

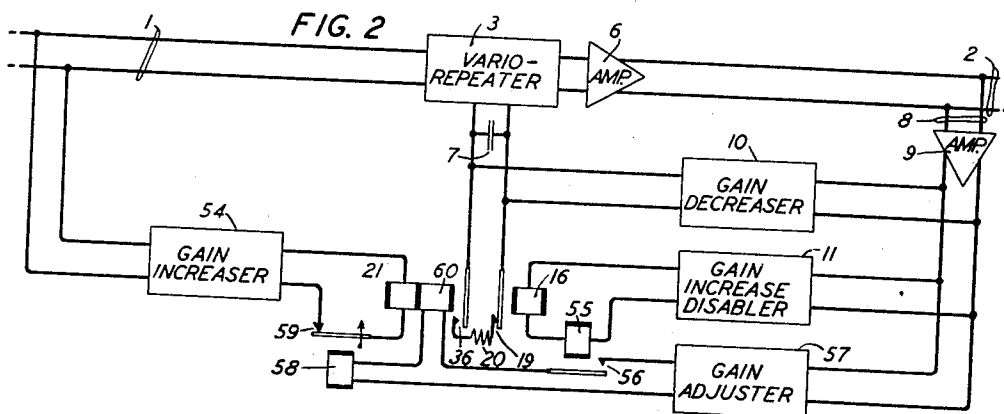
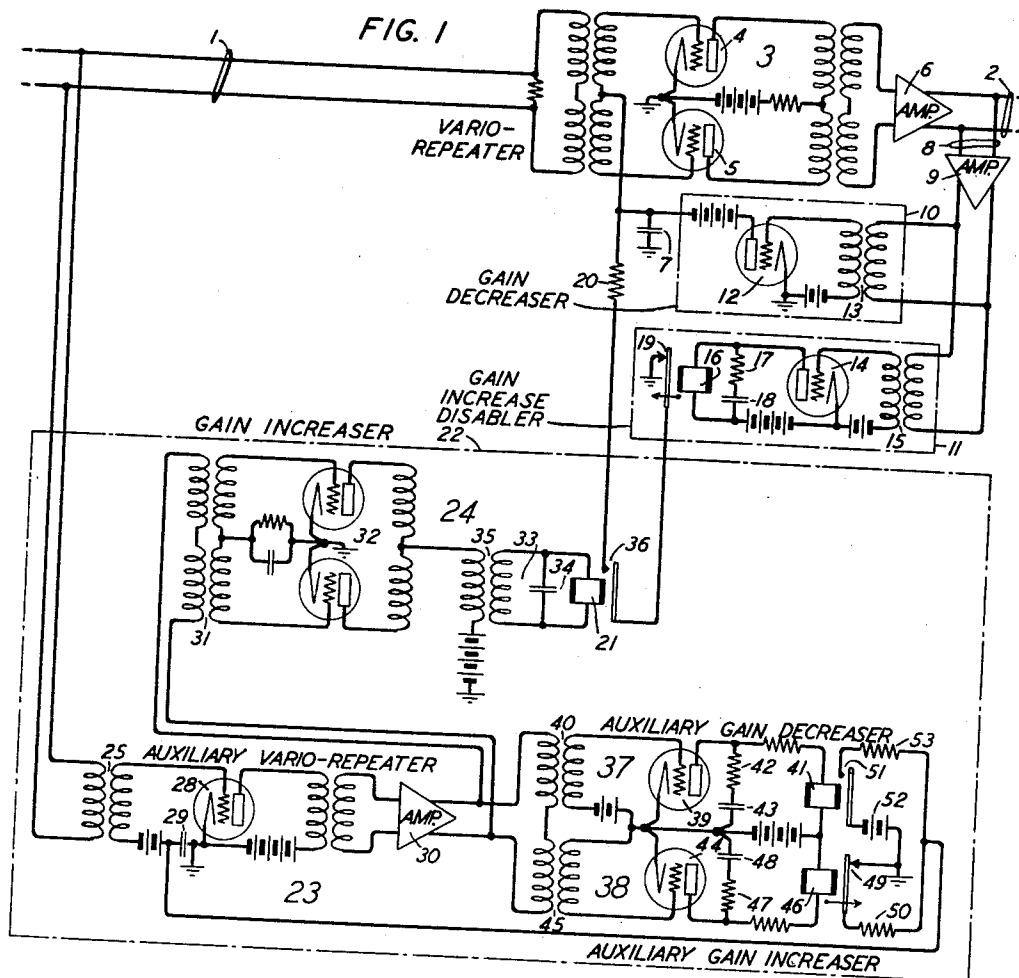
Nov. 28, 1933.

