Nov. 12, 1935. H. L. BARNEY 2,020,452
TRANSMISSION CONTROL IN SIGNALING SYSTEMS
Filed July 20, 1934 2 Sheets-Sheet 1

FIG. 1

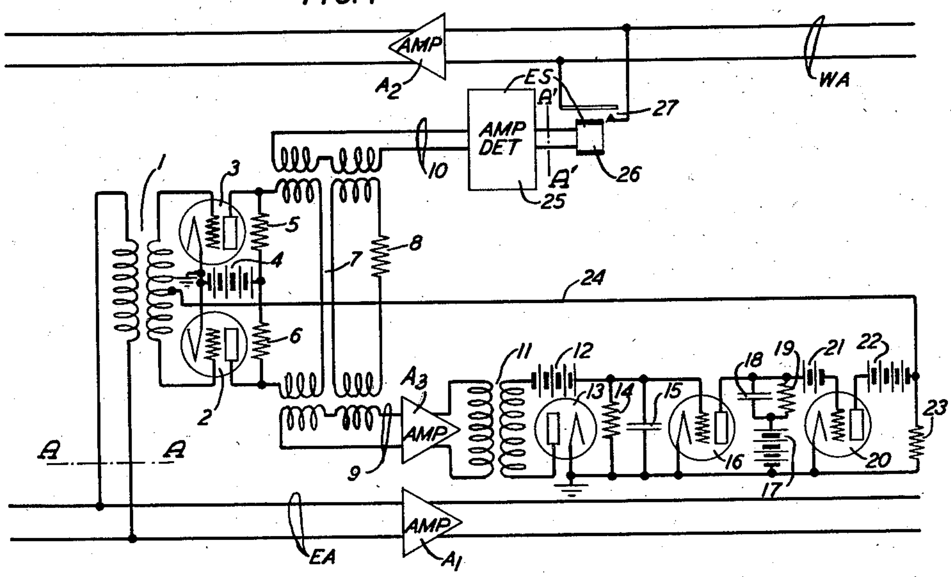

FIG. 2

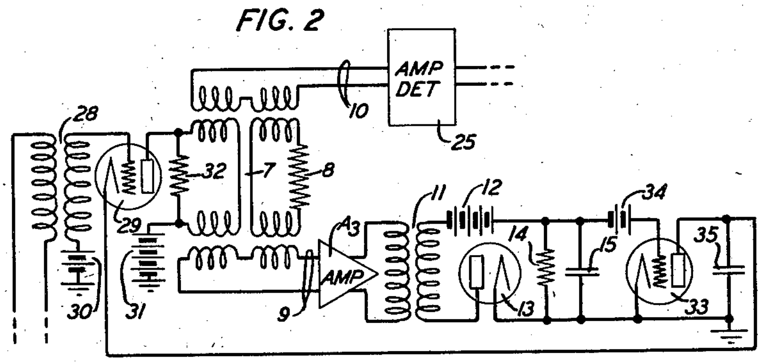

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FIG. 3

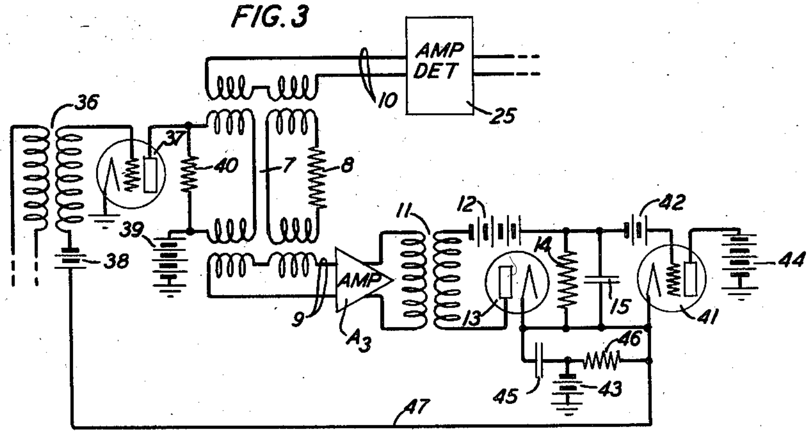
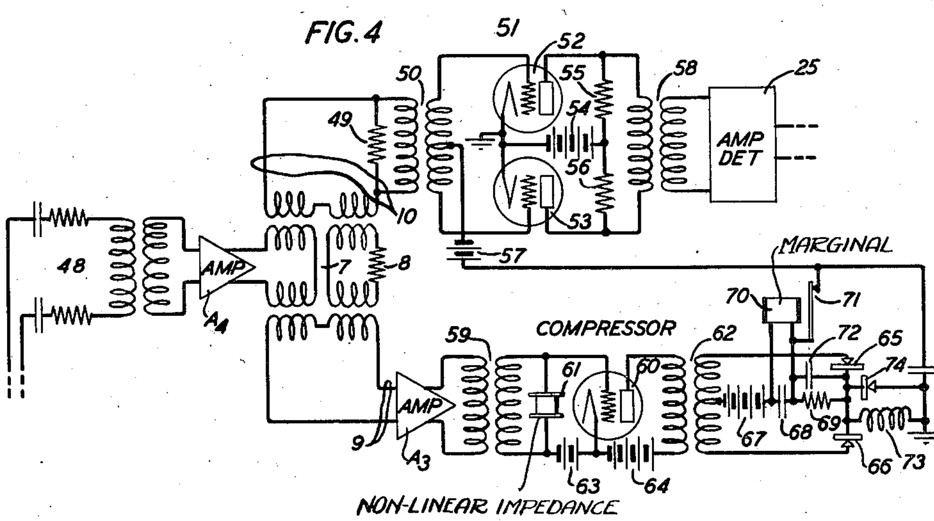


