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2,173,816

TRANSMISSION SYSTEM

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2 Sheets-Sheet 1

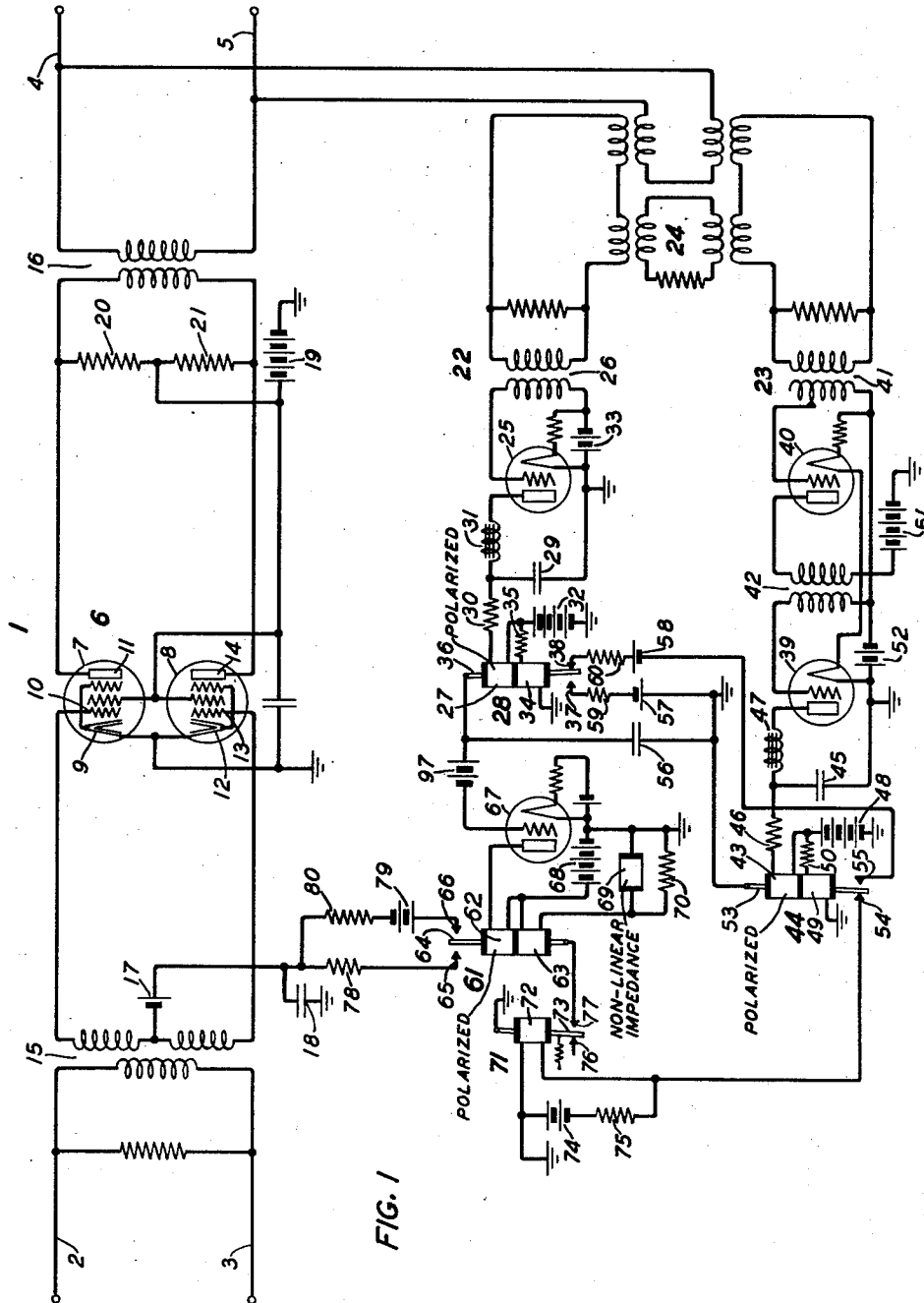


FIG. 1

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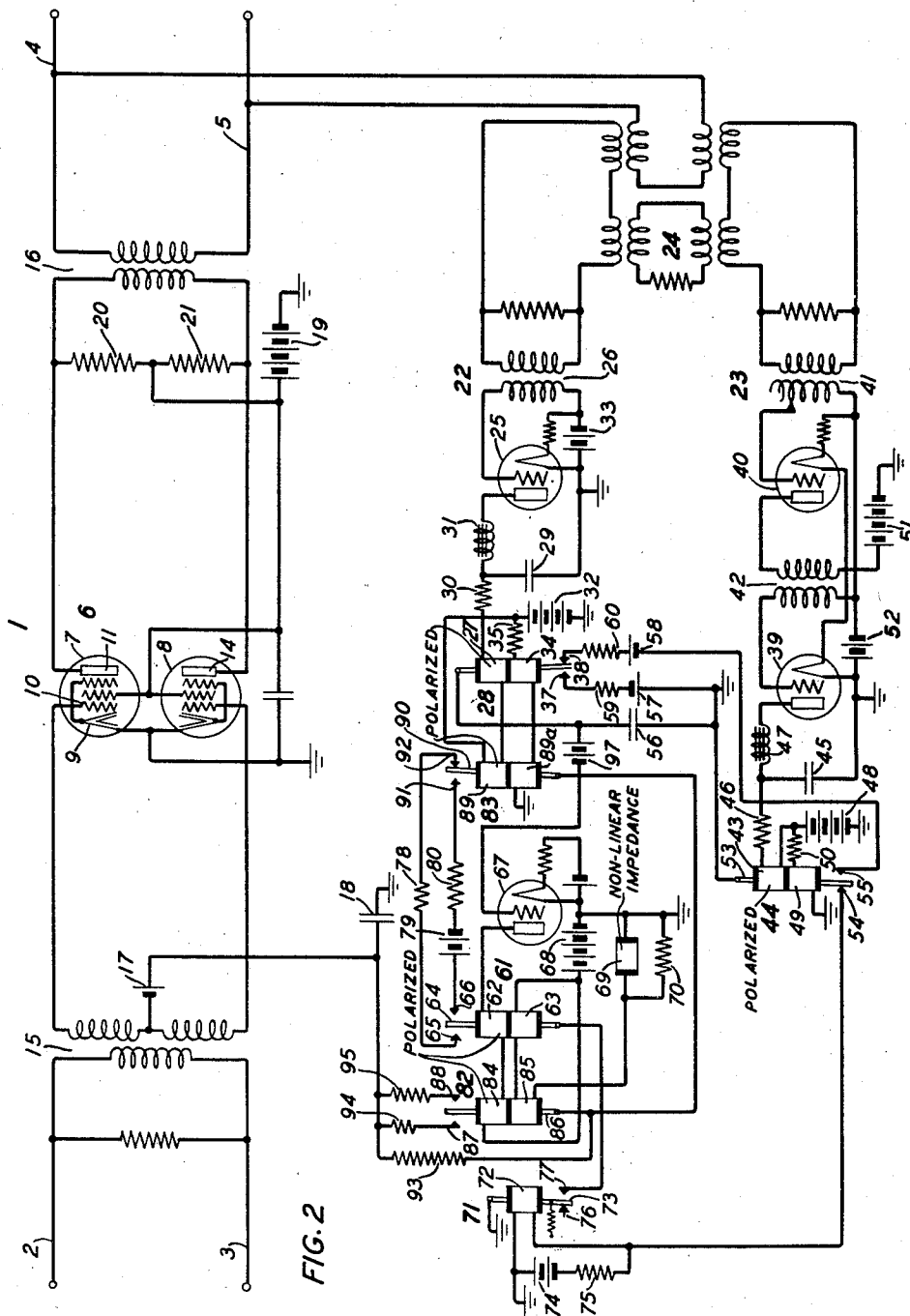
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TRANSMISSION SYSTEM

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2 Sheets-Sheet 2



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2,173,816

TRANSMISSION SYSTEM

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13 Claims. (Cl. 178—44)

This invention relates to signal transmission systems and particularly to volume control circuits for signal transmission systems.

