July 2, 1940. S. B. WRIGHT 2,206,146

CONTROL OF TRANSMISSION AND TWO-WAY SIGNALING SYSTEMS

Filed May 27, 1939 3 Sheets-Sheet 1

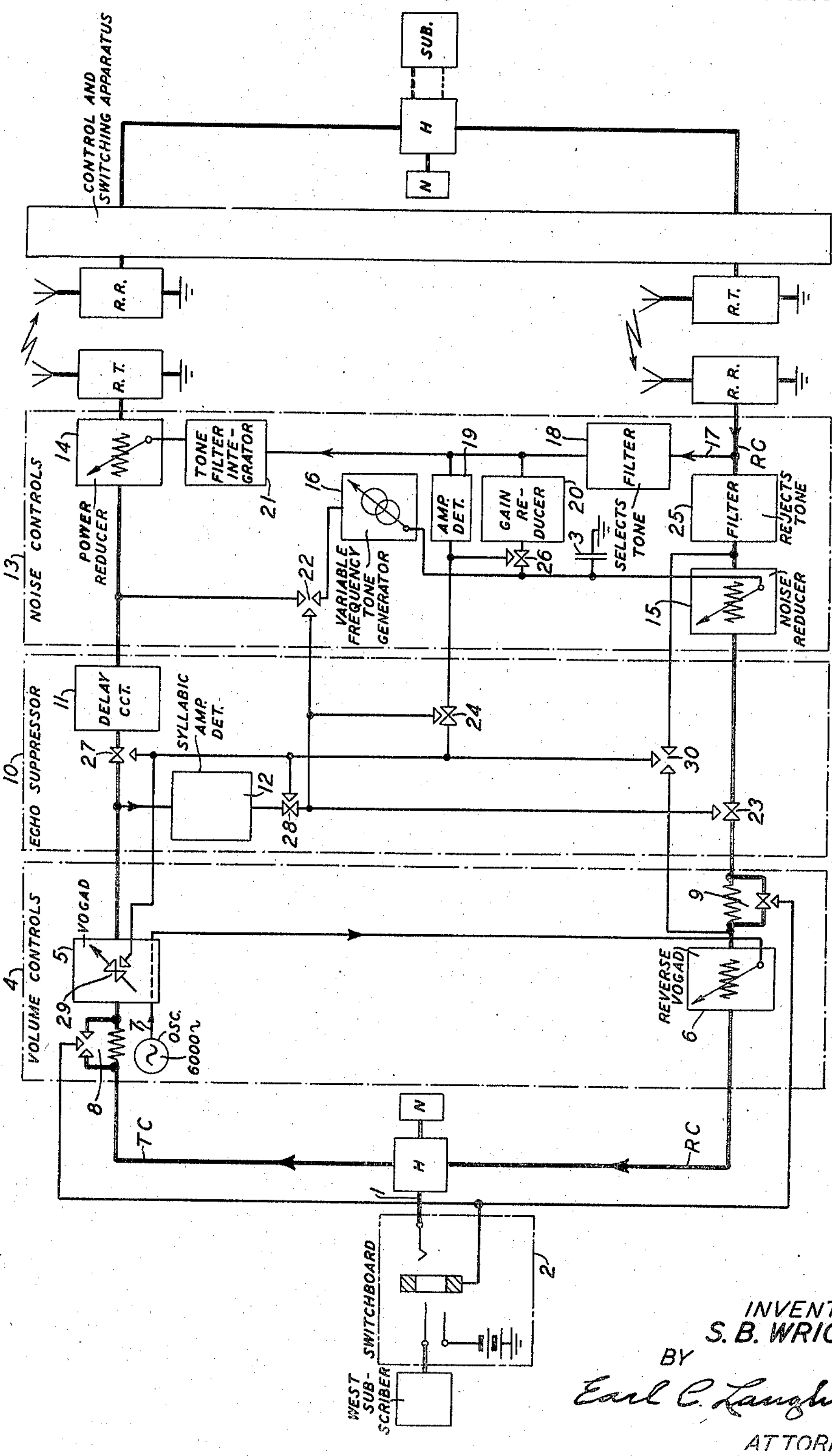

FIG. 1

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CONTROL OF TRANSMISSION AND TWO-WAY SIGNALING SYSTEMS

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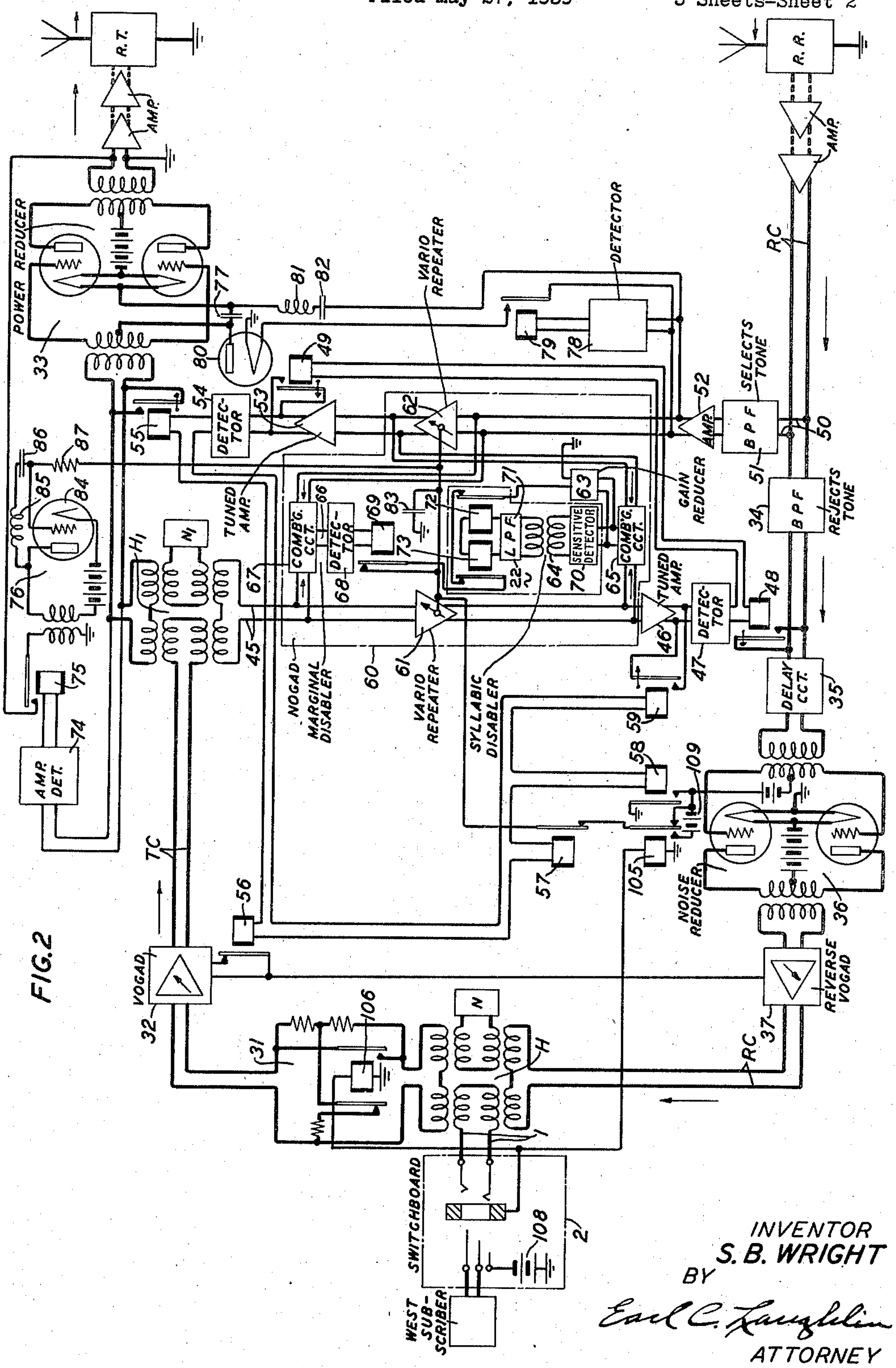