FIG. 4



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TRANSMISSION CONTROL IN SIGNALING SYSTEMS

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8 Claims. (Cl. 178—44)

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

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

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

It is often necessary to use voice operated switching devices, for example, voice operated echo suppressors or anti-singing devices, in connection with toll telephone lines subject to noises of varying amplitudes, such as the usual line noise or noise induced in the line from extraneous sources as from neighboring power lines. Such noise seriously interferes with the proper operation of the 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. In certain circuits of the prior art, these difficulties have been minimized by transmitting the energy from the line subject to the noise into the voice operated switching devices through circuits adapted to discriminate between noise and speech on the basis of differences either in energy distribution with frequency or with time. Band pass filters and tuned input circuits are examples of the first class of circuit and syllabic amplifier detector circuits of the latter. Other 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 just 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 accordance with the present invention, in a circuit of the last mentioned type, 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 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 and a very rapid gain increase when the input energy is reduced.

In one embodiment of the invention this is accomplished by utilizing a backward acting or a forward acting amplifier-rectifier circuit having suitable operating and release time constants to properly control either the bias on the grid, or the voltage applied to the plate of the variable amplifier.

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

Fig. 1 shows schematically a portion of a toll telephone system equipped with a transmission control circuit in accordance with a preferred form of the invention; and

Figs. 2 to 4 show schematically alternative forms of transmission control circuits in accordance with the invention which may be used in the system of Fig. 1.

The four-wire toll telephone circuit of Fig. 1 comprises a one-way transmission path EA including the one-way amplifying device A_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 A_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 coil transformers and associated balancing networks or by any other suitable means.

Bridged across the path EA near the input to the amplifier A_1 is the primary winding of the transformer 1, the secondary winding of which couples in push-pull relation the grid circuits of the variable gain amplifying vacuum tubes 2 and 3. The common plate battery 4 for the vacuum tubes 2 and 3 is connected to the plates of the two tubes respectively through the resistances 5 and 6 which together form one termination for the hybrid coil network 7. The resistance 8 forms the balancing network of the hybrid coil network 7.

The windings of the hybrid coil network 7 couple the inputs of the circuits 9 and 10 in conjugate relation with each other and in energy transmitting relation with the output of the push-pull amplifying tubes 3 and 4. The circuit 9 includes the one-way amplifying device A_3 for amplifying the portion of the output energy of the variable gain amplifying tubes 2 and 3 received by that circuit through the hybrid coil network 7.

Coupled by the transformer 11 to the output of the amplifying device A_3 is a circuit comprising in series the biasing battery 12, the rectifier 13 which may be of the two-element electronic type as shown, and the parallel-connected resistance 14 and condenser 15 which operate as a filter for the output voltage of the rectifier 11 to reduce the alternating current ripple.

