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1,888,227

VOLUME CONTROL SYSTEM

Filed Aug. 29, 1931

2 Sheets-Sheet 1

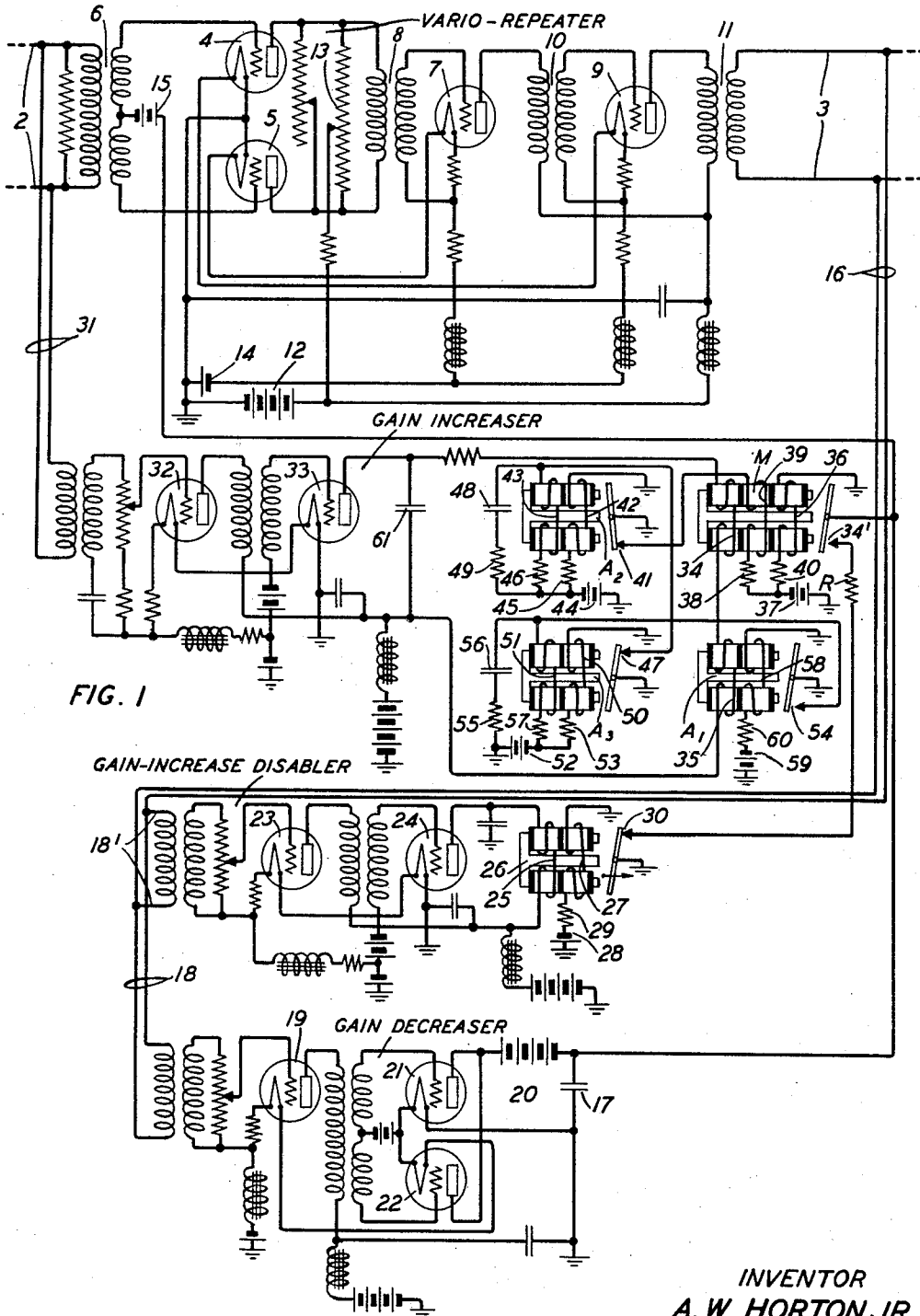


FIG. 1

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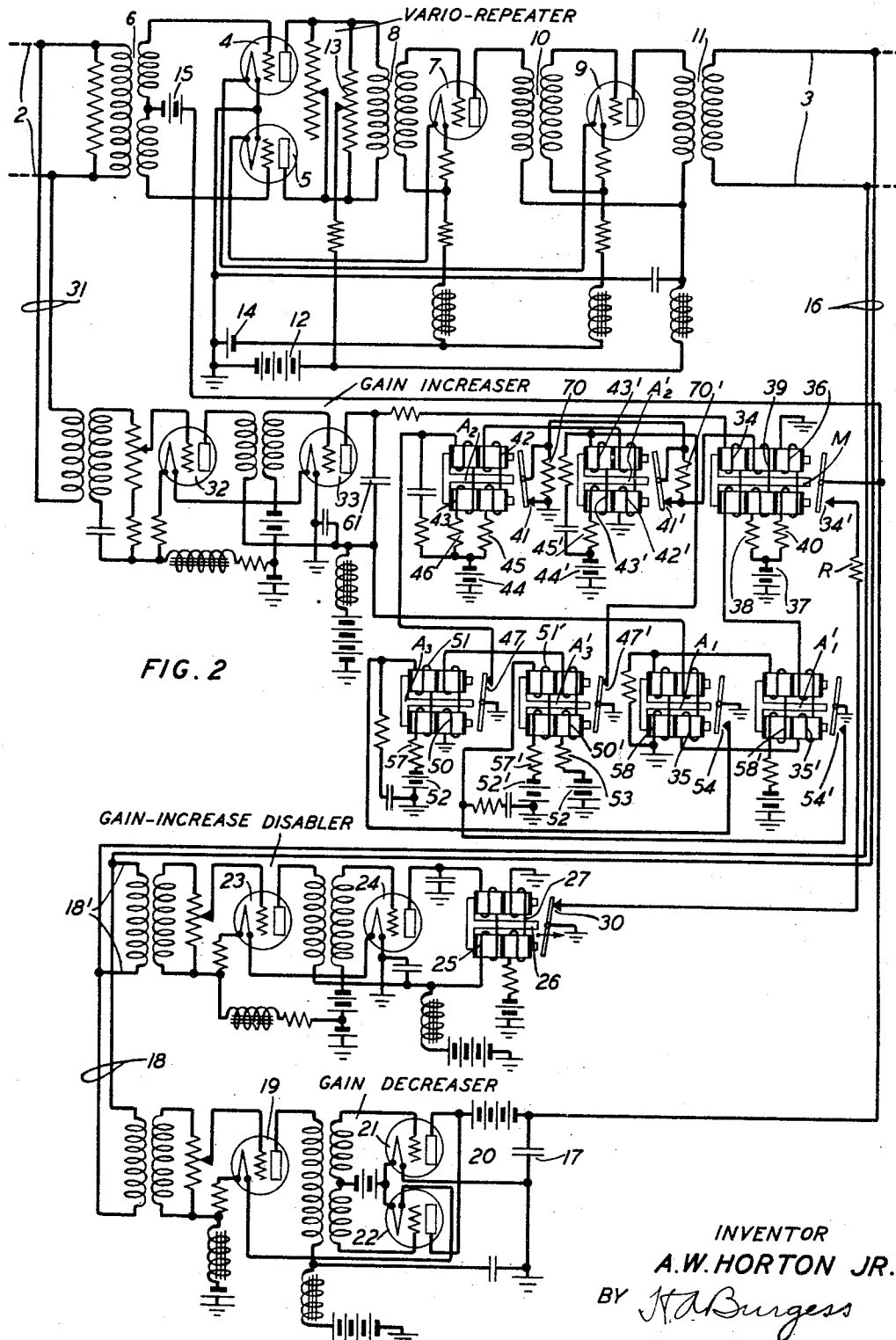
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VOLUME CONTROL SYSTEM

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2 Sheets-Sheet 2



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VOLUME CONTROL SYSTEM

Application filed August 29, 1931. Serial No. 560,131.

This invention relates to signaling systems and particularly to the control of the volume level of signals transmitted over such systems.

5 An object of the invention is to improve the operation of circuits for automatically controlling the volume level of signals in signal transmission systems subject to noise.

10 Another and more specific object is to prevent false operation of a circuit for automatically controlling the gain in a signal transmission path in accordance with the volume level of the signals transmitted thereover, by noise energy in said path without reducing the effectiveness of the gain control circuit as regards operation by useful signals.

15 In signal transmission systems, it is often desirable to maintain the signal volume level within definite limits at one or more points. For example, in a telephone system in which the speech volume delivered at the input varies within wide limits, it is desirable to maintain a substantially constant volume at some given point to insure proper volume at the receiving end of the system, or to insure proper operation of associated voice-operated echo suppressors or anti-singing devices.

20 In certain systems of the prior art this is accomplished by utilizing three-electrode space discharge amplifying devices as loss elements in the signal transmission paths, and automatically controlling the potentials on the grids of these devices by adjusting the charge on condensers in the grid circuits in accordance with the volume level of the signals in said paths to adjust the gain of the space discharge devices in proper manner. Control circuits of this type are disclosed, for example, in the copending applications of S. Doba, Serial No. 443,640, filed April 12, 1930, and Hogg and Doba, Serial No. 445,543, filed April 19, 1930, now Patent No. 1,854,828, issued April 19, 1932, and Patent No. 1,853,974, issued April 12, 1932, respectively.