FIG. 2

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Filed May 27, 1939 3 Sheets-Sheet 3

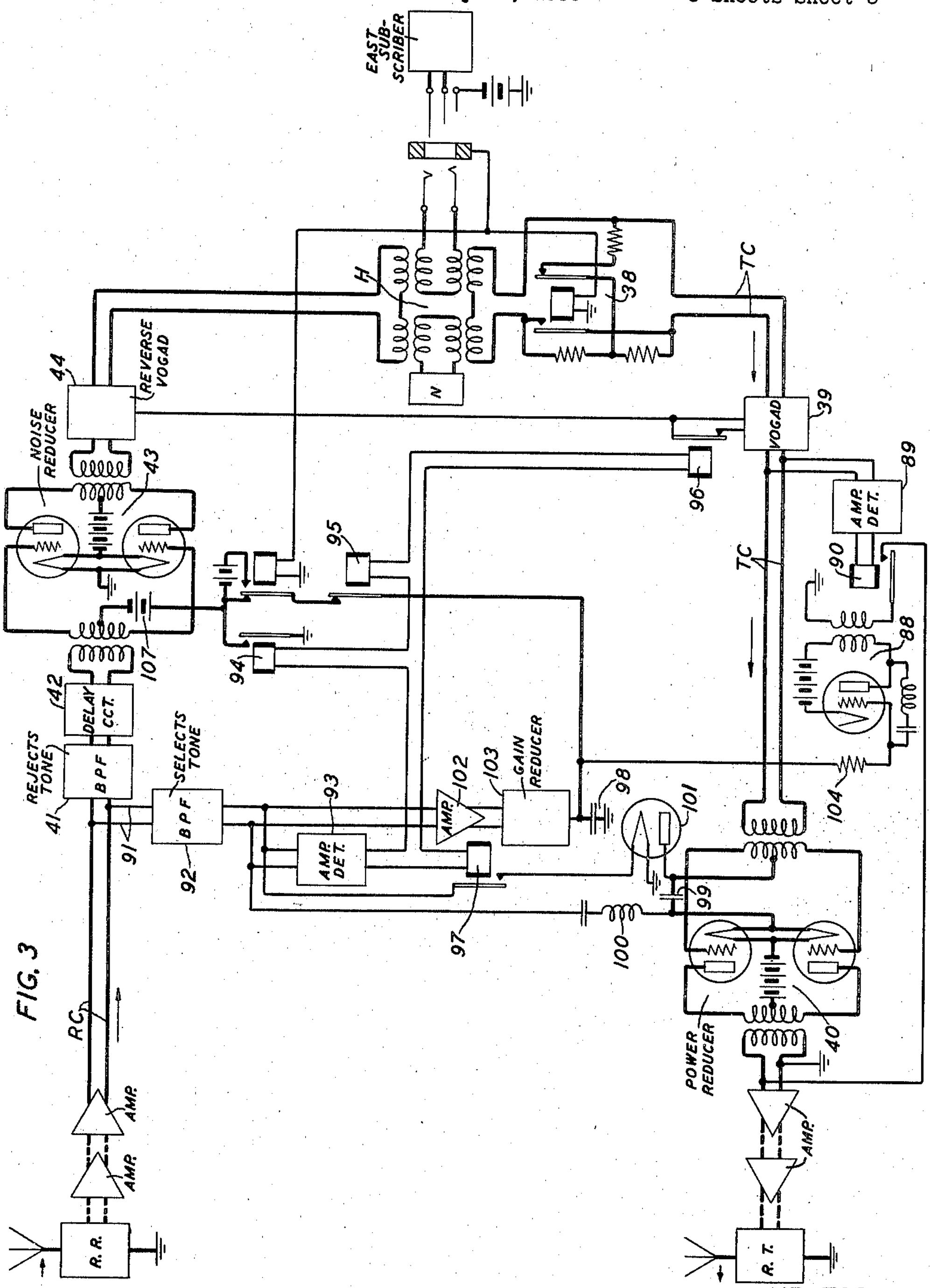

FIG. 3

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CONTROL OF TRANSMISSION AND TWO-WAY SIGNALING SYSTEMS

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Application May 27, 1939, Serial No. 276,112

13 Claims. (Cl. 178—44)

The invention relates to signaling systems, and particularly to circuits for automatically controlling transmission in such systems.

An object of the invention is to combine and relatively arrange automatic devices for exercising different types of control on transmission in a two-way signaling system in such manner as to provide improved operation of the system over a wide range of transmission conditions.

A related object is to provide maximum gain in the transmission paths of a two-way signal transmission system consistent with the maintenance of anti-singing conditions and discrimination against echoes, and room and line noises, and other interference such as that arising in radio paths.

The invention is particularly directed to circuits for controlling the volume and direction of transmission in a two-way telephone transmission system including an intermediate circuit subject to considerable noise, such as a radio link, and in which separate frequency bands or channels are used for transmission in the two directions. The probability of singing in such a system depends primarily on the operation of circuits used for automatically adjusting volume levels, which may at times introduce sufficient gain to cause over-all or round-trip singing. In prior art systems, voice-operated singing suppression is usually obtained by auxiliary devices designed to operate over the range of the settings of the volume controls. Applicant has improved on this method of control by making the singing suppression vary with the settings of the volume controls, which in turn vary with the signal-to-noise ratios in the intermediate circuit.

In the circuit of the invention, the anti-singing loss is made a function of the noise, which is primarily responsible for requiring volume control and the amount of volume control for a particular condition is automatically determined by the amount of noise in the system. Also, by special design and relative arrangement of echo suppressor, volume control and noise control apparatus at the terminals of the system, improved operation is obtained for a wide variation of transmission conditions encountered in service.

A feature of the invention is the use of a control tone transmitted from each terminal of the system along with the signals and under the control thereof to control the amount of loss in the transmitting circuit of the distant terminal in accordance with the frequency of the control tone, the frequency of the tone transmitted from each terminal being made a function of the amount of noise in the receiving path of the terminal in the absence of received signals.