The input electrodes of the three-electrode vacuum tube 16 are connected across the condenser 15 so that the filtered output voltage of the rectifier 13 is impressed on the input of tube 16. The plate current for tube 16 is supplied by the battery 17 through the high resistance 19. A large condenser 18 is connected in parallel with the resistance 19 so as to be normally charged by current from the battery 17. The input electrodes of the three-element vacuum tube 20 are connected across the circuit comprising in series the grid biasing battery 21 for the tube 20, the resistance 19 and the condenser 18 in parallel and the plate battery 17 for tube 16. The plate current for tube 20 is supplied by the battery 22 which is connected in series with the resistance 23 between the plate and cathode of the tube 20. The output of the three-element vacuum tube 20 is fed back to the input circuit of the push-pull vacuum tubes 2 and 3 by a connection 24 from a point in the plate circuit of tube 20 between the battery 22 and resistance 23, to the midpoint of the secondary winding of the input transformer 1, so that as the voltage drop across the resistance 23 increases, the bias on the grids of the push-pull vacuum tubes 2 and 3 becomes more negative.

The circuit 10, which is also coupled to the output circuits of the push-pull tubes 2 and 3 by the hybrid coil 7, comprises a signal-controlled echo suppressor ES. The echo suppressor ES may be of any suitable type which will be responsive to impressed signals to prevent reflected waves of the signals transmitted over the one-way transmission path EA from returning over the one-way transmission path WA. For example, as indicated in Fig. 1, the echo suppressor ES may comprise an amplifier-detector circuit 25 of any of the types well known in the prior art, which will operate to cause operation of a mechanical relay 26 in its output to close its contacts 27, short-circuiting the transmission path WA in the input of amplifier A_2 whenever sufficient energy is received by the circuit 10 from the path EA through the variable gain amplifying tubes 2 and 3 and the hybrid coil network 7.

The operation of the system of Fig. 1 will now be described. It will first be assumed that no speech waves are being transmitted over the system but that noise of a fairly steady character is present on the transmission path EA. A portion of the noise energy from the path EA is impressed by transformer 1 on the push-pull amplifying tubes 2 and 3 and is amplified thereby. The amplified noise energy divides in the hybrid coil 7, one half being supplied to the echo suppressor ES by the circuit 10 while the other half enters the circuit 9.

The portion of the noise energy impressed on circuit 9 after amplification by the amplifier A_3 is supplied through the transformer 11 to the rectifying circuit consisting of the two-element vacuum tube rectifier 13, the bias battery 12 and the filter comprising the resistance 14 and condenser 15. The variations in the rectified noise energy in the output of rectifier 13 are smoothed out by the resistance-condenser filter and the filtered waves are impressed on the input of the tube 16 in such manner as to apply a negative bias to the grid of that tube which normally has zero bias, this bias becoming more negative as the input of the tube increases. When the grid of the three-element vacuum tube 16 becomes negative, its plate impedance rises causing the large condenser 18 normally charged by battery 17 to discharge slowly through the high resistance 19. As condenser 18 discharges, less and less negative bias is applied to the grid of the three-element vacuum tube 20 by the combination of the bias battery 21 and the voltage drop in the resistance 19 due to the current from the plate battery 17. The plate impedance of the vacuum tube 20 decreases as its grid slowly becomes less negative, and the voltage drop in the resistance 23 due to the output current of tube 20 increases, causing a slowly increasing negative bias to be applied to the grids of the push-pull vacuum tubes 2 and 3 through the feedback connection 24 and the secondary winding of the input transformer 1. Increasing the negative bias on the push-pull vacuum tubes 2 and 3 decreases their gain. By proper selection of the constants of the circuit elements in the circuit 9, the amplitude of the noise energy fed by the hybrid coil network 7 to the echo suppressor ES through circuit 10 is reduced automatically in proportion to the amplitude of the noise energy received and rectified by the two-element vacuum tube 13 to such a degree that false operation of the echo suppressor ES on steady noise can not occur.

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 and are received at the input to the one-way amplifying device A_1. A portion of the speech energy is impressed on the input of the push-pull vacuum tubes 2 and 3 by the transformer 1. The gain of the vacuum tubes 2 and 3 will be adjusted by noise energy in accordance with the amount of noise energy present on the path EA in the manner just described and the impressed speech energy will be accordingly amplified. The amplified speech energy will divide in the hybrid coil network 7, half entering the echo suppressor ES through circuit 10 and half entering circuit 9. The half entering circuit 9 will be amplified by the amplifier A_3 therein and will be impressed by the transformer 11 on the rectifying circuit consisting of the two-element vacuum tube rectifier 13, the bias battery 12 and the filter comprising the parallel-connected resistance 14 and condenser 15. Since the speech energy distribution differs from the noise energy distribution in that it consists of pulses rising and falling over syllabic intervals of time, and since one of the distinguishing features of the circuit of the invention is its ability to function differently on increasing energy from the way in which it functions on decreasing energy when the rise and fall is over syllabic intervals of time, it becomes necessary at this point to consider separately the two cases; first, that in which the rectified speech energy is building up, and second, that in which it is dying out.