B. G. BJÖRNSON ET AL

1,936,658

VOLUME CONTROL SYSTEM

Filed Dec. 23, 1932



INVENTORS
B.G.BJORNSON
S. DOBA, JR.
BY *H.A. Burgess*
ATTORNEY

UNITED STATES PATENT OFFICE

1,936,658

VOLUME CONTROL SYSTEM

Björn G. Björnson, Wyoming, N. J., and Stephen Doba, Jr., New York, N. Y., assignors to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application December 23, 1932
Serial No. 648,650

4 Claims. (Cl. 178-44)

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

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. In certain systems of the prior art, this is accomplished by utilizing three-electrode space discharge amplifying devices as variable gain 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 Patent No. 1,853,974, issued April 12, 1932, to Hogg and Doba and the Patent No. 1,854,828, issued April 19, 1932, to S. Doba.

In a special form of the above-mentioned general type of circuit to which the present 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 exceeds a given minimum value, to discharge a condenser in the input circuit of the amplifier so as 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 apply a charge to said condenser so as to decrease the gain of the amplifier, and to disable the gain increasing circuit. The effectiveness of 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.

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.

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 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.

The above objects are attained in accordance with the invention mainly by making the sensitivity of the gain increasing circuit independent of the talker volume after the initial adjustment. In one embodiment, this is accomplished by utilizing an auxiliary circuit controlled by the wave energy in the input of the repeater in the signal transmission path to adjust the gain of an amplifier in the gain increasing circuit in proper manner. In another embodiment, this is accomplished by effectively shifting the gain-increasing circuit so that it is controlled by wave energy in the output of the repeater in the signal transmission path after the initial gain adjustment.

The invention will be clear from the following detailed description thereof when read in connection with the accompanying drawing in which:

Figs. 1 and 2 show schematically volume control circuits embodying different modifications of the invention.

Fig. 1 of the drawing shows a multi-stage vacuum tube repeater connecting an incoming signal transmission circuit 1 to an outgoing signal transmission circuit 2. It is desired to maintain the volume level of the signals transmitted to the circuit 2 constant within definite limits despite wide variations in the level of the signals received over the incoming circuit 1. The first stage 3 of the repeater, 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 second stage 6 of the repeater is coupled to the outgoing signal transmission circuit 2 in any suitable manner.

The plate impedance of the push-pull tubes 4 and 5, which determines the gain of the vario-repeater 3, is controlled by a voltage applied across the control condenser 7 common to the grid circuits of the two tubes. When the condenser 7 is charged by the control voltage, the potentials on the grids of the push-pull tubes 4 and 5 in the vario-repeater are made more negative, thus effectively decreasing the gain of the vario-repeater. Connected across the outgoing trans-

mission circuit 2 in the output of the last stage 6 of the repeater is the input of a control circuit 8 comprising the amplifying device 9, and the "gain-decrease" circuit 10 and the "gain-increase disabler" circuit 11 connected in parallel to the output of the amplifying device 9.

The gain decriaser 10 comprises the highly-biased, three-electrode space discharge rectifying device 12 having its input connected across the output of the amplifying device 9 by the transformer 13, and its output permanently connected across the control condenser 7 common to the grid circuits of the push-pull tubes 4 and 5 in the vario-repeater 3. The sensitivity of the gain decriaser 10 by suitable choice of its circuit elements is made approximately the same as the sensitivity of the gain-increase disabler 11 to be described below. This sensitivity is made such that whenever the volume level of the amplified signal waves in the output of the last stage 6 of the signal repeater exceeds a given value, that is, the level at which the signal energy delivered by the repeater to the outgoing circuit 2 is to be maintained substantially constant, the signal waves diverted into the control circuit 8 and amplified by the amplifying device 9 therein will cause the gain-decriaser 10 to be actuated to apply a charge to the condenser 9 gradually making the potential on the grids of the tubes 4 and 5 in the vario-repeater more negative. This results in a continuously decreasing gain for the signal repeater until the output level thereof falls below the value which will result in the operation of the gain-decriaser.