25 In a special form of the above mentioned general type of circuit to which the invention is especially applicable, a portion of the signal energy in the input of the amplifier in the signal path is utilized to control a relay

which operates when the input level thereto exceeds a given minimum value, to increase the gain of the amplifier; and a portion of the signal energy in the output of the amplifier when the signal level thereat exceeds a given maximum is utilized to decrease the gain of the amplifier. The effectiveness of such a volume control system of the general type described above is limited by the noise present in the system, for the signal controlled device must not be falsely operated by noise when signal currents are not being transmitted over the system. As is well known, the noise in a long signal transmission circuit varies considerably from time to time. If the sensitivity of each portion of the volume adjusting circuit is adjusted so that it will not be operated by the maximum noise to be expected on the signal transmission path, the response of the volume control circuit to signals might be so sluggish that the circuit would not be suitable for use in high quality systems requiring a gain adjustment for small variations in the signal level.

30 In accordance with the present invention, in a system of the above mentioned type means are provided for preventing false operation of the volume control circuit by noise to increase the gain in the signal transmission path, without altering the effectiveness of the circuit to decrease the gain in the signal transmission path whenever a signal overrides the noise. This is accomplished in one embodiment by utilizing the noise energy in said path in the input of the amplifier, as the noise level increases, to control a chain of auxiliary relays similar to those disclosed in the co-pending patent application of Bjornson-Horton-Norwine, Serial No. 480,940, filed September 10, 1930, now Patent No. 1,880,715, issued October 4, 1932, and to decrease the sensitivity of the gain increase relay only to the point where it is inoperative by the noise alone, although operative by the superimposed signal energy.

35 The invention will be better understood from the following detailed description thereof when read in connection with the accompanying drawings, Figs. 1 and 2 of which

show schematically volume control circuits embodying different modifications of the invention.

Fig. 1 of the drawings shows a multi-stage vacuum tube amplifier circuit 1 connecting an incoming signal transmission circuit 2 to an outgoing signal transmission circuit 3. The first stage of the amplifier circuit 1 which will be referred to hereafter as the vario-repeater, comprises two three-electrode space discharge amplifying tubes 4 and 5 (which are preferably matched to prevent distortion) connected in push-pull relationship. The input circuit of the push-pull tubes 4 and 5 is connected to the incoming transmission circuit 2 by the input transformer 6 and the output circuit of the push-pull tubes is connected to the input circuit of the three-electrode space discharge amplifying tube 7 in the second stage of the amplifier by the interstage transformer 8. The output circuit of the tube 7 is connected to the input circuit of the three-electrode space discharge amplifying tube 9 in the last stage of the amplifier circuit by the interstage transformer 10, and the output circuit of the tube 9 is connected to the outgoing signal transmission circuit 3 by the output transformer 11.

Space current is supplied by the battery 12 to the plates of the push-pull tubes 4 and 5 respectively through the upper and lower portions of the resistance potentiometer 13, and to the plates of amplifying tubes 7 and 9 through the primary winding of interstage transformer 10 and the primary winding of output transformer 11, respectively. The battery 14 supplies heating current to the filaments of tubes 4, 5, 7 and 9 in series. Biasing potential is supplied to the grids of the push-pull tubes 4 and 5 by battery 15, and biasing potential for the grids of tubes 7 and 9 is provided by the drop across resistances in the filament heating circuits for the two tubes.

The plate impedance of the push-pull tubes 4 and 5 which determines the gain of the vario-repeater is controlled by the voltage across the control condenser 17 common to the grid circuits of the two tubes. When the condenser 17 is charged by the control voltage, the potentials on the grids of the push-pull tubes in the vario-repeater are made more negative, thus effectively decreasing the gain of the vario-repeater.

Connected across the outgoing transmission circuit 3 in the output of the amplifier circuit 1 is the input of a control circuit 16 comprising two parallel branches 18 and 18' which will be referred to hereafter as the "gain decreaser" and the "gain-increase disabler", respectively. The branch 18 comprises the three-electrode vacuum tube amplifying device 19 and a highly biased full-wave, space discharge rectifier 20 connected in tandem, the output of the rectifier 20 being

permanently connected across the control condenser 17 common to the grid circuits of the push-pull tubes 4 and 5 in the amplifier 1 so that the condenser is charged by the rectified currents in the output of that rectifier when the amplitude level of the current applied to the input of the "gain decreaser" increases above a predetermined value which will cause its operation.

The sensitivity of the "gain decreaser" by suitable choice of its circuit elements is made approximately the same as the initial sensitivity of the "gain-increase disabler" to be described below. This sensitivity is made such that whenever the average amplitude level of the amplified signal currents in the output of the amplifier 1 exceeds the predetermined value, that is, the level at which the output signal energy of the amplifier 1 is to be maintained substantially constant, the signal currents diverted into control circuit 16 cause the gain decreaser to be actuated, and thus the condenser 17 to be charged so as to apply a negative bias to the grids of the tubes 4 and 5 in the vario-repeater. This results in a continuously decreasing gain until the output level of the amplifier falls below the operating value of the gain decreaser.