As the rectified speech energy increases, the positive bias on the grid of the three-element vacuum tube 16 produced by battery 12 is overcome so that the grid becomes negative and the plate impedance of the tube 16 increases. Then, the condenser 18 discharges slowly through the resistance 19 causing the grid of the three-element vacuum tube 20 to become less negative and the plate impedance of tube 20 to decrease, causing more negative bias to be applied to the push-pull amplifier tubes 2 and 3 over the feedback connection 24, thereby reducing the gain of the latter tubes. This reduction in gain is gradual, and can be made so slow by proper selection of the values of condenser 18 and resistance 19 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 over the circuit 10. Furthermore, because of the delay in operation of the circuit 9, the initial weak portion of the speech syllable reaches the echo suppressor ES before the gain of the push-pull amplifying tubes 2 and 3 has been reduced, thus insuring proper operation of the relay 26 on speech to close short-circuiting contacts 27.

When the amplitude of the rectified speech energy in the output of rectifier 13 decreases, the positive bias on the grid of the three-element vacuum tube 16 increases, and the condenser 18 charges up rapidly through the plate impedance of the three-element vacuum tube 16. This quickly increases the negative bias on the grid of the three-element vacuum tube 20, increasing the plate impedance of that tube and reducing the negative bias on the push-pull amplifier tubes 2 and 3, thereby 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.

Fig. 2 shows a circuit arrangement which can be substituted for the portion of the system of Fig. 1 within the dot-dash lines A—A and A'—A'. It provides an alternative means for regulating the gain of a vario-repeater in accordance with the noise level. The input transformer 28 which in the system of Fig. 1 would be connected across the path EA in the input of amplifier A_1, feeds into the single three-element, variable gain vacuum tube 29. The grid of the vacuum tube 29 is biased positively by the battery 30, and the plate current for the tube 29 is supplied by the battery 31 through a resistance 32 which forms one termination for the hybrid coil network 7. The circuit elements of the circuit of Fig. 2 and those of the circuits of the succeeding figures which are identical with those in the portion of the circuit of Fig. 1 for which they are substituted bear the same identifying characters.

The hybrid coil network 7 and associated balancing network 8 couple the circuit 10 leading to the echo suppressor ES and the input of control circuit 9 in conjugate relation with each other and in energy transmitting relation with the output of the tube 29.

As in the system of Fig. 1, the output of the amplifying device A_3 is coupled by transformer 11 to the circuit comprising in series the biasing battery 12, the two-element electronic rectifier 13, and the parallel-connected resistance 14 and condenser 15 forming the filter for reducing the alternating current ripple in the output voltage of the rectifier 13.

The input electrodes of the three-element vacuum tube 33 are connected across the condenser 15, the grid of this tube being biased positive by the battery 34 and its plate current being supplied by the battery 31 through the plate to cathode impedance of the variable gain vacuum tube 29. A large condenser 35 is connected between the plate of the three-element vacuum tube 33 and its grounded cathode.

The operation of the circuit of Fig. 2 will now be described. It will first be assumed that no speech waves are received, but noise of a fairly steady character from the path EA is entering the circuit through the transformer 28. The noise energy is amplified by the variable gain vacuum tube 29 and is divided by the hybrid coil network 7, one half entering circuit 10 leading to the echo suppressor ES and the other half entering circuit 9 and being amplified by the amplifying device A_3 therein. As in the case of the circuit of Fig. 1, the amplified noise energy at the output of the transformer 11 is rectified by the two-element rectifier 13, and creates a charge on the condenser 15 which opposes the bias from the battery 12. This action causes the positive bias on the grid of the three-electrode vacuum tube 33 to decrease. As the positive bias decreases, the plate impedance of tube 33 increases, permitting a higher charge gradually to accumulate on condenser 35 from the plate battery 31. The increasing charge on condenser 35 makes the cathode of the three-electrode tube 29 more and more positive, thereby gradually reducing the gain of tube 29 until equilibrium is established.