The various objects and features of the invention will be better understood from the following detailed description thereof read in conjunction with the accompanying drawings, in which:

Fig. 1 shows a block diagram of a two-way radio telephone system embodying the invention; and

Figs. 2 and 3 show schematically in more detail the apparatus and circuits which may be used at the two terminals of a radio telephone system in acordance with a modification of the invention.

Fig. 1 shows in single line functional schematic form a two-way radio telephone system embodying the invention. In this figure, at each of the two terminals of the system there is a two-wire transmission path, the two terminals being joined by two one-way paths, one for each direction of transmission, and the transmission apparatus associated with these paths is identified by simplified representations of their functions or by suitably labeled boxes. Contacting arrowheads in a transmission path or box indicates that the path at that point or the apparatus represented by the box is normally enabled, and separated arrowheads in a transmission path indicates that the path at that point is normally disabled. An arrow directed towards a normal make point in a path or box indicates that the path at that point or the transmission apparatus represented by the box will be disabled by operation of the apparatus from which the arrow points, and an arrow directed from a box towards a break point in a transmission path indicates that the path will be enabled at that point by operation of the wave-operated device represented by the box. A box containing a simplified representation of a resistance with an arrow crossing through it represents a variable loss or gain device, the value of which is adapted to be varied under control of the apparatus from which the arrow points, and a box containing overlapping circles crossed by an arrow, represents a variable frequency source adapted to be varied by the apparatus from which the arrow points.

The two-way radio telephone system of Fig. 1 comprises a west terminal station and an east terminal station connected by two one-way radio links. Each station comprises a four-wire circuit connecting a two-way telephone line to a radio transmitter and radio receiver. As the circuits and apparatus at the two terminal stations are similar, only that at the west station has been illustrated in detail. The four-wire circuit at the west station comprises a transmitting circuit TC leading to a radio transmitter RT and a receiving circuit RC leading from a radio receiver RR, the input of the transmitting circuit TC and the output of the receiving circuit RC being coupled by the usual hybrid coil H and associated balancing network N in substantially conjugate relation with each other and in energy transmitting relation with a two-wire circuit 1 which may be connected by cord circuits or other suitable means in switchboard 2 to a two-way telephone line leading to a subscriber's telephone circuit.

Directional transmission over the four-wire circuit at the west station is controlled by three different types of devices working together. At the left are the "volume controls" shown within the dot-dash box 4. They include a volume control arrangement comprising a vogad (volume operated gain adjusting device) 5 in the transmitting circuit TC and a similar reverse vogad 6 in the receiving circuit RC, controlled by a 6000-cycle pilot channel 7 which is associated with the vogad and reverse vogad in such manner that when the gain of the former exceeds a certain value the pilot channel adjusts the reverse vogad to put a loss in the receiving circuit RC equivalent in decibels to the increase in gain; and the variable loss switching pads 8 and 9 of optimum values respectively connected in the transmitting circuit TC in front of the vogad 5 and in the receiving circuit RC in front of the reverse vogad 6, which are controlled from the sleeve circuits of the switchboard 2 to set up the conditions for different classes of calls, i. e., terminal calls or calls that are switched through to distant cities.

The vogad 5 and reverse vogad 6 may be, for example, of the type disclosed in Mitchell et al. Patent 2,019,577, issued November 5, 1935, and the pilot channel 7 may be as disclosed in British Patent No. 331,831, complete accepted October 13, 1932 (see Fig. 2 and pages 8 to 10).

In the center is an "echo suppressor" shown within the dot-dash box 10, including a delay circuit 11 in the transmitting circuit TC, a transmitting "syllabic" amplifier-detector 12 connected across that circuit in front of delay circuit 11, and switching devices (relays) controlled from the output of amplifier-detector 12, operating in a manner to be described to suppress echoes and prevent singing during two-way operation of the terminal, to control the transmission of control tone from the terminal and to prevent false operation of the receiving echo suppressor circuit.

At the right, shown within the dot-dash box 13, is an arrangement designated "noise controls." It includes a power reducer 14 connected in the transmitting circuit TC between the delay circuit 11 and the radio transmitter RT, a noise reducer 15 connected in the receiving circuit RC between the radio receiver RR and switching pad 9, a variable frequency control current or tone generator 16 adapted to be connected across the transmitting circuit TC between delay circuit 11 and the power reducer 14, under control of the syllabic amplifier-detector 12 of the "echo-suppressor"; and a tone-operated receiving control circuit 17 connected to the receiving circuit RC at a point between the radio receiver RR and the noise reducer 15.

The tone-operated receiving control circuit 17 includes the tone selecting filter 18, and connected in parallel to its output, the receiving "echo suppressor" switching device (amplifier-detector) 19, the "gain reducer" 20 and the tone filter-integrating device 21. The switching device 19 controls switching apparatus for suppressing echoes and singing on incoming signals, and for producing an interlock with other apparatus in the "noise controls" and the transmitting "echo suppressor." The tone filter-integrating device 21 operates to pass received control tone and as a frequency integrator to adjust the loss value of the power reducer 14 in accordance with the received control tone frequency. The "gain reducer" 20 operates to measure the applied noise, and to adjust the loss or gain value of the noise reducer 15, and the value of the frequency generated by the tone generator 16 in accordance with the noise amplitudes.

The variable frequency tone generator 16 at the west station and the corresponding generator at the east station are selected to generate control waves or tone of a frequency (f_1 or f_2) which is normally just above or just below the voice frequency band, the value of which may be varied under control of the associated "gain reducer" 20.

The manner in which the volume control, echo suppressor and noise controls work together to attain the objects of the invention is brought out in the following complete description of the operation of the system of Fig. 1.

For calls which are connected to low loss or terminal land circuits, the resistance loss pads 8 and 9 are arranged in the condition indicated in Fig. 1 with the pad 8 connected in the transmitting circuit TC to provide a transmitting loss and the pad 9 short-circuited so that it provides little or no receiving loss. When extensions are to be made through the terminal switchboard to long via circuits, the sleeve circuits in switchboard 2 are operated to short-circuit the resistance pad 8 cutting out the transmitting loss, and to remove the normal short circuit from resistance pad 9 to put in a receiving loss. This is in order to compensate for the additional loss in the toll line at the transmitting end and also to preserve the stability. The optimum values of these loss pads for a given system may be readily ascertained by experiment. Actually the loss in the receiving side may not greatly degrade the connection as will be brought out below. Assuming that the sleeve circuits of switchboard 2 have been operated in one or the other direction depending on the type of calls to be handled, the operation of the remaining part of the system for such calls will now be described.

For either connection the terminal circuits are normally enabled in both directions, and the vogad 5 in the transmitting circuit TC and the reverse vogad 6 in the receiving circuit RC are in the loss or gain condition depending on the value to which they have been adjusted in response to the speech currents of the last speaker. Also, the loss in the power reducer 14 in the transmitting circuit TC which, as will be described, is determined by the frequency of the control current last received from the distant station, depends on the noise at the distant terminal at that time.

