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

10 Another and a more specific object is to improve the operation of a signal-controlled device for controlling transmission in a signaling system subject to interfering waves, such as line noise.

15 It is often necessary to use voice-operated switching devices, for example, voice-operated echo suppressors or antisinging devices, in connection with toll telephone lines. Such lines are often subject to noises of varying amplitudes, including the usual line noise introduced by operation of line apparatus and the noise induced in the line from extraneous sources as from neighboring power lines. This noise may seriously interfere with the proper operation of the switching devices on speech energy. Noise waves of high amplitude may either cause false operation of the switching devices or necessitate reducing the sensitivity of the latter to such a degree as to prevent proper operation on speech waves of low amplitude.

20 Certain circuits of the prior art attain proper discrimination against noise by utilizing the noise energy to automatically produce a continuous reduction in sensitivity of the voice-operated 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 H. L. Barney Patent 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 a very slow decrease in its gain when the input energy suddenly increases, 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 ceases and only noise is present on the line. To prevent excessive reduction in the gain of the amplifier by speech during the strong parts of the received speech syllables, a marginal control device connected to the input of the variable gain amplifier is arranged to respond to the peaks of the received

speech impulses to disable the gain-controlling circuit.

5 In accordance with the present invention, the operation of a system of the above-described type is improved by the use therewith of a second control device which is unresponsive to noise but is responsive to the weak as well as the strong speech impulses to disable the gain-controlling circuit. In one embodiment, the second control device comprises a very sensitive syllabic amplifier-detector connected across the output of the amplifier and controlling the operation of mechanical relays to render the gain-controlling circuit ineffective. The syllabic control device in conjunction with the marginal control device prevents any change in the amplifier gain during a very large part of the time when speech is on the circuit and thereby materially reduces the amount of speech desensitization.

10 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, the single figure of which shows schematically a portion of a four-wire toll telephone system equipped with a transmission control circuit in accordance with a preferred form of the invention.

15 The four-wire toll telephone circuit as shown in the drawing comprises a one-way transmission path EA including the one-way amplifying device 1 for repeating telephonic currents in the direction from west to east, and the one-way transmission path WA including the one-way amplifying device 2 for repeating telephonic currents in the direction from east to west. The one-way paths EA and WA 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 hybrid transformers and associated balancing networks (not shown) or by any other suitable means.

20 The outgoing portion of the transmission path EA and the input of the transmission control circuit 3 are connected by means of a network 4 in substantially conjugate relation with each other and in energy-transmitting relation with the output of the amplifying device 1. This is to prevent the short-circuiting of the outgoing portion of EA by an echo suppression unit (not shown) connected to WA from affecting the input to the circuit 3. The network 4 may be a special bridge transformer such as is disclosed in Crisson Patent 1,755,243, issued April 22, 1930, for a similar purpose.

The transmission control circuit 3 has a main portion comprising the vario-amplifier VA and the echo suppressor ES. The input of the vario-amplifier VA is coupled by the transformer 5 to the network 4. The vario-amplifier VA comprises the variable gain amplifying vacuum tubes 6 and 7, which may be screen grid tubes employing heater type cathodes as indicated, connected in push-pull relation. A series resistance 8 is connected in the common portion of the control grid-cathode circuits of the tubes 6 and 7. Plate current is supplied to the anodes of the tubes 6 and 7 from the common grounded plate battery 9, and the screen grids of these tubes are provided with suitable bias by their connection to the voltage divider 11 shunting the plate battery 9. The output transformer 13 couples the output of the vario-amplifier VA to a circuit leading to the input of the echo suppressor ES which may be of any suitable type adapted to disable the path WA in response to voice energy impressed on its input. For example, as indicated, the echo suppressor ES may comprise an amplifier-detector 14 and a mechanical relay 15 in its output responsive to the detected current to close the short-circuiting connection 16 across the path WA in the output of amplifier 2.

The control circuit 3 includes also a branch circuit 17, which will be referred to hereinafter as the "reducer", the function of which is to automatically regulate the gain of the vario-amplifier VA so that the noise input to the echo suppressor ES is always just below the operating amplitude.