The gain-increase disabler 11 comprises the three-electrode space discharge detector 14 having its input connected to the output of the amplifying device 9 by the transformer 15 and its output connected to the winding of the disabler relay 16 across a circuit comprising a resistance 17 and a condenser 18 in series. The detector 14 is preferably a gas-filled "trigger" tube, so that the gain-increase disabler is a marginal trigger device. The disabler relay 16 is preferably designed to be slow-releasing so as to improve the regulation on speech. Whenever the volume level of the amplified signals in the output of the signal repeater exceeds the desired constant value, the waves diverted into control circuit 8 after amplification by the amplifying device 9 therein and rectification by the rectifier 14, will cause quick operation of the disabler relay 16 to open its normally closed contacts 19. The opening of contacts 19 prevents or stops the condenser 7 in the input circuit of the vario-repeater from being discharged through the discharge resistance 20 when the gain-increase relay 21 is operated in the manner to be described below.

The portions of the voice-operated gain adjusting circuit which have been just described are essentially as disclosed in the prior art. The "gain increaser" portion modified in accordance with the present invention will now be described.

The gain-increase circuit 22 of the invention comprises in part an amplifier 23, a syllabic detector circuit 24 and the gain-increase relay 21. The amplifier 23 comprises two stages, the first stage, which will be referred to hereafter as the auxiliary vario-repeater, comprising the three-electrode space discharge amplifying device 28 including the condenser 29 in its grid-filament circuit, having its input connected across the incoming signal transmission circuit 1 in the input of the vario-repeater 3 therein by the input transformer 25. The second stage 30 of the amplifier

23 is coupled to the input of the syllabic detector circuit 24 by the transformer 31.

The syllabic detector circuit 24 may be of any type adapted to detect the syllabic variations found in normal speech, but preferably is of the type illustrated. It is utilized to give the gain increaser circuit a greater speech sensitivity than noise sensitivity. The particular circuit illustrated comprises a duplex vacuum tube detector 32 in which the grids are normally non-biased so that space current normally flows, the space current being decreased below the normal value when the speech waves are impressed upon the input circuit through transformer 31, and a resonant circuit 33 coupled to the output circuit of the duplex detector. The resonant circuit 33 comprises the shunt condenser 34 and the transformer 35, the secondary winding of which is connected to the winding of the gain-increase relay 21 across the condenser 34, and the primary winding of which is connected in series with the space current source in the common portion of the output circuits of the duplex tubes in the detector. The resonant circuit 33 is tuned to the frequency which corresponds to the duration of the greatest number of speech syllables, which is about 5 cycles per second.

When speech waves are applied to the detector circuit 24, the detected speech currents applied to the winding of the gain-increase relay 21 cause the operation of that relay to close its normally open switch contacts 36, closing a connection from ground through the control condenser 7, discharge resistance 20 and the normally closed switch contacts 19 of the gain-increase disabler relay 16 to ground. The control condenser 7 in the input circuit of the vario-repeater 3 in the signal transmission path will thus be caused to discharge through the discharge resistance 20 gradually increasing the gain of the vario-repeater until the output level of the signal repeater increases to that value which will cause operation of the gain-increase disabler 11 to break the connection of the control condenser 7 to ground by opening normally closed switch contacts 19.