The control branch 18' which will be referred to hereafter as the "gain-increase disabler" comprises the three-electrode vacuum tube amplifying tube 23 and the three-electrode space discharge detector tube 24 connected in tandem. Connected between the plate and filament electrodes of the rectifier tube 24 is the operating winding 25 of a disabler relay 26. The disabler relay 26 has, in addition to its operating winding 25, a biasing winding 27, which is normally maintained energized by currents from the battery 28 through the resistance 29 so as to hold the relay contacts 30 closed to connect the discharge resistance R to ground. The detector tube 24 is preferably a gas-filled "trigger" tube, so that the gain-increase disabler is a marginal trigger device. The disabler relay 26 is preferably quite slow releasing so as to improve the regulation on speech.

The initial sensitivity of the "gain-increase disabler" by suitable choice of the values of its circuit elements is made approximately the same as the sensitivity of the "gain decreaser". Whenever the average amplitude level of the amplified signals in the output of the amplifier 1 exceeds the predetermined value, the currents diverted into control circuit 16 cause the operation of the "gain-increase disabler" to open the contacts 30 of relay 26 to disconnect the discharge resistance R from ground, preventing subsequent operation of the gain increase relay M in the "gain increaser" to be described below, from causing the gain of the vario-repeater to be increased. Thus the "gain-increase disabler" operates to nullify the action of the "gain in-

creaser" for amplitude levels above the predetermined value.

Connected across the incoming signal transmission circuit 2 in the input of vario-repeater in the amplifier 1 is the input of another control circuit 31, which will be referred to hereafter as the "gain increaser", comprising the three-electrode vacuum tube amplifying device 32 and the three-electrode space discharge detector tube 33 connected in tandem, and the operating winding 34 of the master "gain increase" relay M and the operating winding 35 of the auxiliary relay A₁ connected in series across the output of the rectifying device 33. The sensitivity of the "gain increaser" by suitable choice of its circuit elements is set so that whenever the amplitude level of the signal waves in the output of amplifier 1 exceeds a predetermined value corresponding to the average peaks of the weakest talkers, the portion of said currents diverted into control circuit 31 causes the "gain increaser" to operate to energize the operating winding 34 of the "gain increase" relay M. The energization of the operating winding of relay M causes the relay to operate to close the normally open contacts 34'. The contacts 34' when closed connect the condenser 17 to ground through the discharge resistance R and the closed contacts 30 of disabler relay 26 when the latter relay is unoperated. The condenser 17 then will discharge through the resistance R causing the gain of the vario-repeater to be increased. The detector tube 33 is preferably a gas-filled "trigger" tube. The gain increaser relay M is, hence, fast-operating, peak-actuated. It is preferably made comparatively slow releasing.

The circuits which have just been described, i. e., the "gain decrease", the "gain increaser" and the "gain-increase disabler" in combination with the vario-repeater form a volume control circuit which is not the invention of applicant.

The chain of auxiliary relays A₁, A₂ and A₃ and associated circuits described below in combination with the master gain increase relay M are associated with the volume control circuit, in accordance with the present invention, in such manner as to prevent false operation of the volume control circuit by noise from increasing the gain of the vario-repeater when signals are not being received in the incoming signal transmission circuit 2, and without altering the effectiveness of the circuit to decrease the gain when incoming signals over-ride the noise, in the following manner:

The master relay M has a biasing winding 36 which is maintained energized at all times by current from the battery 37 through the resistance 40 so that the relay M would operate in the least sensitive condition were it not for a third winding 39 thereon. The

third winding 39 of relay M is normally supplied with energizing current from the battery 37 through the resistance 38 and the normally closed contacts 41 of another auxiliary relay A₂, the third winding 39 of relay M being so wound as to oppose the action of the operating winding 34 thereof. The third winding 39 is utilized to apply back bias to the relay M opposing the normal bias produced by the biasing winding 36, the amount of back bias normally applied being sufficient to allow the relay M to operate in its most sensitive condition. This normally applied back bias is removed in one step when relay A₂ releases to open its contacts 41 causing the sensitivity of the master relay M to be reduced by an equal amount to the point where the master relay will just not be operated by the noise received from the signal transmission circuit 2, although responsive to the signal waves, for example, voice waves, from that circuit.

The auxiliary relay A₂ has two windings, a biasing winding 42 and an operating winding 43. The biasing winding 42 is at all times energized by current from battery 44 through the resistance 45. The operating winding 43 of relay A₂ is normally energized by current from the battery 44 over a path extending from ground through battery 44, resistance 46, winding 43 of the relay A₂ and the normally closed contacts 47 of a third auxiliary relay A₃ to ground, so as to hold the contacts 41 of relay A₂ in the closed condition.