With no speech signals being transmitted, the control device (gain reducer) 20 will be operated by the narrow band of noise waves received from the radio receiver RR through the receiving circuit RC and filter 18 to do two things: first, as the applied noise increases, it operates to apply an increased charge on condenser 3 in its output which controls the noise reducer 15 to increase the loss inserted thereby in the receiving circuit in proportion to the noise amplitude, thereby reducing the volume which will be delivered to the subscriber associated with the terminal to the proper value for the existing noise conditions. The second accomplishment of the control device 20 actuated by the applied noise is, through the charge produced on condenser 3, to change the frequency of the control tone generator 16 so that the generated tone is of a particular frequency determined by the amount of noise. Actually, these two results are not accomplished until control tone is received from the distant terminal, the charge on the condenser 3, proportional to the amplitude level of the noise applied to the gain reducer 20 being stored therein until the switching device 19 is operated by received tone to disconnect the device 20 from the condenser at which time condenser 3 discharges to adjust noise reducer 15 and tone generator 16.

The corresponding "gain reducer" at the east terminal of the system operates similarly to store indications for adjusting the loss value of the noise reducer in the receiving circuit and the frequency of the control tone generator at that terminal to particular values determined by the amount of noise in the receiving circuit at that station.

Assume now that the west subscriber starts speaking. His voice waves will be impressed by the hybrid coil H on the transmitting circuit TC, and will pass through the transmitting vogad 5 which will operate to maintain a predetermined constant volume in its output, while the 6,000 pilot channel 7 operates to make a compensatory adjustment in the reverse vogad 6 in the receiving circuit RC to put in the proper amount of loss in the latter circuit to maintain the singing margin, if it is necessary.

West's speech waves in the output of the vogad 5 are divided between the delay circuit 11 in the speech transmission circuit and the input of the transmitting "syllabic" amplifier-detector 12 in the "echo suppressor" circuit. The portion of west's speech energy applied to the syllabic amplifier-detector 12 will cause its operation to simultaneously close switching contacts 22 to connect the control current generator 16 to the transmitting circuit TC so that control tone therefrom is impressed on that circuit; to open the switching contacts 23 in the receiving circuit RC to suppress echoes in that circuit; and to open switch contacts 24 to disable the output of the receiving "echo suppressor" device 19 so as to prevent the speech currents of the subscriber associated with the distant east station from obtaining control of the west terminal station while west continues to speak. The delay circuit 11 in the transmitting circuit TC provides sufficient delay in the transmission of the voice currents therethrough, so as to allow the control tone to be slightly in advance of the voice signals when applied to the radio link.

The control tone from source 16, of a frequency determined by the amount of noise present in the receiving circuit RC at the station, and the following voice currents, pass through the power reducer 14 in which they are attenuated in accordance with its adjustment, to the radio transmitter RT and are radiated thereby.

As the control and switching apparatus in the box so labeled at the east terminal station have not been illustrated in detail, their operation in response to the tone and voice waves received from the west terminal station and picked up and detected in the radio receiver RR at the east station will be described by identifying the control and switching apparatus thereat with the same reference characters as used for the corresponding apparatus at the west terminal station but followed by a prime (') mark.

The incoming control tone and speech waves are separated at the east station by the control tone select filter 18' in the receiving control circuit 17' and the parallel tone reject filter 25' in the receiving circuit RC'. The tone waves selected by filter 18' are impressed in parallel on the tone filter-integrating device 21', the amplifier-detector 19' and the "gain reducer" 20'. The tone filter-integrating device 21' passes the applied control tone and also operates as an integrator to adjust the loss value of the power reducer 14' in the transmitting circuit TC' at the station in accordance with the control tone frequency.

The portion of the control tone impressed on the amplifier-detector 19' will cause its operation to simultaneously open switch contacts 26' to 29', inclusive, and to close switch contacts 30'. The opening of switch contacts 26' will disable the gain reducer 20' in its output thereby discharging condenser 3' to adjust noise reducer 15' and the frequency of the tone generated by the control tone generator 16' in accordance with the noise in the receiving circuit at the station, and to prevent operation of the gain reducer 20' by the applied tone from charging condenser 3'. The opening of switch contacts 27' will disable the transmitting circuit TC' at a point in front of delay circuit 11' so as to prevent echoes of signals incoming in the receiving circuit from passing out over that circuit to the radio transmitter and being radiated thereby, and the opening of switch contacts 28' and 29' respectively disable the syllabic amplifier-detector 12' in its output and the vogad 5' thereby preventing false operation of these controls by echoes. The closing of switch contacts 30' will close a short-circuiting connnection around the portion of the receiving circuit RC' including the noise reducer 15' and the loss pad 9', thereby effectively cutting out the losses normally inserted by these elements in the receiving circuit and allowing the received voice currents to pass with little attenuation from the output of filter 25' over the outgoing portion of the receiving circuit RC' to the east subscriber.

The combined operation of the volume control, echo suppressor and noise control apparatus at the two terminals of the system of Fig. 1, as described, results in only enough power output or volume control at the sending end of the system to deliver the necessary signal-to-noise ratio at the receiving end while, by limiting the noise, cutting down the received volume at the receiving end by an amount necessary for maximum intelligibility. Whenever conditions are such that the circuits operate to take out loss at the sending end of the system, a corresponding amount of loss is put in at the receiving end so that the net effect of this arrangement on singing can be made negligible. The effect of the gain reducer associated with the tone-operated receiving circuit at each terminal station when control currents and speech are not coming in, when noise increases at the receiving end, is to increase the loss of the noise reducer in the receiving circuit to prevent the subscriber from hearing so much noise, and to change the frequency of the control current generator at the station so as to indicate to the opposite end of the system what attenuation should be put in the power reducer at that end, which, in this case, would be a decreased loss in order to raise the volume of the speech and control current coming in and thereby over-ride the noise to a better degree.

Stability is maintained under all conditions in the circuit of Fig. 1, as described, largely due to the compensating adjustment in the transmitting and receiving sides of the circuit. At times of low noise, power is saved in the radio transmitter by having a large loss in the power reducer while at the same time high volumes are delivered to the receiving subscriber because of low loss in the noise reducer. The arrangement of the circuit, so that incoming control current switches out the noise reducer loss and any loss which may be present in switching pad 9, insures that, even though the noise reducer loss increases, the received speech volume is not materially affected but the volume of the noise received in the intervals between speech sounds is reduced.

Preferred circuit arrangements for the power reducer, noise reducer, variable frequency tone generator and the gain reducer circuit shown diagrammatically in Fig. 1, are illustrated in Figs. 2 and 3 which show schematically the west and east terminal stations respectively of a two-way radio telephone system embodying a modified form of the invention.

As in Fig. 1, the west and east terminal stations of the system of Figs. 2 and 3 each includes a transmitting circuit TC and a receiving circuit RC, the input of the former and the output of the latter respectively being coupled by the hybrid coil H and associated balancing network N to a two-wire circuit 1 which is adapted to be connected through switchboard 2 to a two-way line leading to a telephone subscriber.