One object of the invention is to provide a signal transmission line with a gain varying device therein that shall have control circuits for governing the gain varying device to maintain a predetermined average ratio of the times two different signal energy levels obtain on the transmission line beyond the gain varying device.

Another object of the invention is to provide a signal transmission line with a gain varying device and a balancing condenser that shall charge said balancing condenser with potentials of different polarity according to the durations of two signal energy levels on the line and that shall control the gain device according to the polarity of the charge on the condenser when charged above a predetermined level to maintain a predetermined average ratio of the times said energy levels obtain on the transmission line beyond the gain device.

A further object of the invention is to provide a signal transmission line having a gain varying device therein that shall control said gain varying device according to the duration of two different energy levels in the signals on said line, that shall increase the rate of gain change in case the two energy levels are exceeded a predetermined amount and that shall prevent operation of the gain varying device to increase the gain on the line when the energy on the line goes above the upper energy level.

It has been discovered empirically that when a speaker talks with constant volume two different energy levels are exceeded different per cents of time and that the ratio of the different per cents is approximately constant. It has also been discovered that the volume of a speaker may be measured within certain limits by determining the durations of two different energy levels in speech.

According to the present invention the above-mentioned empirically determined relation between two different energy levels of signals has been employed to measure the volume of signals and to control the volume of signals. Two different energy levels E_1 and E_2 in speech may be taken which are exceeded respectively t_1 and t_2 per cent of the time. A ratio t_1/t_2 which is approximately constant may be found which will give the desired signal volume.

In practicing the invention, a signal transmission line may be provided with a variable loss or gain device to control the loss or gain so that

two energy levels in speech E_1 and E_2 are exceeded only t_1 and t_2 per cents of the time. A balancing condenser is charged by potentials of opposite polarity under control of two detector circuits which are connected to the transmission line beyond the gain control device therein in any suitable manner, as by means of a hybrid coil. Each detector circuit comprises a marginal space discharge device which is preferably in the form of a three-element gas-filled tube. One of the marginal devices is set to operate or trigger off when the energy level E_1 is on the transmission line and the other marginal device is set to operate when an energy level E_2 is on the transmission line. Two relays are respectively operated by the two marginal devices. One of the relays, which is operated by the detector device when a level of E_1 obtains on the transmission line, completes a circuit for charging the balancing condenser by potential of one polarity from a battery through a resistance for example, of 50,000 ohms. The other relay which is operated by the other detector device when a level of E_2 obtains on the transmission line completes a circuit for charging the balancing condenser by potential of opposite polarity from a battery through a resistance for example, of 130,000 ohms.

The resistance elements which are included in the charging circuits for the balancing condenser are of such size that the condenser is charged at rates inversely proportional to the times the voltages E_1 and E_2 are exceeded. In the arrangement under consideration

Let

T_B = the operated time of the relay operated by voltage V_2 and

T_A = the operated time of the relay operated by voltage V_1 .

Assume 50,000 ohm resistance is r and 130,000 ohm resistance is R .

Then the relation between r and R is

$$\frac{R}{r} = \frac{T_B - T_A}{T_A}$$

and

$$\frac{T_B}{T_A} = \frac{r + R}{r} = 3.6$$

Thus, if the detector device operated by the voltage V_1 is operated 15 per cent of the time, the detector device operated by the voltage V_2 will be operated 54 per cent of the time.

When the charge on the balancing condenser is raised above a predetermined value by a charge

of either polarity a transfer relay is operated to change the charge on a control condenser. The control condenser governs the gain control device in the transmission line. If the balancing condenser is charged with one polarity under control of the relay operated by the high voltage V_1 then the transfer relay will be operated to impress a negative charge on the control condenser to increase the loss effected by the gain control device.