It will now be assumed that while noise is still being received, speech waves are also transmitted over the path EA and a portion thereof is impressed on the input of tube 29 by the transformer 28. The speech waves after amplification by the tube 29 are divided by hybrid coil transformer 7 between the circuits 9 and 10. The half of the speech wave energy transmitted into circuit 9 is amplified by the amplifying device A_3 therein and is rectified by the two-electrode rectifier 11, while the other half is supplied by circuit 10 to the echo suppressor ES. As the speech syllable builds up, the bias on the grid of the three-electrode vacuum tube 33 becomes less positive, and the resulting slowly increasing charge on the condenser 35 causes the gain of the vacuum tube 29 gradually to decrease. The time constants of the circuit are such that the decrease in gain lags behind the rise in amplitude of the signal wave sufficiently so that the speech wave energy entering the echo suppressor ES will always be great enough to operate it. When the speech syllable energy decreases, the bias on the grid of the three-electrode vacuum tube 33 becomes more positive allowing the condenser 35 to discharge rapidly through the lowered plate to cathode impedance of the vacuum tube 33. The comparatively rapid discharge of the condenser 35 lowers the positive bias on the cathode of the variable gain vacuum tube 29, thus quickly restoring the gain of the latter tube to the value set by noise. The weak initial portion of the succeeding syllable therefore encounters maximum gain in the variable gain vacuum tube 29, assuring proper functioning of the echo suppressor ES.

The control circuit of Fig. 3 also may be substituted for the portion of the circuit of Fig. 1 within the dot-dash lines A—A and A'—A' to provide another alternative means for regulating the gain of a vario-repeater in accordance with the noise level. When used in the system of Fig. 1, the input terminals for the input transformer 36 for the three-element variable gain amplifying tube 37 in the circuit of Fig. 2 would be connected across the path EA preferably in front of the amplifier A_1 thereon. The grid of the vacuum tube 37 is biased negatively by the battery 38 and the plate current for the tube is supplied by the battery 39 through the resistance 40 which forms one termination for the hybrid coil network 7. As in the circuits of Figs. 1 and 2, the resistance 8 forms a termination for hybrid coil 7 conjugate to the resistance 40.

As in Figs. 1 and 2, the windings of the hybrid coil network 7 couple the circuit 9 leading to the echo suppressor ES and the control circuit 10 leading to the amplifier A_3 in conjugate relation with each other and in energy transmitting relation with the output of the variable gain amplifier tube, in this case, tube 37.

Transformer 11 couples the output of the amplifying device A_3 in the input of circuit 9 to the circuit comprising in series the biasing battery 12, the two-element electronic rectifier 13 and the parallel-connected resistance 14 and condenser 15 forming the filter for reducing the alternating current ripple in the output voltage of the rectifier 13.

The input electrodes of the three-electrode vacuum tube 41 are connected across the condenser 15 in the filter. The grid of the tube 41 is biased positively by the battery 42 and the plate current for this tube is supplied by the batteries 43 and 44 effectively in series. A large condenser 45 in parallel with a resistance 46 is connected in series in the plate-cathode circuit of tube 41 between the cathode and the negative terminal of plate battery 43. The positive terminal of the grid biasing battery 38 for the amplifier 37 is connected to a point between the cathode of tube 41 and the resistance 46 by conductor 47.

The operation of the circuit of Fig. 3 will now be described. It will first be assumed, as in the descriptions of the operation of the circuits of the previous figures that no speech waves are being received, but that noise of a fairly steady character is entering the control circuit from the path EA through the transformer 36. The noise energy is amplified by the tube 37 and the noise energy is divided by hybrid coil 7 between the circuits 9 and 10. The noise energy in circuit 9 is amplified by the amplifier A_3, is rectified by rectifier 13 and in a manner similar to that described for the circuits of the previous figures reduces the positive bias on the grid of the three-electrode vacuum tube 41, thereby increasing its plate to cathode impedance and permitting the condenser 45 to discharge slowly through the resistance 46. As the condenser 45 discharges, the grid of the variable gain vacuum tube 37 becomes more negatively biased due to the drop in resistance 46, and the gain of the latter tube decreases correspondingly until the level of amplified noise energy transmitted into the circuit 10 through hybrid coil network 7 is reduced to the point where the noise alone will not cause operation of the associated echo suppressor.