A condenser 48 and a resistance 49 in series are connected across the circuit comprising the winding 43 of relay A₂ and the resistance 46 in series, so that the condenser 48 will be normally charged by current from battery 44 through resistance 49. When the normally closed contacts 47 of auxiliary relay A₃ are opened by operation of that relay, the normal energizing circuit for the operating winding 43 of relay A₂ is broken. However, the relay A₂ will not release for a definite time thereafter because the winding 43 will be maintained energized while the condenser 48 discharges through that winding and the resistances 46 and 49. This holdover period of time may be made of any desired length by a proper choice of the values of condenser 48 and the resistances 46 and 49 to regulate the time constants of the relay A₂. The time constants of relay A₂ are preferably made such that the relay will not release unless the contacts 47 of auxiliary relay A₃ remain open for a time longer than the average speech syllable. Thus, the contacts 47 will never be closed long enough by operation of relay A₃ when speech energy alone is supplied to the preceding relay A₁ in the chain to cause relay A₂ to release. The speech waves applied to relay A₁ then will not be effective to cause

any reduction in the sensitivity of the master relay M through relays A_3 and A_2 .

Auxiliary relay A_3 has two windings, a biasing winding 50 and an operating winding 51. The biasing winding 50 is always energized by current from battery 52 through resistance 53. The operating winding 51 is arranged to be energized by current from the battery 52 when the normally open contacts 54 of auxiliary relay A_1 are closed by operation of the latter relay over a path extending from ground through battery 52, resistance 57, winding 51, closed contacts 54 to ground.

A resistance 55 and a condenser 56 are connected in series across the circuit comprising the winding 51 of relay A_3 and the series resistance 57. When the contacts 54 of relay A_1 are closed, the current from the battery 52 besides energizing the operating winding 51 of relay A_3 also charges the condenser 56 through resistance 55. When the energizing circuit for the winding 51 of relay A_3 is broken by the opening of contacts 54 of relay A_1 , the condenser 56 slowly discharges through resistances 55 and 57 and the winding 51, causing the winding 51 to be maintained energized, and thus the relay A_3 to be maintained operated to hold the contacts 47 open, for a definite holdover period after the supply of energizing current to winding 51 from battery 52 ceases. The value of the condenser 56 and the values of the resistances 55 and 57 are chosen so as to give the relay A_3 a holdover in its operation which is sufficient to bridge the intervals between peaks of intermittent noise of a particular type which will be referred to below.

The auxiliary relay A_1 has, in addition to its operating winding 35, a biasing winding 58 which is always maintained energized by current from the battery 59 through the resistance 60. The values of the battery 59 and the resistance 60 are preferably chosen so that the relay A_1 is about three decibels more sensitive than the master relay M.

A condenser 61 of suitable value is connected across the operating winding 34 of master relay M and the winding 35 of relay A_1 to prevent chattering of the contacts of these relays.

The operation of the system of Fig. 1 as a whole will now be described.

It will be assumed that speech waves are being received over the incoming circuit 2 which is subject to a varying amount of line noise.

The received speech and noise waves will be divided between the amplifying circuit 1 and the input of the control circuit 31. The main portion of these waves will be amplified by the multi-stage amplifier 1 and the amplified waves transmitted to the outgoing circuit 3.

The portion of the incoming speech and

noise waves diverted into the control circuit 31 will be amplified by the amplifying device 32 therein and rectified by the rectifying device 33 connected to the output of the amplifying device 32. The resulting rectified currents in the output of the rectifying device 33 will be transmitted through the operating winding 34 of the master relay M and the operating winding 35 of the auxiliary relay A_1 . The master relay M and the auxiliary relay A_1 are designed to operate at a syllabic frequency. The frequency of their operation depends upon the sensitivity of the associated amplifier-rectifier devices, the type of the impressed waves and their rapidity and various other factors including the relay design. Auxiliary relay A_1 being more sensitive than relay M, will operate in advance of relay M to start the chain of operations which will be described later.

If the amplitude level of the incoming signals diverted into the control circuit 31 is above a predetermined value corresponding to the average peaks of the weakest talkers, the rectified current passing through the operating winding of the relay M will be sufficient to cause that relay to operate to close its normally open contacts 34'. The closing of the contacts 34' will connect the discharge resistance R to one terminal of the control condenser 17 in the common grid circuit for the push-pull tubes 4 and 5 in the amplifier 1, and, if the normally closed contacts 30 of the mechanical relay 26 have not been opened by the previous operation of the "gain-increase disable" circuit, the control condenser 17 is thus connected to ground through the discharge resistance R and the contacts 30 of relay 26. The charge on the condenser 17 will then leak off through the resistance R to ground gradually reducing the negative bias applied to the grids of the push-pull tubes 4 and 5 in the vario-repeater so as to cause the gain of the vario-repeater to be raised.

Because of its greater sensitivity the auxiliary relay A_1 will operate in response to the rectified speech waves impressed upon its operating winding 35 slightly before the master relay M operates. If the noise impressed on the relay A_1 is continuous and above a given amount, the contacts 54 will close and remain closed. When contacts 54 are closed, the operating winding 51 of auxiliary relay A_3 is energized by current from battery 52 over a path extending from ground through battery 52, resistance 57, winding 51 and the closed contacts 54 of relay A_1 to ground. Relay A_3 will then operate to open its contacts 47 to break the normal energizing circuit for the operating winding 43 of auxiliary relay A_2 .