At the west terminal station of Fig. 2, the transmitting circuit TC includes connected between the hybrid coil H and the radio transmitter RT, a removable loss pad 31, the vogad 32 and the power reducer 33, and the receiving circuit RC includes connected between the radio receiver RR and the hybrid coil H, the band-pass filter 34 adapted to pass the speech band and to reject waves of the frequency of the tone transmitted from the east terminal station, a delay circuit 35, a combined noise reducer and variable loss device 36 and the reverse vogad 37, the vogad 32 and the reverse vogad 37 being associated, as illustrated diagrammatically, for example, by a pilot channel circuit similar to circuit 7 described in connection with Fig. 1, so that when the vogad gain increases above a certain value the reverse vogad operates to insert a loss in the receiving circuit RC equivalent in decibels to the increase in gain of the vogad.

Similarly, at the east terminal station shown in Fig. 3, the transmitting circuit TC includes a removable loss pad 38, a transmitting vogad 39 and a power reducer 40, and the receiving circuit RC includes band-pass filter 41 for passing the speech band and rejecting the tone transmitted from the west terminal, the delay circuit 42, the combined noise reducer and variable loss device 43 and the reverse vogad 44 which is associated with the vogad 39 in the manner referred to above for the similar devices at the west terminal station.

The arrangement of volume control, echo suppressor and noise control circuits employed at the west terminal station shown in Fig. 2 is essentially the same as the similar circuits employed at both terminals in the system of Fig. 1, except that the echo suppressor switching circuits in the case of the west terminal shown in Fig. 2 are arranged to be desensitized by noise. However, at the east terminal station shown at Fig. 3, the echo suppressor circuits are eliminated and the volume and noise controls employed thereat are essentially the same as described above for the system of Fig. 1.

The echo suppressor circuits at the west terminal station shown in Fig. 2 comprise a transmitting switching circuit 45 including the tuned amplifier 46, the detector 47 and the switching relays 48 and 49 controlled from the output of the detector 47, having its input coupled by hybrid coil H_1 and associated balancing network N_1 in energy transmitting relation with the incoming portion of the transmitting circuit TC and in substantially conjugate relation with the outgoing portion thereof; and the tone-operated receiving switching circuit 50 including the tone selecting filter 51, the one-way amplifier 52, the tuned amplifier 53, the detector 54 and the switching relays 55 to 59 controlled from the output of the detector 54, having its input connected across the receiving circuit RC in front of the filter 34.

Associated with the transmitting and receiving switching circuits of the echo suppressor at the west station of Fig. 2 is a "Nogad" (noise operated gain adjusting device) shown within the dot-dash box 60, for regulating the sensitivity of the transmitting and receiving echo suppressor switching circuits according to the amplitude of the line noise applied to their inputs so as to prevent false operation of these circuits on the line noise while maintaining them at maximum sensitivity for operation on applied tone or speech currents. The particular nogad device illustrated is essentially as disclosed and described in Bjornson Patent 2,081,422, issued May 25, 1937, and need only be briefly described here.

The nogad 60 includes a vario-repeater 61 in the transmitting echo suppressor circuit 45 and a vario-repeater 62 in the receiving echo suppressor circuit 50.

The nogad 60 also includes a gain reducer portion 63 and a "syllabic disabler" portion 64 having their inputs connected in parallel through a combining circuit 65, which may comprise a hybrid coil connection and a common amplifier, such as disclosed in Bjornson Patent 1,873,268, issued August 23, 1932, to the transmitting suppressor circuit 45 in the output of vario-repeater 61, and to the receiving suppressor circuit 50 in the output of the vario-repeater 62 in such manner as to be supplied with an input from the output of each vario-repeater.

The nogad 60 also includes a "marginal disabler" circuit 66 connected through a combining circuit 67, similar to the combining circuit 65, to the transmitting suppressor circuit 45 in the input of vario-repeater 61 and to the receiving suppressor circuit 50 in the input of the vario-repeater 62 in such manner as to receive an input from the input of each vario-repeater.

The gain reducer 63, which as disclosed in the Bjornson Patent No. 2,081,422 may comprise a stage of alternating current amplification, a half-wave rectifier followed by two stages of direct current amplification, operates to change the gain of the vario-repeaters 61 and 62 in response to the wave energy applied to the input of the gain reducer in such manner as to cause a very slow decrease in the gain of each vario-repeater when the input energy suddenly increases, i. e., when tone or speech energy is first applied to the gain reducer and a very rapid increase in gain when the input energy is reduced, i. e., when speech transmission ceases and only noise received from the associated speech transmission path is present in the input.

The disabler circuit 66 comprises a marginal detector 68 and a relay 69 controlled from its output, operating in response to the peaks of the tone or speech impulses applied to the vario-repeater 61 or the vario-repeater 62 to disable the gain-reducer circuit 63 in its output thereby preventing excessive reduction in the gain of the vario-repeaters in response to the strong parts of applied tone or speech impulses.

The syllabic disabler circuit 64, which, as indicated, may comprise a sensitive detector 70 with a transformer and a low-pass filter 71 having a cut-off at about 22 cycles per second in its output, controlling the operation of the series electromagnetic switching relays 72 and 73, is substantially unresponsive to applied noise waves but responds to the applied weak as well as strong tone or speech impulses in the input of vario-repeater 61 or in the input of vario-repeater 62 to disable the output of gain reducer 63. The syllabic disabler circuit 64 in connection with the marginal disabler circuit 66 prevents any change in the gain of the vario-repeaters 61 and 62 during a very large part of the time when speech is on the circuit and thereby materially reduces the amount of speech or tone desensitization.

Connected across the transmitting circuit TC between the disabling point therein in front of the power reducer 32 and the hybrid coil H_1 is the input of a circuit, including an amplifier-detector 74 and a relay 75, adapted to operate in response to applied speech waves to connect the output of the variable frequency control generator 76 to the transmitting circuit TC at a point in the output of the power reducer 33.

The power reducer 33 comprises two three-electrode vacuum tubes connected in push-pull and having a control condenser 77 in series in the common portion of the control grid-cathode circuits of the two tubes. The output of a circuit, corresponding to the tone filter-integrating device 21 in the system of Fig. 1, is connected across condenser 77. This circuit comprises one normally disabled "integrating" branch including half-wave vacuum tube rectifier 80 and a filter including a series inductance 81 and a series condenser 82 connected in series with the control condenser 77, and a parallel branch for enabling the integrating branch, including a detector 78, the sensitivity of which is adjusted so that it will be unresponsive to noise but will respond to the applied tone waves, and relay 79, the inputs of both branches being connected across the output of amplifier 52 in the receiving switching circuit 50.

The noise reducer 36 in the receiving circuit RC at the west station comprises two three-electrode vacuum tubes connected in push-pull, the common portion of the control grid-cathode circuits of the two tubes including in series the control condenser 83, which condenser is also connected across the output of gain reducer 63 of the nogad 60 through the normally closed switching contacts of relays 69, 73 and 72.