The reducer 17 comprises a stage of alternating current amplification 18, the input of which is connected across the control circuit 3 at a point between the output of the vario-amplifier VA and the input of the suppressor ES, a half-wave vacuum tube rectifier 19 and two vacuum tube stages 20 and 21 of direct current amplification. The battery 22 with its positive side grounded and the voltage dividers 23, 24 shunting it provide means for obtaining the plate and grid voltages for the tubes 20 and 21, and for operating the cathodes of the tubes 19, 20 and 21 at negative potentials with respect to ground.

The parallel-connected resistance 25 and condenser 26 in the output of rectifier 19 operate as a filter for its output voltage to reduce the alternating current ripple. The input electrodes of the three-electrode amplifier tube 20 are connected across the terminals of the condenser 26 so that the filtered output voltage of the rectifier is impressed on the input of the tube 20.

Plate current is supplied to the plate of the amplifier tube 20 from the battery 22 through the large series resistance 27. A large condenser 28 in series with a portion of the voltage divider 24 shunting battery 22 is normally connected in parallel with resistance 27 through the normally closed contact 29 and armature of the "disabler master" relay 30, so as to be normally charged by current from battery 22. The input electrodes of the three-element vacuum tube 21 are connected across condenser 28. Plate current is supplied to the plate of tube 21 from battery 22 through the resistance 8 also connected in the common branch of the input circuits of tubes 6 and 7 in the vario-amplifier VA, so that as the output current of tube 20 increases the bias on the grids of the vacuum tubes 6 and 7 becomes more negative and the gain of the vario-amplifier VA is proportionately decreased.

The time constants of the reducer just de-

scribed are such that an impulse of high amplitude suddenly applied to the input thereof requires a comparatively long time to decrease the gain of the vario-amplifier VA, but when the impulse is suddenly removed, the vario-amplifier gain quickly increases. This time characteristic of the reducer is obtained by proper selection of the values of the resistances 25, 27 and 8, and condensers 26 and 28 associated with the two stages of direct current amplification 20, 21 as will be explained later in connection with the description of the complete operation of the system.

Connected across the input of the vario-amplifier VA is the input of a circuit 31, which will be referred to hereinafter as "disabler #1", the function of which is to prevent the strong parts of applied speech syllables from causing the reducer to make a false gain adjustment.

Disabler #1 comprises a single stage of amplification 32 followed by a three-electrode vacuum tube detector 33 and a relay chain comprising the relay 34 and the "master disabler" relay 39, the operation of which is controlled by operation of the detector.

The detector 33 is a marginal device designed by suitable selection of the circuit constants to have a fixed low sensitivity of such value with respect to the path EA that it will not operate to cause operation of the relay 34 in the output of the detector, and thus of the master relay 39, in response to the noise of maximum amplitude received from the path EA, but will operate to cause operation of these relays in response to the peaks of the stronger syllables of applied speech waves.

Bridged across the circuit connecting the output of vario-amplifier VA and the input of echo suppressor ES, and therefore across the input of the reducer, is another disabler circuit 43, which will be referred to hereinafter as "disabler #2". The function of disabler #2 is to prevent adjustment of the gain of vario-amplifier VA in response to speech sounds not strong enough to operate disabler #1. It is connected across the input of the reducer so that its sensitivity bears a fixed relation to that of the reducer, and its sensitivity is adjusted so that it operates at least on the beginning and ending of practically all speech sounds.

Disabler #2 comprises a syllabic amplifier-detector circuit and a chain of mechanical relays 36, 37 and 38. As indicated, the amplifier portion of this circuit may comprise the same amplifier 18, employed in the input of the reducer 16, and the detector portion comprises a three-electrode vacuum tube detector 45, the circuit constants of which are adjusted to make it highly sensitive.