By proper selection of the values of the condenser 56 and resistances 55 and 57 comprising the holdover circuit for relay A_3 , and the values of the condenser 48 and resistances 49 and 46 comprising the holdover circuit for

relay A_2 , the holdovers of these two relays are made such that relay A_2 will not release for operation of relay A_3 by the syllabic variations in speech but will release for operation of relay A_3 on intermittent noise of a certain kind.

The A_3 relay is provided to introduce a holdover action to take care of certain types of noise especially those with pronounced low frequency components which would cause auxiliary relay A_1 to vibrate freely without effecting operation of the auxiliary relay A_2 .

The holdover time of auxiliary relay A_3 preferably should be greater than 0.01 seconds to bridge the interval between 60 cycle noise peaks.

The noise waves impressed with the speech waves from the output of the rectifier 33 in the gain increase circuit upon the operating winding of auxiliary relay A_1 are steady compared to the fluctuations in the speech waves. The noise waves will cause the contacts 54 of relay A_1 to be maintained closed long enough to cause such operation of auxiliary relay A_3 that its contacts 47 will remain open for a sufficient length of time to enable relay A_2 to release to open its contacts 41. The opening of the contacts 41 will break the energizing circuit for winding 39 of master relay M thus removing the normal back bias from the latter relay. The removal of the back bias from the relay M in response to the noise waves in the manner pointed out will cause relay M to be made sufficiently less sensitive so as just not to be falsely operated by noise alone impressed upon its operating winding, while still being responsive to the impressed speech waves when the latter over-ride the noise.

The means provided for varying the sensitivity of the master relay M so as to prevent its false operation by line noise when no speech is being transmitted over the main transmission path does not alter the effectiveness of the means for decreasing the gain of the vario-repeater when the input level there-to increases above the predetermined value, for the operation of the gain decrease is entirely independent of the operation of the gain increaser as will be shown.

Now let it be supposed that the level of the amplified signals in the output of the amplifier 1 in the main signal transmission path increases above the predetermined value at which the output level is to be maintained substantially constant. The sensitivity of the gain decrease branch 18 and that of the "gain-increase disabler" branch 18' are adjusted so that the amplifier detectors in these branches will be operated for input waves above that predetermined level diverted into control circuit 16. The rectified speech waves in the output of the full wave rectifier 20 in the "gain decrease" circuit will be impressed across the control condenser 17 in the vario-repeater input circuit causing

that condenser to be charged and thus applying a gradually increasing negative bias to the grids of the push-pull tubes 4 and 5 in the vario-repeater. This will result in a continually decreasing gain for the vario-repeater until the level of the amplified waves in the output of the amplifier 1 falls below the operating value of the "gain decrease" circuit. Hence, the average level of the speech waves transmitted to the outgoing signal transmission circuit 3 will be maintained substantially constant for wide variations in the volume levels of signals impressed on the input of the amplifier circuit 1. The "gain decrease" in the circuit which has been described operates by reducing the gain of the vario-repeater and not by cutting off the high peaks.

Meanwhile, the portion of the amplified speech waves diverted into control branch 18' if above the required predetermined level, are further amplified in the amplifying tube 23 and then rectified by the rectifying tube 24. The rectified speech waves in the output of the detector tube 24 in the control branch 19 are transmitted through the operating winding 25 of the relay 26 causing the operation of that relay. The operation of relay 26 causes its normally closed contacts 30 to open to disconnect the normal ground from the discharge resistance R . Subsequent operation of the gain increase relay M will, therefore, not result in any increase in the gain of the vario-repeater since ground has been effectively removed from the discharge resistance R and, therefore, from the control condenser circuit.

In the manner which has just been described, the relay circuits shown in Fig. 1 operate when there is noise present in the incoming signal transmission circuit above a certain level to reduce in one step the sensitivity of the master gain increase relay M to the point where it will just not be operated by the impressed noise. It is apparent, of course, that a closer approximation of continuous variation of the sensitivity of the master relay with noise may be obtained by using additional relays to cause the sensitivity to be changed in small steps. This may be obtained, for example, as shown in Fig. 2 by providing additional steps in back bias on the master relay M controlled by other sets of auxiliary relays, such as A_1' , A_2' and A_3' corresponding to auxiliary relays A_1 , A_2 and A_3 in the circuit of Fig. 1, each set of relays having the required design to produce a different proportion of the reduction in the sensitivity of the master relay.

In Fig. 2, the relays A_1' to A_3' are identical with relays A_1 to A_3 except that by suitable choice of the biasing elements thereof the relay A_1' is made less sensitive than the relay A_1 . The elements of relays A_1' to A_3' corre-

sponding to those of relays A_1 to A_3 , respectively, are identified in Fig. 2 with the same reference characters identifying the elements of the latter relays but followed by a prime (') mark.