The variable frequency control generator 76 comprises a single three-electrode vacuum tube 84 having its plate connected through a series inductance 85 and series condenser 86 to the control grid of the tube to form an oscillating circuit determining the frequency of the generated tone waves. The control condenser 83, connected in common to the output of the gain reducer 63 and the control grid-cathode circuits of the noise reducer 36, is also connected in series with resistance 87 across the control grid and cathode of the oscillator tube 84, so that its charge will control the bias on the control grid of tube 84 and thus the frequency generated by tone generator 76.

As will be described, the gain reducer 63 of the nogad 60 besides operating to desensitize the echo suppressor switching circuits 45 and 50 in accordance with the noise amplitudes, also operates to perform the same functions as the gain reducer 20 in the system of Fig. 1.

At the east terminal station of the system shown in Fig. 3, the variable frequency control tone generator 88, similar to the control tone generator 76 at the west terminal shown in Fig. 2, is adapted to be connected to the transmitting circuit TC in the output of the power reducer 40 by operation of a circuit including amplifier-detector 89 and switching relay 90, connected across transmitting circuit TC in front of the power reducer 40.

Connected across the receiving circuit RC at a point in front of the tone rejecting band-pass filter 41 therein is the input of a tone-operated receiving switching circuit 91 including the tone selecting filter 92 and three control branches, similar to the receiving control circuit branches provided for the same purpose at the west terminal station of Fig. 2 just described, connected to the output of that filter, respectively operating in the absence of signal transmission from the station, to adjust the loss value of the noise reducer 43 in the receiving circuit RC and the value of the frequency generated by tone control generator 88 in accordance with the amplitude of the noise passing from the receiving circuit RC through the narrow band tone selection filter 92, and to control the gain of the power reducer 40 in the transmitting circuit TC at the station in accordance with the frequency of tone waves received from the other station under control of voice signal transmission initiated thereat in a manner which will be described in connection with the following complete description of operation of the system of Figs. 2 and 3.

When no speech signals are being transmitted over the system in either direction, the receiving switching circuits at the west and east stations shown respectively in Figs. 2 and 3 are adjusted under control of the noise present in the receiving circuits of the station in the following manner.

At the west station, shown in Fig. 2, the narrow band of noise passing through the tone selecting filter 51 and amplified by the amplifier 52 will be divided between the receiving echo suppressor branch, the nogad 60 including the gain reducer 63, and the input of the detector 78 in the tone filter-integrating branch. The portion diverted into the receiving echo suppressor branch will not be effective to cause operation of the echo suppressor relays because the sensitivity of the vario-repeater 62 in that branch is normally adjusted to be inoperative by noise. The portion of the received noise waves impressed on detector

78 also will have no effect as the sensitivity of that detector is adjusted so that it is unresponsive to noise.

The noise waves applied to the input of the gain reducer 63 will cause its operation to adjust the gain of the vario-repeaters 61 and 62 to vary the sensitivities of the transmitting and receiving echo suppressor switching circuits in accordance with the amount of noise in the manner previously described, and to charge up the condenser 83. Any increase in the charge on the condenser 83, which will be roughly proportional to an increase in some component of the noise applied to the gain reducer 63, will increase the normal grid voltages on the tubes of the noise reducer 36, reducing its gain accordingly, and will also apply a biasing voltage through resistance 87 to the control grid of the tube 84 of the control tone generator 76 at the station, effectively reducing its generated frequency to a value determined by the amount of noise present in the receiving circuit at the station. Similarly, a decrease in the charge on condenser 83 corresponding to a decrease in the amount of noise applied to gain reducer 63 will proportionately increase the gain of noise reducer 36 and the frequency of the tone generated by tone generator 76.

At the east station shown in Fig. 3, the narrow band of noise transmitted through the tone selecting filter 92 and amplified by amplifier 102 will cause operation of the gain reducer 103 to charge the condenser 98 in accordance with the noise amplitudes, thereby controlling the gain of the noise reducer 43, and through resistance 104 the bias on the control grid of the oscillating tube of tone generator 88 to adjust the value of the generated tone frequency in accordance with the amount of noise in the receiving circuit at the station.

Assume now that a west subscriber starts speaking from a telephone near the west station, so that the loss pad switching relays 105 and 106 adapted to be energized from the switchboard 2 when the terminal is connected to long via circuits remain in their normally inoperative condition. His voice waves will pass through the transmitting switching pad 31 and enter the vogad 32 where they will cause its gain to be adjusted to maintain the desired output volume of the voice signal current, and at the same time result in a reverse adjustment of the gain of the reverse vogad 37 in the receiving circuit at the terminal, if the gain adjustment exceeds the stability gain requirements.

From the output of the vogad 32, west's voice waves as regulated in volume by the vogad, pass to the hybrid coil H_1 in which they are divided, part being transmitted over the transmission circuit towards the power reducer 33 and the other portion being diverted into transmitting echo suppressor switching circuit 45 through hybrid coil H_1. The portion passing over the main transmission circuit will be divided between the input of the power reducer 33 and the input of the amplifier-detector 74. The portion impressed on the amplifier-detector 74 will cause its operation to operate relay 75 connecting the output of the control tone generator 76 to the circuit TC in the output of the power reducer 33. The tone waves with a frequency determined by the previous adjustment of the control tone generator 76 by the noise waves, as described above, will be transmitted to the radio transmitter RT and will be radiated to the distant east station. The other portion of west's speech waves in passing through the power reducer 33 will be attenuated in accordance with its last adjustment by tone waves from the east station, and the attenuated speech waves will follow the tone waves to the radio transmitter RT and will also be radiated to the east station.

Meanwhile, the portion of west's speech waves along with the noise waves present passing into the transmitting switching circuit 45 will be transmitted through the vario-repeater 61, the gain of which is adjusted to vary the sensitivity of switching circuit 45 in accordance with the amount of noise only in circuits 45 and 50, under control of the circuits 63, 64 and 66 of the nogad 60 respectively connected to circuit 45 on either side of the vario-repeater 61 and to circuit 50 on either side of vario-repeater 62, in the manner previously described. The speech waves in the output of vario-repeater 61 will pass through tuned amplifier 46 and detector 47 and will cause operation of the switching relays 48 and 49. The operation of relay 48 will connect a disabling short circuit across the receiving circuit RC in front of the delay circuit 35 which will serve to suppress any echo of west's speech currents which may be returned over the receiving circuit RC at the west station. The operation of switching relay 49 will cause a short-circuiting connection to be connected across the receiving echo suppressor switching circuit 50 in front of the detector 54 thereby preventing subsequent false operation of the receiving switching relays by tone energy subsequently received from the east terminal station.

When the control tone and the following speech waves from the west station arrive at the east station shown in Fig. 3, they will be picked up by the radio receiver RR and will pass over the associated receiving circuit. The band-pass filter 41 will suppress the control tone but pass the received speech waves, whereas the parallel connected filter 91 in the receiving switching circuit 90 will select the received tone and suppress the received speech waves of other frequencies.