The output of the detector 45 is coupled by the transformer 46 to the input of a low pass filter 47 having a cut-off at approximately 22 cycles per second. Connected in series across the output of the low pass filter 47 are the windings of two relays 36 and 37 reversely wound. Relay 36 is designed to be slightly, say, about 2.5 decibels, more sensitive than relay 37, so that relay 36 will be operated by the impulse of one polarity produced in the output of filter 47 due to the first part of each speech syllable applied thereto, and relay 37 will be operated by the impulse of the opposite polarity produced in the output of filter 47 by the final part of each applied speech syllable. Speech waves applied continuously to the input of disabler #2, therefore, will keep the armatures of relays 36 and 37 in vibration so that

when the armature of relay 36 is on its back contact, the armature and contact of relay 37 are closed, and when the armature of relay 36 is on its front contact the armature and contact of relay 37 will be open.

When the relays 34, 36 and 37 are unoperated, the armature of relay 34 is held on the back contact of that relay, and the operating winding 35 of the master disabler relay 30 is short-circuited through a circuit which may be traced from ground through the normally closed armature and back contact of relay 34, closed armature and back contact of relay 36, normally closed armature and contact of relay 37 and operating winding 35 of relay 30 to ground, so that the winding 35 is deenergized. The other "hangover" winding 40 of the master relay 30 is also deenergized, so that relay 30 is unoperated and its armature and contact 29 are closed to maintain the reducer operative.

When relay 34 operates to shift its armature from the back to the front contact, the short circuit around the operating winding 35 of relay 30 is removed, and that winding is supplied with energizing current from battery 38 over a circuit extending from the positive terminal thereof through winding 35 and series resistance 39 to the negative terminal of the battery. This causes the operation of relay 30 to open its armature and contact 29, and thus to disable the reducer circuit.

When the armature of relay 34 reaches the front contact of the relay, an energizing circuit for the second "hangover" winding 40 of relay 30 is closed from battery 41 through the latter winding, series resistances 42 and 43, front contact and armature of relay 34 and ground, and the condenser 44, normally charged by battery 41 through winding 40 of relay 30 and resistance 42, is discharged to ground through resistance 43 and closed front contact and armature of relay 34. When relay 34 releases after operation to return its armature to the back contact the operating winding 35 of relay 30 is again short-circuited and therefore deenergized, and the energizing circuit for the winding 40 of relay 30 from battery 41 through the front contact and armature of relay 34 is broken. Relay 30, however, will not immediately release, but will be held operated to hold its armature and contact 29 open for an additional hangover period while condenser 44 is being charged up to the potential of battery 41 by flow of current therefrom through winding 40 of relay 30 and resistance 42.

If relay 34 is operated and then relay 36 operates, the operation of the master relay 30 will not be affected by the latter operation. However, if relay 34 is unoperated and relay 36 then operates to shift its armature from the back to the front contact, the short circuit around the operating winding 35 of relay 30 through the armature and back contact of relay 36 will be removed, and that winding will be energized by current from battery 38 through resistance 39 causing the operation of relay 30 to open its armature and contact 29. The hangover winding 40 of relay 30 will then be energized from battery 41 through series resistances 42 and 43, front contact and armature of relay 36 and back contact and armature of relay 34, and the normally charged condenser 44 will be discharged to ground through resistance 43, front contact and armature of relay 36 and back contact and armature of relay 34.

When relay 36 releases at the end of the impulse causing its operation, the closing of its

armature and back contact reapplies the short circuit around operating winding 35 of relay 30, and the energizing circuit for winding 40 from battery 41 through the armature and front contact of relay 36 is broken. However, relay 30 will not immediately release, but will be held operated to maintain its armature and contact 29 open for an additional hangover time interval by winding 40 while condenser 44 is being charged up to the potential of battery 41 by current therefrom through winding 40 and resistance 42. By properly proportioning the values of the elements in the hangover circuit, this hangover interval is made long enough to bridge the time interval between the release of relay 36 and the operation of relay 37 for the longest applied speech syllable, and thus to prevent premature closing of the armature and contact 29 of relay 30 to cause variation of the gain of the vario-amplifier VA by speech.