The operating winding 35' of auxiliary relay A_1' is connected in series with the operating winding 35 of relay A_1 and the operating winding 34 of master relay M across the output of the rectifying device 33 in control circuit 31.

The biasing winding 50' of relay A_3' in series with the biasing winding 50 of relay A_3 is energized by current from battery 52 through resistance 53. The operating winding 51' of relay A_3' is arranged to be energized by current from battery 52' through resistance 57' when the normally open contacts 54' of relay A_1' are closed by operation of relay A_1' .

The biasing winding 42' of auxiliary relay A_2' in series with the biasing winding 42 of relay A_2 is energized by current from battery 44 through the resistance 45. The operating winding 43' of relay A_2' is normally energized by current from battery 44' over a path extending from ground through battery 44', resistance 45', winding 43' of relay A_2' and the normally closed contacts 47' of auxiliary relay A_3' to ground, so as to hold the contacts 41' of relay A_2' closed. Similarly, the operating winding 43 of relay A_2 is normally energized by current from battery 44 over a path extending from ground through battery 44, resistance 46, winding 43 of relay A_2 and the normally closed contacts 47 of relay A_3 to ground, so as to hold relay contacts 41 of relay A_2 closed.

As in Fig. 1, the biasing winding 36 of master relay M is energized at all times by current from the battery 37 through resistance 40 so that the relay would operate in the least sensitive condition were it not for the third winding 39. The third winding 39 of relay M is wound so as to oppose the action of the operating winding 34 thereof, is normally energized by current from battery 37 over a path extending from ground through battery 37, resistance 38, winding 39, normally closed contacts 41' of relay A_2' and normally closed contacts 41 of relay A_2 to ground, thus supplying back bias to the relay M opposing the normal bias produced by the biasing winding 36 of that relay. The value of the elements in the series circuit are so chosen that the amount of back bias normally applied is sufficient to allow the relay M to operate in its most sensitive condition.

The sensitivity of the auxiliary relay A_1 is adjusted by means of the resistance shunting its winding 58 so that the relay A_1 will operate to close its contacts 54 whenever the amount of continuous noise impressed upon its operating winding 35 from the output of the rectifying device 33 exceeds a given low

value. Also, the sensitivity of auxiliary relay A_1' is adjusted by suitable choice of biasing elements so that the relay will operate to close its contacts 54' when the amount of continuous noise impressed upon its operating winding 35' from the output of the rectifying device 33 exceeds a given higher value.

Let it be assumed that noise is present in the incoming signal transmission path 2 in sufficient amount so that when it is amplified by the amplifying device 32 and rectified by the rectifying device 33 in control circuit 31, it will cause the operation of relay A_1 but not the operation of relay A_1' . This will start the chain of operations, as described above in connection with Fig. 1, culminating in the release of the relay A_2 to open its normally closed contacts 41.

The opening of contacts 41 will remove the normal short circuit around the resistance 70 thus connecting that resistance in the energizing circuit for the third winding 39 of master relay M, the energizing circuit for that relay winding now extending from ground through battery 37, resistance 38, winding 39 of relay M, the normally closed contacts 41' of relay A_2' and resistance 70 to ground. The value of the resistance 70 is so selected that the amount of back bias removed from the relay M by its inclusion in the energizing circuit for its third winding, is just sufficient to prevent operation of that relay by noise of said given low amount impressed on its operating winding, while allowing its operation when the signals over-ride the noise.

Now let it be supposed that the amount of noise impressed from the output of the rectifying device 33 on the series circuit comprising the operating winding 35' of relay A_1' , the operating winding 35 of relay A_1 and the operating winding 34 of relay M increases to such a value as to cause the operation of relay A_1' in addition to relay A_1 , causing the contacts 54' of relay A_1' to close. This will start the chain of operations culminating in the opening of normally closed contacts 41' of auxiliary relay A_2' through the operation of relay A_3' and the consequent release of relay A_2' .

The opening of contacts 41' of relay A_2' will remove the normal short circuit around resistance 70', causing that resistance to be connected in series with the resistance 70 in the energizing circuit for the third winding 39 of relay M. The value of the resistance 70' is so selected that its inclusion in the energizing circuit of winding 39 of relay M in series with resistance 70 will cause the amount of back bias removed from the relay M to be sufficient so that the latter relay will just not be operated by an amount of noise of said higher value impressed upon its operating winding. By the use of additional chains of relays corresponding to the relays A_1' to A_3' and additional resistances corresponding to

resistances 70 and 70' and connected in similar manner, it may be seen that the sensitivity of the master relay M may be changed in still smaller steps, so as to obtain a closer approximation of continuous variation of sensitivity with the amount of noise.

The auxiliary relays A_3 , A_3' may be dispensed with in systems not subject to noises of the type for which those relays are provided, that is, noises which have pronounced low frequency components. If the relays A_3 , A_3' are not used, the winding of the auxiliary relay A_2 would be controlled directly from the contacts of the auxiliary relay A_1 and the winding of auxiliary relay A_2' would be controlled directly from the contacts of auxiliary relay A_1' .