A portion of the tone waves in the output of filter 92 will be diverted into the amplifier-detector 93 and will cause its operation to operatively energize the switching relays 94 to 97 connected to its output. Relays 94 and 95 will operate, respectively, to connect ground to the grid biasing battery 107 for the tubes of noise reducer 43, and to break the connection of the gain control condenser 98 to the control grid-cathode circuits of the amplifier tubes in noise reducer 43, thereby effectively removing the normal high negative grid bias on the tubes of the noise reducer 43 so as to increase its gain. The result of this operation is that west's speech currents transmitted through the noise reducer 43 after passing through the band-pass filter 41 and delay circuit 42 are increased in volume. These speech currents are then passed through the reverse vogad and hybrid coil H to the telephone circuits of the east subscriber associated with the east terminal.

The simultaneous operation of relay 96 effectively disables the vogad 39 in the transmitting circuit TC. The simultaneous operation of relay 97 closes a circuit from the output of the tone selecting filter 92 to the gain control condenser 99 common to the control grid-cathode circuits of the push-pull amplifier tubes in the power reducer 40 in the transmitting circuit, through the filter 100 and the half-wave rectifier 101 in series. As in the case of the similar filter-integrating circuit at the west terminal station, the elements of this filter-rectifier circuit are selected so that the higher the value of the tone frequency received through the tone filter 92, the greater the voltage appearing across the condenser 99, the effect being to increase the grid biasing voltage on the power reducer 40 and thereby reduce its gain in proportion to the increase in the frequency of the control tone, and vice versa.

The charge on condenser 98 under control of the gain reducer 103, which is similar to the nogad gain reducer 63 at the west station, described above, will be proportional to the amplitude of the noise applied thereto through amplifier 102 from filter 92, and will not be substantially changed by the applied tone or speech passing through that filter because of the inherent slow operation of the reducer on such waves, as described above. The applied tone waves, therefore, will not materially change the adjustment of the frequency of control tone generator 86 provided by condenser 98.

The action of the system of Figs. 1 and 2 for speech currents transmitted in the opposite direction is similar. East's speech currents at the east station of Fig. 3, after passing through the loss pad 38 and the vogad 39 will be divided between the input of the power reducer 40 in the transmitting circuit and the input of the amplifier-detector 89 connected across that circuit in front of the power reducer. The portion impressed on the amplifier-detector 89 will cause its operation to connect the output of the variable frequency tone generator 86 to the transmitting circuit in the output of power reducer 40 so that the tone waves generated by that generator with a frequency determined by its previous adjustment by the noise currents in the receiving circuit, described above, will be transmitted out over that circuit to the radio transmitter RT in advance of the speech currents and will be radiated thereby. The speech currents in transmission through the power reducer 40 will undergo an attenuation determined by its previous gain adjustment in accordance with the frequency of the tone wave last received from the west terminal station, and will then be transmitted to the radio transmitter RT and also radiated thereby.

The tone and speech waves from the east terminal will be picked up and detected by the radio receiver RR at the west terminal, shown in Fig. 2, and will be transmitted over the receiving circuit RC. The band-pass filter 34 in the receiving speech path will pass the speech waves and suppress the received tone whereas the parallel filter 51 in the receiving switching circuit 50 will suppress the speech waves and pass the received tone waves.

The tone waves in the output of filter 51 will be amplified by the amplifier 52 and divided between the receiving control branches connected to the output thereof. A portion amplified by amplifier 51 will pass through the vario-repeater 62, the tuned amplifier 53 and the detector 54 and cause the operation of the switching relays 55 to 59. The operation of relays 59 and 55 will respectively disable the transmitting echo suppressor circuit 45 at a point in front of the detector 47, and to disable the transmitting circuit TC at a point in front of the power reducer 33, thus preventing subsequent false operation of the transmitting suppressor circuit by echoes of east's speech waves and the transmission of such echoes over the transmitting circuit TC to the radio transmitter RT. The operation of relay 56 will disable the vogad 33, and the operation of relays 57 and 58 will respectively break the connection of gain control condenser 83 to the control grid-cathode circuits of the tubes in noise reducer 36 and connect ground to the grid biasing battery 109 for those tubes, thereby effectively removing the high negative grid bias on the tubes of noise reducer 36 so as to increase its gain.

A portion of the waves in the input of the vario-repeater 62 will be transmitted through the combining circuit 67 into the input of the marginal disabler circuit 66 of nogad 60 and another portion in the output of the vario-repeater 62 will be transmitted through the combining circuit 65 into the input of gain reducer 63 and the input of the syllabic disabler circuit 64 of the nogad. The marginal disabler circuit 66 and the syllabic disabler circuit 64 will then operate, in the manner previously described, to disable the output of the gain reducer 63 to prevent it from controlling vario-repeaters 62 and 63 to cause desensitization of the transmitting and receiving echo suppressor switching circuits on the applied tone and speech waves, and to prevent the applied tone and speech from varying the charge on condenser 83 to vary the gain of the noise reducer 36 in the receiving speech path and the frequency of the variable frequency control generator 76 at the west terminal. The gain setting of the noise reducer and the frequency of the tone generator 76, therefore, will be maintained as previously adjusted by the gain reducer 63 under control of the noise in the receiving circuit at the terminal.

Another portion of the tone and speech waves in the output of amplifier 52 in the receiving switching circuit 50 impressed on the detector 78 will be detected thereby and cause the operation of relay 79 to close a connection between the output of amplifier 52 and control condenser 77 through rectifier 80 and the filter comprising coil 81 and condenser 82 in series. The voltage across condenser 77 will then be varied by the applied control tone waves in accordance with its frequency, the higher the frequency the greater the voltage across the condenser and vice versa. The effect of the variation in the voltage across condenser 77 will be to vary the bias on the grids of the push-pull vacuum tubes in the power reducer 33 in the transmitting circuit TC to change the gain of the power reducer to a value determined by the control tone frequency.

Meanwhile, the received speech waves in the receiving circuit at the west terminal station will pass through the band-pass filter 34, delay circuit 35, power reducer 36, reverse vogad 37, and hybrid coil H to the listening west subscriber associated with the terminal.

When a long distance telephone circuit is connected to the west terminal station by operation of the sleeve circuits in switchboard 2, current from the sleeve battery 108 will energize the windings of relays 105 and 106 causing the operation of these relays respectively to insert an additional battery 109 in series with the control grid circuits of the tubes in noise reducer 36, and to remove switching pad 31 from the transmitting circuit of the west station. The addition of battery 109 to the control grid circuits of the tubes of noise reducer 36 changes the bias on the grids of these tubes in such manner as to effectively increase the loss inserted by the noise reducer in the receiving circuit. The values of the transmitting switch pad 31 and the battery 109 are selected so that the loss thus removed from the transmitting circuit and inserted in the receiving circuit is sufficient to compensate for the additional loss in the connected long distance telephone line and also to preserve the stability. Relay 57 is operated by the receiving switching circuit 50 under control of incoming tone waves to remove the additional battery 109 from the grid circuits of the noise reducer 36 and thus to remove the additional loss in the receiving circuit RC when speech waves are being received from the east terminal. Similar circuits at the east terminal station of Fig. 3 operate in similar manner to increase the loss inserted in the receiving circuit of that station and to cut out the loss pad 38 from the transmitting circuit when that terminal is connected to a long distance telephone line, and to cut out additional loss in the receiving circuit when tone waves are received from the west terminal.