When relay 37 operates at the end of the applied speech syllable its armature and contact will be opened removing the normal short circuit across operating winding 35 of relay 30 through the closed armature and contact of relay 37, closed armature and back contact of relay 36, closed back contact and armature of relay 34 and ground. Then, the operating winding 35 of relay 30 will be operatively energized by current from battery 38 through resistance 39 holding relay 30 operated to maintain its armature and contact 29 open. However, no hangover is supplied to relay 30 by operation of relay 37, so that on the release of relay 37 with cessation in the supply of speech energy to disabler #2 the relay 30 will release quickly to close its armature and contact 29, and thus to make the reducer immediately operative.

From the above description, it will be apparent that the relay 34 of disabler #1 and relays 36 and 37 of disabler #2 are so interconnected with the operate windings of the disabler master relay 30 as to cause the operation of the latter relay on operation of any one of the three relays 34, 36 or 37 and to produce a hangover in operation for the case of relays 34 and 36 but not in the case of relay 37.

The complete operation of the system shown in the drawing will now be described.

When neither noise nor speech energy is present on the path EA, the reducer 17 does not produce any output voltage, the biases applied to the grids of tubes 6 and 7 are such that the vario-amplifier VA is at maximum gain, and the echo suppressor ES, therefore, is effectively at maximum sensitivity.

Now, let it be assumed that speech waves are not being transmitted over path EA, but that noise of a fairly steady character is present in that path. A portion of this noise is diverted into control circuit 3 through network 4. The portion of this noise transmitted into circuit 31 (disabler #1) will be dissipated in the input of the marginal detector 33 which is set so as not to be operated on the maximum noise expected in the path EA.

The remaining portion of the diverted noise energy will be impressed by transformer 5 on the input of vario-amplifier VA and will be amplified thereby, and the amplified noise in the output of vario-amplifier VA will be divided between the input of the suppressor ES and the common input of the circuit 17 (reducer) and circuit 48 (disabler #2). The initial portion of the noise impressed on suppressor ES, because of the high gain of the vario-amplifier VA before the reducer has op-

erated, may be of such amplitude level as to cause momentary operation of the suppressor (amplifier-detector 14 and relay 15) to disable the path WA. However, as soon as the reducer has built up its output voltage in response to noise in the manner to be described, the gain of the vario-amplifier VA will be reduced to the proper point to cut down the level of the noise applied to the echo suppressor so that it will not hold the suppressor operated.

The remaining portion of the noise energy in the output of vario-amplifier VA will be amplified by amplifier 18 in the common input of circuits 48 and 17. The portion transmitted into circuit 48 (disabler #2) and detected by detector 45 therein will be dissipated in filter 47 as this filter passes only the low envelope frequencies of speech, and the usual line noise, whose envelope is relatively steady, does not produce frequencies in this range. If the noise energy is suddenly applied relay 36 may momentarily operate.

The other portion of the amplified noise in the output of amplifier 18 will be rectified by rectifier 19 in the reducer, filtered by the resistance-condenser network 25, 26 and the filtered rectified energy will be impressed on the amplifier tube 20 in such manner as to apply a negative bias on the grid of that tube which becomes more negative as the input to the tube increases. The time constants of the resistance 25 with condenser 26 by suitable selection of values is made large enough to carry over a bias between peaks of 60 cycle noise but not so large as to carry over a bias between succeeding speech syllables.

When the grid of tube 20 becomes negative its plate impedance increases causing the large condenser 28 in the plate-cathode circuit of tube 20 normally charged by battery 22 to discharge slowly through the resistance 27. As condenser 28 discharges less and less negative bias is applied to the grid of the amplifier tube 21.

The plate impedance of the vacuum tube 21 decreases as its grid voltage becomes less negative, and the voltage drop in the resistance 8 due to the output current of tube 21, increases, causing a slowly increasing negative bias to be applied to the grid of the push-pull vacuum tubes 6 and 7 in the vario-amplifier VA. This increase of the negative bias on the grids of the push-pull vacuum tubes 6 and 7 causes the gain of the vario-amplifier VA to be decreased proportionately. By proper selection of the constants of the circuit elements in the reducer circuit 17, the amount of reduction in the gain of the vario-amplifier VA with increase in the level of the noise input thereto is made sufficient to insure that the noise input to the suppressor ES is always below that value necessary to cause operation of the suppressor.