Now, it is apparent that if the sensitivity of the gain-increase circuit is normally adjusted so that it will be operated in response to the speech energy of the weakest talker there is a possibility that when there is noise on the signal transmission path, the gain-increase relay may be continuously operated by noise. In accordance with the present invention, this is prevented by utilizing the auxiliary gain-decriaser 37 and the auxiliary gain-increase 38 operating in conjunction with the auxiliary vario-repeater in the first stage of the amplifier 23 in the main gain-increase circuit to bring the speech or noise waves to some constant average value before applying them to the syllabic detector circuit. Due to the difference in nature between speech and ordinary line noise, the constants of the auxiliary gain-decriaser and auxiliary gain-increase may be chosen so that the peaks of speech are much greater in amplitude than the peaks of noise when applied to the syllabic detector circuit. The auxiliary gain decriaser 37 comprises the three-electrode space discharge rectifying device 39 having its input connected across the output of the amplifier 23 in the main gain-increase circuit by means of transformer 40, and its output connected to the winding of the mechanical relay 41 across the resistance 42 and condenser 43 in series.

The auxiliary gain increaser 33 comprises the three-electrode space discharge rectifying device 44 having its input connected across the output of the amplifier 23 in the main gain-increaser circuit by the transformer 45, and its output connected to the winding of the mechanical relay 46 across the resistance 47 and condenser 48 in series. The relay 46 by suitable choice of elements 47 and 48 is made to be slow releasing (its hang-over preferably being of the order of 2 seconds). Relay 41 is designed to have a shorter hang-over.

The values of the circuit elements of the auxiliary gain-decreaser 37 and the auxiliary gain-increaser 33 are so chosen that the latter is slightly more sensitive than the former. Now, if no speech energy is being received over the incoming circuit 1, but there is a steady tone (noise) on that circuit, this steady tone after amplification by the amplifier 23 in the gain-increaser circuit will be impressed by the transformer 31 on the syllabic detector circuit 24, and by transformers 40 and 45, respectively, on the auxiliary gain-decreaser 37 and on the auxiliary gain-increaser 33. The syllabic detector circuit 24 is initially adjusted so that it will not be held operated by the steady applied tone. The applied tone will be rectified by the rectifying devices 39 and 44 in the auxiliary gain-increaser and decreaser circuits, respectively, causing the windings of relays 41 and 46 connected to their outputs to be energized.

Relay 46 will operate first to open its normally closed contacts 49, effectively removing the discharge resistance 50 from its connection to the condenser 29 in the auxiliary vario-repeater. Then relay 41 will operate to close its normally open switch contacts 51, connecting the direct current source 52 to the condenser 29 in the auxiliary vario-repeater through the resistance 53. The current from the battery 52 will then charge up the condenser 29 through resistance 53 causing the gain of the auxiliary vario-repeater to be reduced until the energy level in the output of the second stage 30 of the amplifier 23 is brought to the value at which the input of the syllabic detector circuit is to be maintained constant which will cause the auxiliary gain-decreaser relay 51 to release disconnecting the direct current source 52 from the condenser 29 so that it is no longer being charged up. As the auxiliary gain-increaser is more sensitive than the auxiliary gain-decreaser, the gain-increaser relay 46 is still held operated, and therefore the auxiliary vario-repeater would stay at a fixed gain if the condenser 29 were without leakage. However, eventually the charge will have leaked off the condenser 29 sufficiently to again cause operation of the relay 41. These operations will create slight pulsations in the volume level in the output of the amplifier 23, but by suitable design of the circuit elements of the auxiliary circuits their period can be made so long that the syllabic detector circuit 24 will not respond to them. Thus, it is seen that in silent intervals, that is, when no speech is being received over the circuit 1, the noise on the circuit regulates the gain of the auxiliary vario-repeater.

On land line noise which is of a fairly steady nature, the auxiliary device will operate in similar manner as on steady tone.

Now suppose that speech waves are being received substantially continuously over the transmission circuit 1. A portion of the speech energy will be impressed by the transformer 25 on the

input of the amplifier 23 in the main increaser circuit and will be amplified thereby. The amplified waves in the output of the second stage 30 of the amplifier will be impressed by transformers 31, 40 and 45, respectively, on the input of the syllabic detector circuit 24 which has a high sensitivity with respect to the incoming speech and will be operated, and the inputs of the auxiliary gain-decreaser and auxiliary gain-increaser circuits. Both the auxiliary gain-decreaser relay 41 and the auxiliary gain-increaser relay 46 will be operated causing the gain of the auxiliary vario-repeater in the amplifier 23 to be reduced in the manner described above for noise until the average level of amplified waves in that output of the second stage 30 of the amplifier 23 are brought to the desired constant level. The peaks of speech may be at an appreciably higher level. Then, the syllabic amplifier detector 24, which has on the average five decibels greater sensitivity to speech than to noise, will still operate on the strong syllables sufficiently often to effect satisfactory volume regulation. The detected waves will cause the operation of the gain-increaser relay 21 which will cause the gain of the vario-repeater 3 in the first stage of the signal repeater to be increased until the output level of the repeater is brought to the desired constant value when the gain-increase disabler will operate to disable the gain-increaser in the manner described above.