It will now be assumed that while the noise is adjusting or after it has adjusted the vario-repeater 37 in the manner just described, speech waves from the path EA are received at the input to the transformer 36. The speech waves after amplification by the vario-repeater tube 37 will be divided by the hybrid coil network 7 between the inputs of circuits 9 and 10. The half of the speech energy entering circuit 9 will be amplified therein by the amplifier A_3 and then will be rectified by the two-electrode rectifier 13. When the speech syllable is building up, the bias on the grid of the three-electrode vacuum tube 41 becomes still less positive, and its plate to cathode impedance increases further, permitting the condenser 45 to discharge slowly through resistance 46. This gradually reduces the gain of the variable gain vacuum tube 37 still more. The circuit elements have such values that the time delay is such that the level of the speech energy entering the echo suppressor ES through the circuit 10 will exceed the minimum operate value of the latter while the syllable energy is on the increase.

As the syllable dies out, the bias on the grid of the three-electrode vacuum tube 41 becomes more positive, and the condenser 45 charges comparatively rapidly through the reduced plate to cathode impedance of the tube 41. This action quickly reduces the negative bias on the variable gain vacuum tube 37 to the value set by the received noise, thus effectively causing the sensitivity of the echo suppressor ES to remain high enough to assure operation on the weak beginning of the next syllable.

The circuit of Fig. 4 shows another type of circuit which may be substituted for the portion of the system shown within the dot-dash lines A—A and A'—A' to regulate the gain of a vario-repeater in accordance with the noise level. This circuit differs from the three previously described in that it employs a forward-acting control circuit instead of a backward-acting one. When the circuit of Fig. 4 is used in the system of Fig. 1, the high impedance input circuit 48 of the amplifying device A_4 would be bridged across the transmission path EA. The windings of the hybrid coil network 7 connect the inputs of the circuits 9 and 10 in conjugate relation with each other and in energy transmitting relation with the output of amplifier A_4. The resistance 8 forms the conjugate termination to the output circuit of the amplifier A_4 and the resistance 49 is connected across the input of circuit 10 to form another termination for the coil 7.

In the circuit 10, the input transformer 50 couples the input of a variable gain amplifier 51 across the terminating resistance 49. The variable gain amplifier 51 comprises two three-electrode vacuum tubes 52 and 53 connected in push-pull relation. The common battery 54 supplies plate current for the vacuum tubes 52 and 53 through the resistances 55 and 56, respectively, and the battery 57 supplies a fixed part of grid bias for the two tubes. A transformer 58 connects the output of the variable gain amplifier 51 to the input of the amplifier-detector 25 of the echo suppressor ES.

In the input of the circuit 9 is the amplifying device A_3. Coupled to the output of the amplifier A_3 by the transformer 59 is the input of a volume range compressing amplifier which comprises a three-electrode vacuum tube amplifier 60, a non-linear impedance device 61 such as a block comprising silicon carbide crystals and an insulating binder (kaolin) which is disclosed in a patent to K. B. McEachron, No. 1,822,742, issued September 8, 1931, bridged across the grid-cathode circuit of the vacuum tube 60, an output transformer 62, a grid-biasing battery 63 and a plate current battery 64. The function of the device 61 is to present a shunting impedance across the input circuit to the vacuum tube 60 which varies with the alternating current voltage applied to the grid of that tube from the amplifying device A_3 in such a way that the alternating current voltage at the secondary winding of the output transformer 62 is proportional to the logarithm of the alternating current voltage at the output of the amplifying device A_3 over a wide range.

The outer terminals of the secondary winding of the transformer 62 are connected through the oppositely-poled rectifiers 65 and 66 which may be of the copper oxide type. The bias battery 67, the condenser 68 and the resistance 69 are connected in series between the center tap on the secondary winding of transformer 62, and the common terminal of the rectifiers 65 and 66. Connected in parallel with the condenser 68 is the winding of a marginal relay 70 which operates to open the normally closed contacts 71 whenever the voltage across the condenser 68 exceeds a predetermined value. The resistance 69 and the shunting condenser 72 form a filter which smooths out the ripples in the rectified wave from the rectifiers 65 and 66. A retardation coil 73 shunted by a rectifier 74 is connected in series with the condenser 75 and the normally closed contacts 71 of the relay 70 so as to shunt the condenser 72. The condenser 75 is connected in series between ground and the common grid bias battery 57 for the push-pull tubes 52 and 53 of the vario-amplifier 51 so that the voltage across the condenser 75 controls the gain of the vario-amplifier.