It will now be assumed that, while noise is still present on the path EA, speech waves are being transmitted from west to east over that path. A portion of the speech energy along with the noise energy on the path will be diverted into the control circuit 3 through network 4. The diverted energy will be divided between the input of the vario-amplifier VA and the circuit 31 (disabler #1). The strong parts of the speech energy transmitted into disabler #1 will cause operation thereof to disable the reducer circuit in the manner which will be described later.

The other portion of the speech energy in control circuit 3 will be impressed on the input of the vario-amplifier VA, the gain of which has been previously adjusted by the reducer in accordance with the amount of noise energy on the path EA

as described above, and will be amplified accordingly.

The main portion of the amplified speech energy in the output of vario-amplifier VA will be impressed on the amplifier-detector 14 of the echo suppressor ES causing its immediate operation to energize the winding of relay 15, and consequently cause the operation of that relay to close the short-circuiting connection 16 across the path WA.

The other portion of the amplified speech energy in the output of VA will be transmitted into the common input circuit of the circuit 17 (reducer) and the circuit 48 (disabler #2), and will be amplified by the common amplifier 18 therein.

A portion of the amplified speech energy in the output of amplifier 18 will be impressed on the input of the detector 45 in disabler #2 and will cause operation of the latter to disable the reducer circuit in the manner which will be described later.

The other portion of the amplified speech energy in the output of amplifier 18 will be impressed on the rectifier 19 and will be rectified thereby, and the rectified output will be filtered by the circuit comprising condenser 26 and resistance 25 in parallel. The reducer circuit functions differently on increasing energy from the way it functions on decreasing energy when the rise and fall is over syllabic intervals of time, so it is necessary to consider here what happens (1) when the rectified speech energy is building up; and (2) when the rectified speech energy is dying out.

As the rectified speech energy increases, the normal positive bias on the grid of the amplifier tube 20 is overcome so that the grid becomes negative and the plate impedance of tube 20 increases. Then, the condenser 28 in the output of tube 20 discharges slowly through the resistance 27 causing the grid of the amplifier tube 21 to become less negative and the plate impedance of the latter tube to decrease. This causes more negative bias to be supplied to the push-pull vario-amplifier tubes 6 and 7 due to the increasing voltage drop in the resistance 8 common to the output of tube 21 and the input circuits of the vario-amplifier tubes 6 and 7, thereby reducing the gain of the vario-amplifier. This reduction in gain will be gradual, and can be made so slow by proper selection of the values of the condenser 28 and resistance 27 that the duration of any one speech syllable will be too short to cause any appreciable reduction in gain and thus of the amplitude of the speech waves applied to the echo suppressor ES. Furthermore, because of the delay in operation of the reducer circuit 17, the initial weak portions of the speech syllables reach the echo suppressor ES before the gain of the push-pull amplifying tubes 6 and 7 has been reduced, thus insuring proper operation of the echo suppressor to close the short-circuiting connection 16 across the path WA.

When the amplitude of the rectified speech energy in the output of rectifier 19 decreases, the positive bias on the grid of the amplifier tube 20 increases, and the condenser 28 in the output thereof charges up rapidly through the plate impedance of the amplifier tube 20. This quickly increases the negative bias on the grid of the vacuum tube 21, increasing the plate impedance of that tube and reducing the negative bias on the push-pull vario-amplifier tubes 6 and 7, thereby quickly restoring the gain of the latter tubes to the amount set by the steady noise. Thus, it will

be seen that the effective sensitivity of the echo suppressor ES will be as high as the noise permits when the next syllable is received.