Various modifications of the system described above and illustrated in the drawings which are within the spirit and scope of the invention will occur to persons skilled in the art. For example, in practice it might be found desirable to combine the function of the vogad and power reducer in the transmitting circuit at each terminal station in a single device. Also, it might be advantageous to use switching devices in place of the relays illustrated, which employ dry rectifiers, vacuum tubes or other elements operating more gradually on speech than a relay, and to employ noise-desensitized echo suppressor switching circuits at both terminals of a two-way system instead of at only one terminal as illustrated.

What is claimed is:

1. In a two-way signal transmission system having at each terminal one-way transmitting and receiving circuits for repeating the signals transmitted in opposite directions, means at each terminal for making the transmitted signal power a function of the amount of noise in the receiving circuit of the other terminal, and for making the anti-singing loss in the receiving circuit of the terminal when signals are being transmitted therefrom a function of the amount of noise in the receiving circuit at the same terminal.

2. In combination with a two-way signal transmission system comprising at least near the terminals thereof oppositely directed one-way repeating paths subject to interfering noise, for the signals transmitted in opposite directions, means inserting an anti-singing loss in one of said paths when signal transmission is taking place over the other path, and means to make the value of said anti-singing loss a function of the amount of noise in said one path.

3. In combination with a two-way signal transmission system having a transmitting signal repeating path and a receiving signal repeating path at each terminal, said paths being subject to interfering noise, a volume control device in the transmitting path at a terminal of said system, and means to make the amount of volume control of the transmitted signals exercised by said volume control device a function of the amount of noise in the receiving repeating path at the other terminal.

4. In combination with a two-way signal transmission system having a transmitting signal repeating path and a receiving signal receiving path subject to interfering noise, at each terminal, volume control means in the transmitting path at one terminal of said system, means inserting an anti-singing loss in the receiving path at said one terminal when signal transmission is taking place over the transmitting path thereat, means to make the amount of anti-singing loss inserted a function of the noise at the time in the receiving path at said one terminal and means to make the amount of volume control exercised by the volume control means in the transmitting path at said one terminal a function of the amount of noise in the receiving path of the other terminal just prior to said signal transmission.

5. In a two-way signal transmission system having at the terminals thereof oppositely directed one-way repeating paths for the signals transmitted in opposite directions, means at each terminal responsive to outgoing signals in the transmitting path for causing an alternating control wave to be transmitted to the other terminal along with the signals, means at each terminal responsive to the control wave received from the other terminal for inserting a power reducing loss in the transmitting path at the first terminal in an amount dependent on the frequency of the received control wave and means for making the frequency of the control wave transmitted from each terminal a function of the amount of noise in the receiving path of the terminal in the absence of received control waves.

6. In a two-way signal transmission system having signal transmitting and signal receiving circuits at each terminal, means for measuring the amount of noise in the receiving circuit at a terminal of said system and means for automatically regulating the volume of transmitted signals in the transmitting circuit at the other terminal in accordance with the measured value of the noise in the first terminal just prior to the signal transmission.

7. In combination with a two-way signal transmission system having oppositely-directed one-way repeating paths at each terminal for the signals transmitted in opposite directions, each terminal comprising an anti-singing loss in the receiving path, a source of alternating control waves, means in the absence of signal transmission in either direction over the system, for automatically adjusting the value of said anti-singing loss and the frequency of the control waves generated by said source in accordance with the amount of noise in the receiving path at the terminal, control means responsive to the initiation of signals for transmission in the transmitting path to disable said receiving circuit, and to cause control waves from said source to be transmitted along with the signals to the other terminal, switching means selectively responsive to control waves received from the other terminal to adjust the gain of the transmitting circuit in accordance with their frequency, to remove said anti-singing loss from the receiving circuit and to disable the transmitting circuit and the means for controlling the transmission of control waves from the terminal, and means responsive to the signals initiated in said transmitting circuit in the absence of prior received control or signal waves in the receiving circuit to disable the selective switching means at the terminal.

8. In a two-way signal transmission system having at the terminals thereof oppositely directed one-way repeating paths for the signals transmitted in opposite directions, means at each terminal responsive to outgoing signals for caus-

ing an alternating control wave to be transmitted to the other terminal, control means at each terminal for automatically controlling the amount of loss in the receiving path and the frequency of the transmitted control wave in accordance with the amount of noise in the receiving path at the same terminal and other control means at each terminal for automatically regulating the gain of the transmitting path in accordance with the frequency of the control wave received from the other terminal whereby the transmitted signal volume at each terminal is a function of the amount of noise in the receiving path at the other terminal.

9. The system of claim 8 in which the first-mentioned means comprises a variable frequency control wave generator having a frequency determining circuit, and means responsive to the out-going signals for connecting said generator to the transmitting path at the terminal, said receiving circuit includes a variable gain amplifier having a biasing circuit, and the first-mentioned control means comprises a condenser connected to the frequency determining circuit of said generator and to the biasing circuit of said amplifier so that the frequency of the generated wave and the gain of said amplifier vary in accordance with the charge on said condenser and means for charging said condenser in accordance with the amount of noise in said receiving circuit.

10. The system of claim 8 in which said other control means at each terminal includes a variable gain amplifier in the transmitting path, having a biasing circuit including a condenser the charge of which determines the amplifier gain, and frequency integrating means responsive to the received control wave to vary the charge on said condenser in accordance with the received control wave frequency.

11. The system of claim 8, in which said other control means at each terminal comprises a condenser associated with the transmitting path thereat so that its charge determines the gain of said transmitting path, means for selecting the received control wave, and means responsive to the selected wave for charging said condenser in accordance with its frequency.

12. In a two-way signal transmission system having at the terminals thereof oppositely directed one-way repeating paths for the signals transmitted in opposite directions, means at each terminal responsive to outgoing signals for sending out to the other terminal a control wave of a frequency determined by the amount of noise in the receiving path at the other terminal, and means at each terminal responsive to the received control wave for varying the amount of power in outgoing signals in accordance with the frequency of the received control wave.

13. In a two-way signal transmission system, comprising transmitting and receiving circuits and associated echo suppressors at each terminal, means for automatically making the anti-singing loss in the receiving circuit at each terminal a function of the amount of noise in that circuit, the sensitivity of the echo suppressors at each terminal a function of the noise in both the transmitting circuit and receiving circuit at the terminal, and the transmitted signal power at each terminal a function of the amount of noise in the receiving circuit at the other terminal.

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