On steady speech the relay 46 in the auxiliary gain-increaser circuit, because of its long hang-over, will be held operated practically continuously. So, during a normal conversation, the auxiliary gain-increaser relay 46 rarely releases. When the speech input level to the gain-increaser circuit falls off with a reduction in the level of the speech currents incoming over the circuit 1, so that the level of the waves in the output of amplifier 23 falls below the desired constant value, relays 41 and 46 will release. Battery 52 will then be disconnected from the condenser 29, and condenser 29 will be discharged through resistance 50 increasing the gain of the auxiliary vario-repeater and thus the output level of the amplifier 23 until it is restored to the desired value when relay 46 will again operate to disable the discharging circuit. The amount of the adjustment in gain on applied speech depends upon the hang-overs of relays 41 and 46 and the time constants of the charging and discharging circuits.

When conversation ceases, the gain of the auxiliary vario-repeater in the main gain-increaser circuit is readjusted by the applied noise in the manner which has been described so that the circuit is returned quickly to its most sensitive condition.

It will be apparent from the above description of operation that in the circuit of the invention the reduced sensitivity of the gain-increaser circuit for strong talkers completely eliminates the liability of noise operation during speech intervals. Also, it may be seen that unnecessary operation of the gain-increaser for strong talkers is prevented, which will result in better volume regulation. The silent intervals are long enough to allow the gain of the auxiliary-vario-repeater to increase. The noise itself will hold the gain down to such a value that the syllabic detector does not operate on the normal variations in the noise voltage.

Fig. 2 shows schematically a modification of the invention in which the sensitivity of the gain-increaser is made independent of the talker vol-

ume after the initial adjustment without requiring the use of the syllabic detector circuit, or the auxiliary vario-repeater, auxiliary gain-decreaser and auxiliary gain-increaser. Referring to Fig. 2 the circuits of the vario-repeater 3, the gain-decreaser 10 and the gain-increase disabler 11, which are indicated by boxes only, except for the slight modifications pointed out below, may be similar to those of the correspondingly designated apparatus shown in Fig. 1.

In the system of Fig. 2, the gain-increaser 54, which may be a vacuum tube amplifier-detector circuit such as is well known in the art, has its input connected to the incoming circuit 1 in the input of the vario-repeater 3 and controls the gain-increase relay 21 when the volume level of the speech signals in the output of the signal repeater falls below the desired level, to increase the gain of the vario-repeater by causing the control condenser 7 in the input circuit thereof to be discharged in a manner similar to that described for the corresponding apparatus in the system of Fig. 1. The gain-increaser circuit 54, however, in the system of Fig. 2 is used only for making the initial adjustment in the gain of the vario-repeater 3. As soon as the talker has completed the initial adjustment of the gain of the vario-repeater by operating the gain-increaser 54, the gain-increase disabler 11 operates to control the gain-increase disabler relay 16 to disable the gain-increaser circuit in the manner similar to the described in connection with the system of Fig. 1.

The gain-increase disabler 11 in operating also causes the operation of a mechanical relay 55 connected to its output in series with the gain-increase disabler relay 16 to close its switch contacts 56 putting into operation an auxiliary circuit 57, which may be called the gain adjuster, which is controlled from the output of the amplifying device 9 in the control circuit 8 in parallel with the gain-increaser 10 and the gain-increase disabler 11.