In addition to the time constants of the reducer circuit as described above, disablers #1 and #2 operate to prevent any changes in the gain of vario-amplifier VA under certain conditions. Disabler #1 is utilized to prevent change in gain when the amplitude of the input energy from the path EA is greater than a predetermined value. This predetermined value is the amplitude of the peaks of the loudest noise which can be tolerated on a commercial circuit. The peak amplitudes of speech syllables of the stronger talkers are usually greater than this value so that disabler #1 is effective in preventing operation of the reducer to decrease the vario-amplifier gain on a large proportion of the speech sounds. Disabler #1 operates as follows:

The portion of the speech energy from the path EA entering circuit 31 (disabler #1) is amplified by amplifier 32, and the amplified speech energy is impressed on the input of the marginal detector circuit 33. When the amplitude of an impressed speech syllable is above the operating value of the relatively insensitive detector 33, current flows in the output of the detector through the winding of relay 34 causing the operation of the latter to shift its armature from its back contact to its front contact. When the amplitude of the impressed speech syllable then falls below the marginal operating value of the detector, relay 34 releases to return its armature to the back contact.

In the manner described previously, the operation of relay 34 causes energizing current to be supplied to the operating winding 35 of the master disabler relay 30 causing operation of that relay to open its armature and contact 29. This disconnects resistance 27 and the preceding portion of the reducer circuit from condenser 28, thereby preventing any further increase in the charge on condenser 28. Thereafter, the bias on the grids of the vario-amplifier tubes 6 and 7, and thus the gain of the vario-amplifier VA, is held fixed at the value present at the time relay 30 operated.

When relay 34 operates, hangover is also applied in the manner previously described to the master disabler relay 30 through its winding 40 so that when relay 34 releases with a falling off in the level of the speech energy applied to detector 33 below the marginal operating value, or with cessation in the speech input to detector 33, the master disabler relay 30 does not immediately release but remains operated for a desired hangover time interval. By suitable design of the relays disabling the reducer and the associated hangover circuit, this hangover may be made such as to maintain the gain of the vario-amplifier VA fixed after cessation in the applied speech long enough for the speech echoes to be dissipated.

If the vario-amplifier tube gains are high corresponding to low noise on the path EA, there will be a considerable range of speech sounds not strong enough to operate disabler #1, but strong enough to cause regulation of the gain of the vario-amplifier by the reducer, which is highly undesirable. To prevent this, disabler #2 is used. It is designed to operate on at least the beginning and ending of practically all speech sounds and supplements the operation of disabler #1 in preventing desensitization of the echo suppressor ES by speech.

Disabler #2 operates as follows: A portion of the amplified speech energy in the output of the amplifier 18 in its input along with the amplified noise energy is impressed on the input of the detector circuit 45 and is detected thereby. The detected waves are impressed by output transformer 46 on the input of the low pass filter 47 which suppresses all except the low envelope frequencies of the speech syllables which are passed to the windings of the reversely wound relays 36 and 37 connected in series across the output of the filter. Relay 36 operates on the transmitted impulse due to the initial part of each speech syllable and relay 37 on the transmitted impulse due to the final part of each speech syllable.

Relay 36, as previously described, operates to cause the energization of the operating winding 35 of the master disabler relay 30 with consequent operation of the latter relay to break the connection between the resistance 27 and condenser 28 in the reducer circuit. The operation of relay 36 also causes hangover to be applied to relay 30 through the hangover winding 40, which hangover becomes effective on the release of relay 36 at the end of the operating impulse, to hold relay 30 operated until relay 37 operates on the final part of the speech impulse.

When relay 37 operates, as previously described, in response to the impulse produced in the output of filter 47 at the end of each applied speech syllable, energizing current is applied to the operating winding 35 of the master disabler relay 30, or if energizing current is already applied to that winding in response to operations of relay 36, maintains it applied so that relay 30 is operated in either case. Relay 37 does not apply any hangover to relay 30, so that on the release of relay 37 at the end of the final applied speech impulse, relay 30 will release quickly to allow the reducer circuit to quickly readjust the gain of the vario-amplifier VA in accordance with the amount of noise present at that time on the path EA.