The noise desensitization circuits of the invention have been described as applied to a particular type of volume control circuit in which the apparatus is arranged in a particular way. It is apparent, however, that the invention would be applicable to types of volume control circuits other than that shown, and that various modifications in the noise desensitization circuit may be made by persons skilled in the art without departing from the spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. In a signal transmission system, a signal transmission path subject to interfering noise waves, wave-controlled means connected to said path and responsive to waves therein above a given level to adjust the gain of said path, and means under control of the noise waves in said path above said certain level, for reducing the operating sensitivity of the gain adjusting means to prevent its false operation by said noise waves alone.

2. In a signal transmission system, a signal transmission path subject to interfering noise waves, wave-controlled means connected to said path and responsive to the waves transmitted thereover when they exceed a certain minimum level, to increase the gain of said path, and means for automatically reducing the operating sensitivity of said wave-controlled means to operation when the amount of noise in said path increases above a given value, to prevent false operation by noise.

3. In a signal transmission system, a signal transmission path subject to interfering noise waves, wave-controlled means connected to said path and responsive to an increase in the volume level of the signals therein above a given level to adjust the gain of said path, and means under control of the noise waves in said path above a certain level for reducing the operating sensitivity of the gain adjusting means in proportion to the amount of noise in said path to prevent false operation of said gain adjusting means by noise

in the absence of signal transmission in said path.

4. In a signal transmission system, a signal transmission path subject to interfering noise waves, wave-controlled means connected to said path and responsive to the signal waves transmitted over said path when they exceed a predetermined level to increase the gain of said path, and means for reducing the operating sensitivity of said wave-controlled means in proportion to the amount of noise in said path when it increases above a given value, to prevent false operation by said noise.

5. In a signal transmission system in combination with a signal transmission path subject to interfering noise waves, wave-controlled means connected to said path and responsive to waves therein above a given low volume level, to increase the gain of said path, means connected to said path and responsive to signals therein when they exceed a certain higher volume level to reduce the gain of said path, and means connected to said path and responsive to the signals therein exceeding said higher volume level, to disable said gain increasing means, and means responsive to noise in said path above said low volume level, for reducing the sensitivity of the gain increasing means to the point where it is just inoperative by said noise alone although operative by signals over-riding the noise.

6. In a signal transmission system, a signal transmission path subject to interfering noise, wave-controlled relay means connected to said path and responsive to waves transmitted thereover when they exceed a certain low level to increase the gain of said path, means connected to said path and responsive to the signals therein when their volume level exceeds a given value higher than said certain low level, to prevent operation of said wave-controlled means from increasing the gain of said path, and means responsive to the noise above said certain low level in said path for continuously biasing said relay means to the point where it is just inoperative by said noise alone although operative by signals over-riding the noise.

7. In combination with a system for maintaining the volume of signals transmitted over a signal transmission path subject to noise substantially constant at a given average level comprising an amplifier in said path for amplifying said signals, means connected to said path in the input of the amplifier and responsive to the incoming waves exceeding a predetermined level lower than said given level, to increase the gain of said amplifier, means connected to said path in the output of said amplifier and responsive to the amplified signals exceeding said given level, to decrease the gain of said amplifier until the volume of the amplified signals is reduced to said given level, and means also connected to said path in the output of said amplifier

and responsive to the amplified waves when they exceed said given level, to disable said gain increasing means, means responsive to noise in said path above said predetermined level, for reducing the sensitivity of said gain increasing means to maintain said gain increasing means inoperative by said noise alone although operative by said incoming signals over-riding said noise.

8. The system of claim 7 and in which said sensitivity reducing means comprises a chain of relays operating in sequence in response to the noise waves received from said path and having different operating and holdover times determined by the types of noises against which protection is desired, to bias said gain increasing means against operation by said noise according to the amplitude level of said noise.

9. The system of claim 7 and in which said gain increasing means comprises a relay controlled by the waves in the input of said amplifier for applying a biasing potential to said amplifier proportional to the input level of the waves impressed thereon, and said sensitivity reducing means comprising means unresponsive to said signals but responsive to noise, for biasing said relay against operation by said noise, and without altering the effectiveness of said gain decreasing means.

10. The system of claim 7 and in which said amplifier comprises a space discharge amplifying device having a condenser connected between its input electrodes, the charge on said condenser controlling the gain of said device, said gain decreasing means comprises means for rectifying said incoming signals and applying the rectified signals to charge said condenser in proportion to the signal amplitude level, said gain increasing means comprises a relay which when operated causes said condenser to be discharged, and the sensitivity reducing means comprises means controlled by the noise in said path and unresponsive to signals therein, for biasing said relay against operation in proportion to the amount of noise on said path.

In witness whereof, I hereunto subscribe my name, this 24 day of August 1931.

ARTHUR W. HORTON, JR.