The gain-adjuster 57, which may be a vacuum tube rectifier similar to the rectifier 14 in the gain-increase disabler circuit 11 as shown in detail in the system of Fig. 1, is operated by the amplifying device 9 when the initial gain adjustment of the vario-repeater 3 has been made, to energize the winding of a relay 53 and an additional winding 60 on gain-increase relay 21 connected in series across the output of gain-adjuster 57. Relay 53 then operates to open the normally closed switch contacts 59 in the output circuit of the gain-increaser 54 thereby deenergizing the winding of the gain-increase relay 21 normally connected to the output of gain-increaser 54. The gain-increase relay 21 is then maintained operated through the winding 60. In other words, after the initial gain adjustment, the gain-increaser is controlled for subsequent changes in volume during a conversation from the output of the vario-repeater instead of from the input thereof.

The sensitivity of the gain-adjuster 57 will depend upon the degree of regulation required and upon whether a hang-over is used. The relay 53 is made to have a long hang-over, for example, by making it slow releasing to the required degree by suitable mechanical design, so that it will remain operated during the usual pauses in normal conversation. In general the constants of the gain-adjuster circuit should be adjusted so that the relay 58, the relay 21 through the operation

of winding 60 and the relay 55 will not release during a normal conversation.

The effect of transferring the gain-increaser circuit after the initial gain adjustment from the input of the vario-repeater to the output thereof is to make the sensitivity of the gain-increaser independent of the talker volume after the initial adjustment. It is apparent that when volume control circuits such as disclosed in Fig. 2 are used in connection with four-wire telephone circuits, for example, that they provide protection against false operation by echoes of received noise.

It is apparent that the invention is not limited to the specific circuits described in the specification and illustrated in the drawing but that many modifications thereof within the scope of the invention will occur to persons skilled in the art. The scope of the invention is only limited by the appended claims.

What is claimed is:

1. In a signal transmission system, a wave transmission path supplied with speech waves varying in volume and subject to interfering noise waves, said path including wave-amplifying means, wave-controlled means connected to said path and responsive to waves therein above a given volume level to adjust the gain of said wave amplifying means, and means for minimizing the effects of noise on the operation of the gain adjusting means comprising means responsive to the waves in said path to make the sensitivity of the gain adjusting means independent of variations in the volume level of the speech waves supplied to said path, after the initial gain adjustment of the amplifying means therein.

2. In a signal transmission system, a wave transmission path supplied with signal waves varying in volume and subject to interfering noise waves, said path including wave amplifying means, wave-controlled means connected to said path in the input of said wave amplifying means and responsive to the supplied waves above a given volume level to adjust the gain of said wave amplifying means, and means for minimizing the effect of said noise waves on the operation of the gain adjusting means, comprising means making said wave-controlled means more sensitive to the applied signal waves than to the applied noise waves, and means operative after the initial gain adjustment of said wave amplifying means to adjust the amplitude level of the waves applied to said wave-controlled means to a constant value.

3. In a signal transmission system, a wave transmission path supplied with speech waves and subject to interfering noise waves, said path including wave-amplifying means, wave-controlled means connected to said path in the input of said wave-amplifying means and responsive to waves therein above a given volume level to adjust the gain of said wave-amplifying means, said wave-controlled means comprising an amplifier connected to said path, a syllabic detector circuit connected to the output of said amplifier, and means automatically responsive to the applied waves to so regulate the gain of said amplifier as to maintain the volume level of the waves supplied to said syllabic detector circuit substantially constant after the initial gain adjustment of the amplifying means in said path.

4. In a signal transmission system, a wave transmission path supplied from a source of speech waves and subject to interfering noise waves, said path including wave-amplifying

means, wave-controlled means which when actuated operates to increase the gain of said amplifying means continuously until the amplitude level of the amplified waves in the output thereof reaches a desired high value, control means connected to said path in the input of said amplifying means and responsive to waves therein when their amplitude level exceeds a certain lower value to actuate said wave-controlled means, other control means connected to said path in the output

of said amplifying means and responsive to waves therein of amplitude level higher than said desired high value, to disable the first-mentioned control means, and to assume control of said wave-controlled means for subsequent adjustments of gain during the substantially continuous supply of speech waves from said source.

BJÖRN G. BJÖRNSON.
STEPHEN DOBA, Jr.

80

85

90

95

100

105

110

115

120

125

130

135

140

145

150