The operation of the circuit of Fig. 4 will now be described. Let it be assumed that noise alone is present on the path EA and is impressed on the input 48 of amplifier A_4. The amplified noise energy in the output of amplifier A_4 divides one half entering the circuit 10 where it is impressed across the resistance 49 on the input of the variable gain push-pull amplifier 51 and the other half entering circuit 9 and being impressed on the input of the amplifying device A_3 therein. The amplified noise energy in the output of the amplifying device A_3 is impressed by the transformer 59 on the input of the amplifier tube 60 across the device 61 which attenuates the impressed energy by an amount proportional to its amplitude. The attenuated energy is again amplified by the three-electrode amplifying vacuum tube 60 and is impressed by the transformer 62 on the oppositely poled rectifying elements 65 and 66. The impressed noise energy is rectified by the rectifiers 65 and 66. The rectified noise currents cause a voltage to be built up across resistance 69. The alternating current ripples in this voltage are filtered out to some extent by condenser 72. This voltage across resistance 69 and condenser 72 is impressed on the condenser 75 through the contacts 71 of marginal relay 70 and through impedance 73. The rectified noise currents flow also through marginal relay 70 which is shunted with by-passing condenser 68. Relay 70 which when operated opens the charging path to condenser 75 through the relay contacts 71, is designed and adjusted to remain unoperated on normal noise currents but will be operated by the peaks of strong speech, thus preventing the excessive reduction of gain of the vario-repeater by speech.

The voltage across resistance 69 and condenser 72 (due to rectified noise currents) causes a current to flow through the high impedance 73, thereby slowly charging condenser 75 in such direction as to make the bias more negative on the grids of tubes 52 and 53 and decreasing the vario-repeater gain. When the noise energy is suddenly removed from the input to the device, the voltage across condenser 72 and resistance 69 decreases rapidly and condenser 75 discharges back through the unidirectional conducting element 74. Thus the gain is allowed to increase rapidly.

Now, when a speech syllable is initiated on the path EA, it will be impressed on the input circuit 48 of the amplifier A_4 and after amplification therein the amplified speech energy will be divided by hybrid coil 7 between circuit 9 and circuit 10. The portion of the speech energy passing into circuit 10 will be amplified by the amplifier 51 therein and cause the operation of amplifier-detector 25 to control the echo suppressor ES. The other portion of the energy of the speech syllable passing into circuit 9 will be amplified by amplifier A_3 therein. The amplified energy will be compressed in volume by the compressor comprising tube 60 and the device 61 and then will be rectified by rectifiers 65 and 66. While the energy of the speech syllable is rising, the charge on condenser 75 will be slowly increased. When the rectified currents flowing through relay 70 which is by-passed by (the small) condenser 68, reach a sufficiently large amplitude, the relay 70 will operate to open the contacts 71 breaking the circuit shunting condenser 75. Thereby, any further increase in the charge on the condenser 75 is prevented. This action prevents excessive reduction in the sensitivity of the echo suppressor ES by speech.

As the speech syllable dies out, the relay 70 releases and closes contacts 71. The condenser 75 then quickly discharges through the copper oxide half wave rectifier 74 in series with resistance 69, restoring the bias on the grids of the variable gain amplifier tubes 52 and 53 to the value set by the received noise. Thus the sensitivity of the echo suppressor ES is always great enough to assure proper operation on the following initial speech currents.

It will be seen that the marginal relay 70 in the manner described above adds to the switching circuit of Fig. 4 a discrimination between speech and noise on the basis of differences in amplitude to supplement the discrimination between speech and noise on the basis of differences in energy distribution with time. The marginal relay 70 may be also used with the systems of the previous figures to give thereto discrimination between speech and noise on the basis of amplitude differences if such additional discrimination is required. The manner of application of the relay to the systems of the previous figures to produce this result will be readily apparent to persons skilled in the art.

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 shown in Figures 1, 2, 3 and 4 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. This 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 modifications of the above described systems which are within the spirit and scope of the invention will be apparent to persons skilled in the art. For example, the device 61 used to obtain a compressing action in the control circuit of Fig. 4 could be replaced by a vacuum tube "rooter" device such as is disclosed in N. C. Norman Patent No. 1,922,602 issued August 15, 1933 for this purpose; the three copper oxide rectifiers 65, 66 and 74 in the system of Fig. 4 could be replaced by a single duo-diode triode vacuum tube, such as the R. C. A. No. 55 and the function of the retardation coil 73 could also be performed by a high resistance; and the three-electrode variable gain vacuum tubes shown in Figs. 1 to 4 inclusive, could be replaced by variable μ screen grid vacuum tubes or variable μ pentode tubes.

The invention is not limited to the specific variable gain amplifier circuits and control circuits therefor disclosed in Figs. 1 to 4. Other circuit arrangements providing a variable gain amplifier with a control circuit which can increase its gain at a fast rate and reduce it at a comparatively slow rate will occur to persons skilled in the art and are within the spirit and scope of the invention.