As previously stated, during the continuous application of speech waves to the input of disabler #2 the armatures of relays 36 and 37 are kept in vibration so the two relays are alternately operated and thus maintain relay 30 continuously operated to disable the reducer circuit while speech is present in the path EA. Therefore, the gain of the vario-amplifier VA is maintained fixed at a value corresponding to the amount of noise on the path EA at the time disabler relay 30 is first operated, and thus the echo suppressor ES is maintained effectively at maximum sensitivity for that amount of noise until speech transmission ceases in the path EA.

When the speech input to disablers #1 and #2 cease, with cessation in the transmission of speech over the path EA, after a hangover interval provided by the design of the circuit to take care of the echoes of speech, the disabler relays 34, 36 and 37 all return to the unoperated condition as shown in the drawing. The reducer then is in condition to quickly adjust in the manner previously described the gain of the vario-amplifier VA and thus the effective sensitivity of echo suppressor ES in accordance with the amount of noise present on the path EA thereafter.

It has been found that the syllabic disabler (disabler #2) is more sensitive to one type of noise which contains energy variations in the syllabic frequency range. With the syllabic dis-

abler connected at the output of the noise-operated gain adjusting device, the reducer voltage is built up as soon as the disabler releases, with a corresponding decrease of input to the syllabic disabler. These reductions are cumulative so that the vario-amplifier is quickly adjusted to its normal gain for the particular noise, at which point the noise input to the syllabic detector is below the value required to operate it more than occasionally.

It has been found that the use of the syllabic disabler (disabler #2) alone, that is, without disabler #1, will not be effective under all conditions to prevent false adjustment of the reducer on speech because the former is effective over only a limited voltage range, about 20 decibels, whereas for proper operation under all conditions the disabler should operate over a larger voltage range, about 60 decibels. By utilizing disabler #1 to take care of the higher voltage range of speech syllables, and disabler #2 to take care of the lower range, proper operation over the desired wide voltage range is attained. It has been found that the two disablers in combination prevent any change of the vario-amplifier gain during a very large part of any speech syllable and therefore materially reduce the amount of speech desensitization of the voice-operated switching circuit.

A second reason for placing the syllabic disabler at the output of the vario-amplifier rather than at the input thereof is the limited range of the former device. It has been found that the syllabic amplifier-detector tends to be "paralyzed" by inputs of noise or tone which are about 18 decibels above the just operate value, so that speech superimposed on noise of large amplitude might not cause the disabling relays to be operated. Placing the syllabic disabler at the output of the noise-operated gain adjusting circuit serves to protect the syllabic amplifier-detector from loud noise, thus permitting maximum sensitivity to speech in the syllabic device.

An important function of the two disablers, other than their prevention of speech desensitization of the noise-operated gain adjusting device, occurs when a second toll telephone circuit with ordinary echo suppressors is connected in tandem with a link having the desensitized suppressors. In this case, the disablers would prevent false adjustment of the vario-amplifier gain due to the noise being cut off by the suppressor on the other link. Without the disablers, the vario-amplifier gains might increase to a maximum during the short interval after speech operated the desensitized echo suppressor while the other suppressor would have the noise cut off. Then, when noise came back on, the suppressor with the noise-operated gain-adjusting circuit would be momentarily operated, thus causing mutilation of the speech which was continuing on the same side of the circuit. The disablers prevent this by operating the disabler master relay and applying a comparatively long hangover to it so that no false adjustment of gain is made while noise is cut off by operation of the far end suppressor on speech.

For simplicity, the invention has been described and illustrated as applied to the desensitization of a single echo suppressor unit operating to disable one one-way repeating path of a four-wire toll telephone circuit in response to speech transmission over the other oppositely directed one-way repeating path, whereas in a complete system two echo suppressor units are

usually employed each connected respectively to a different one of the two repeating paths and operating to disable the other one-way path. In such a system preferably each suppressor would be equipped with a noise-operated gain-adjusting device of the invention each comprising a vario-amplifier, a reducer, a disabler #1, and a disabler #2.