What is claimed is:

1. In combination, a source of alternating current waves of an intermittent character similar to speech, and subject to interfering noise waves which are comparatively continuous, a wave responsive device connected to said source through a rectifier so as to be supplied with waves from said source in rectified form and means for minimizing the effects of said noise waves on the operation of said device, comprising a wave amplifier connected between said source and said device, and means automatically responsive to the waves received from said source prior to their rectification to cause the gain of said amplifier to be reduced slowly when the amplitude level of the impressed waves increases above a given value and to be increased rapidly when the amplitude level of impressed waves is reduced below said given value.

2. In combination, a line transmitting alternating current waves representing speech and subject to interfering noise waves which are comparatively steady, a wave-responsive device connected to said line through a rectifier so as to be supplied with said waves in rectified form and means for minimizing the effects of said noise waves on the operation of said device comprising a wave amplifier connected between said line and said device and means automatically responsive to the amplified waves prior to their rectification by said rectifier for controlling the gain of said amplifier in such manner as to reduce the gain slowly when the amplitude level of the impressed waves increases suddenly above a given value and to increase the gain rapidly when the amplitude level of the impressed waves is reduced below said given value.

3. The combination of claim 2 and in which said wave amplifier comprises a vacuum tube amplifying device, and said gain controlling means comprises an amplifier-rectifier circuit having its input connected across the circuit connecting said line to said rectifier, and responsive to the waves impressed thereon to apply a biasing voltage to an electrode of said vacuum tube device proportional to the amplitude level of the impressed waves, said amplifier-rectifier circuit having such time constants as to make the value of said biasing voltage vary in proper manner to produce the desired variation in gain for the amplifier.

4. The combination of claim 2 and in which said wave amplifier comprises a vacuum tube amplifying device having a control electrode, connected between said line and said rectifier, and said gain controlling means comprises an amplifier-rectifier circuit connected effectively across the circuit connecting said rectifier to said amplifier, and responsive to the waves impressed thereon from the output of said amplifier to apply a biasing voltage to said control electrode which is proportional to the amplitude level of the impressed waves, said amplifier-rectifier including condenser-resistance circuits having such values as to make the value of the biasing voltage vary in proper manner to produce the desired variation in gain for said amplifier.

5. In combination, a line transmitting alternating current waves representing speech and subject to interfering noise waves which are comparatively steady, a wave-responsive device connected with said line so as to be supplied with waves therefrom, and means for minimizing the effects of noise waves on the operation of said device comprising a vacuum tube amplifying device in the circuit connecting said wave responsive device to said line, and means for controlling the gain of said amplifying device in such manner as to reduce the gain slowly when the amplitude level of the impressed waves increases suddenly above a given value and to increase the gain quickly when the amplitude level of impressed waves is reduced below said given value, the last-mentioned means comprising a condenser connected in the input circuit of said amplifying device so that the voltage across said condenser controls the gain of said amplifying device, and a circuit having its input connected across said line and responsive to the wave energy therein to apply such a biasing voltage across said condenser as to produce the desired variation in gain for said amplifying device.

6. 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 with said line so as to be supplied with waves therefrom, means for minimizing the effects of said noise waves on the operation of said device, comprising a vacuum tube amplifier connected between said line and said device and means automatically responsive to the waves impressed on said amplifier to cause its gain to be reduced slowly when the amplitude level of the impressed waves increases suddenly above a given value and to be increased quickly when the amplitude level of the impressed waves is reduced below said value, and means comprising a marginal relay for preventing reduction in the gain of said amplifier in response to certain peaks of the signal waves.

7. 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 with said line so as to be supplied with waves therefrom, means for minimizing the effects of said noise waves on the operation of said device, comprising a wave amplifier connected between said line and said device, and means automatically responsive to the waves received from said line to cause the gain of said amplifier to be reduced slowly when the amplitude level of the received waves increases suddenly and the gain of said amplifier to be increased quickly when the amplitude level of the received waves is reduced, and means including a marginal relay for preventing reduction in the gain of said amplifier in response to certain amplitude peaks of the signal waves.

8. The combination of claim 7 in which said marginal relay is controlled by the waves impressed on the input of said amplifier, and is adjusted to operate on the strong amplitude peaks of the impressed signal waves to disable effectively the means for controlling the amplifier gain, and to be unoperated by the impressed noise waves.

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