The circuits of the invention have been described for the sake of convenience as applicable to noise desensitization of echo suppressors on a four-wire toll telephone circuit. The usefulness of the circuits of the invention is not limited in any way to noise desensitization of echo suppressors, or to any other voice-operated devices on four-wire toll telephone circuits. The invention is applicable equally well to any signal-operated device where discrimination between the signal and unwanted interference is possible on the basis of relative differences in the energy distribution with time or differences in amplitude level.

Various other modifications of the above-described system which are within the spirit and scope of the invention will be apparent to persons skilled in the art.

What is claimed is:

1. In combination, a source of alternating current, signal waves of a syllabic character similar to speech and subject to interfering noise waves, a wave responsive device, a circuit connecting said device to said source, and means for improving the operation of said device on said signal waves while preventing its operation by the noise waves, comprising one control means automatically operating to reduce the gain of said circuit slowly when the amplitude level of the received waves increases and to increase the gain of said circuit quickly when the amplitude level of the received waves is reduced, and means making said one control means ineffective to change the gain of said circuit when said signal waves are received thereby from said source including a second control means also supplied with waves from said source, said second device being unresponsive to applied noise waves but operatively responsive to the applied signal waves of low as well as high amplitudes to disable the gain changing means.

2. The combination of claim 1, in which said second control means comprises a very sensitive circuit for selectively detecting the syllabic variations in the applied signal waves and relay means responsive to the detected variations to break effectively the electrical connection between said one control means and the circuit connecting said wave-responsive device to said source.

3. In combination a line for transmitting alternating current signal waves representing speech and subject to interfering noise waves which are comparatively steady, a wave-responsive device connected to said line so as to be supplied with said waves, a wave amplifier between said line and said device, means automatically responsive to the waves impressed on said amplifier to cause its gain to be reduced when the amplitude level of the impressed waves increases and to be increased quickly when their amplitude level is reduced, a control circuit also supplied with the waves from said line, said control circuit being unresponsive to the comparatively steady applied noise waves but being operatively responsive to the syllabic variations in the applied signal waves of low as well as high amplitudes, and means responsive to operation of said control circuit to

prevent change of the gain of said amplifier in response to said signal waves.

4. In combination, a line for transmitting alternating current signal waves representing
5 speech and subject to interfering noise waves which are comparatively steady, a wave responsive device connected to said line so as to be supplied with waves therefrom, a wave amplifier connected between said line and said device,
10 and means for minimizing the effects of said noise waves on said device without reducing the sensitivity thereof to said speech signal waves comprising means automatically responsive to the waves impressed on said amplifier to cause its gain to be
15 reduced slowly when the amplitude level of the impressed waves increases and to be increased quickly when their amplitude level is reduced, and means for substantially preventing reduction of the gain of said amplifier in response to the applied speech signal waves comprising a sensitive control circuit bridged across the output of said
20 amplifier so as to be supplied with amplified waves therefrom, said control device being unresponsive to the comparatively steady noise waves but being
25 operatively responsive to the syllabic variations of the applied speech signal waves of low as well as high amplitudes, and means responsive to operation of said control circuit to disable the gain changing means.

5. In combination, a voice frequency telephone line subject to interfering noise waves which are steady compared to the transmitted voice waves, a wave responsive device connected to said line
5 so as to be supplied with waves therefrom, and means for minimizing the effects of noise waves on said device while retaining its sensitivity to voice waves, comprising means automatically responsive to the waves in the output of said amplifier to cause its gain to be reduced slowly when
10 the amplitude level of the applied waves increases and to be increased quickly when their amplitude level is reduced, and means for substantially preventing reduction in the gain of said amplifier by voice waves over a wide range of amplitudes
15 comprising one control device also connected to said line having such sensitivity as to be unoperated by the maximum noise on the line but to be operated by the peaks of applied voice waves, a second comparatively very sensitive control device connected to the output of said amplifier, said
20 second control device being unresponsive to the comparatively steady noise waves but being operatively responsive to the syllabic variations in applied voice waves of low as well as high amplitudes, and means responsive to operation of either
25 said one control device or said second control device to disable the gain changing means.

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