10 If the balancing condenser is charged above the predetermined value with opposite polarity under control of the relay operated by the lower voltage V_2 then the transfer relay will be operated to discharge a portion of the negative charge on the control condenser to decrease the loss effected by the gain control device.

In a modification of the invention, an adjusting relay is operated in series with the transfer relay. The adjusting relay is only operated when a much larger charge is on the balance condenser than the charge necessary to operate the transfer relay. The adjusting relay when operated increases the rate of change of the charge on the control condenser. A disabling relay is operated whenever the relay controlled by the higher voltage V_1 is operated. The disabling relay serves to prevent any change in the charge on the control condenser to increase the gain on the transmission line when the energy on the line goes above the value V_1 .

In the accompanying drawings:

Fig. 1 is a diagrammatic view of a transmission line provided with volume control circuits constructed in accordance with the invention.

Fig. 2 is a diagrammatic view of a modification of the circuits shown in Fig. 1.

Referring to Fig. 1 of the drawings, a signal transmission line 1 having input conductors 2 and 3 and output conductors 4 and 5, is provided with a variorepeater 6 in the form of two space discharge devices 7 and 8. The device 7 is shown in the form of a pentode and is provided with a cathode 9, a control grid 10 and an anode 11. The device 8 is in the form of a pentode having a cathode 12, a control grid 13 and an anode 14. The variorepeater 6 is effectively connected in series with the transmission line 1 and is connected to the input conductors 2 and 3 by a transformer 15. The variorepeater is connected to the output conductors 4 and 5 by means of a transformer 16. A fixed biasing potential for the grids 10 and 13 of the pentodes 7 and 8 is supplied by a battery 17. A variable biasing potential for the control grids of the pentodes 7 and 8 is supplied by a control condenser 18. The charge on the control condenser 18 is governed in a manner to be hereinafter set forth, for controlling the variorepeater 6 to govern the volume of the signals on the transmission line. A plate battery 19 is connected to the anodes of the devices 7 and 8 through resistance elements 20 and 21.

Two detector circuits 22 and 23 are connected to the output conductors 4 and 5 of the transmission line by means of a hybrid coil 24. The detector circuit 22 comprises a three-element gas-filled tube 25. The input circuit of the tube 25 is connected to the hybrid coil 24 by means of a transformer 26. The output circuit of the tube 25 is connected in series with a coil 27 of a polarized relay 28. A condenser 29 associated with a resistance element 30 and an inductance element 31 is provided to insure a hangover in the operation of the relay 28 by the tube 25. The hangover effected by the condenser resistance arrangement 31 is preferably of the order .02 of a second. A bat-

tery 32 is provided for supplying plate potential to the anode of the tube 25. A battery 33 is provided for supplying filament heating current and grid bias to the tube 25.

The relay 28 is provided with a biasing winding 34 which is connected through a resistance 35 to the battery 32. An armature 36 of the relay 28 which is operated by the coil 27 engages contact members 37 and 38. In the release position when the coil 27 of the polar relay is not energized, the armature 36 engages the contact member 38.

The detector circuit 23 comprises a three-element gas-filled tube 39 which is marginal in operation and an amplifier tube 40 of any suitable type. The input circuit of the amplifier 40 is connected by a transformer 41 to the hybrid coil 24. The output circuit of the tube 40 is connected by a transformer 42 to the input circuit of the detector tube 39. The output circuit of the detector tube 39 is connected in series with the operating winding 43 of a polarized relay 44. A condenser 45 associated with a resistance element 46 and an inductance element 47 is provided for insuring a hangover in the operation of the relay 44 by the detector 39. The hangover time is of the order of .02 of a second. A battery 48 is provided for supplying anode potential to the detector 39 and for energizing a biasing winding 49 of the relay 44. The biasing winding 49 is connected to the battery 48 in series with a resistance element 50. A battery 51 supplies anode potential to the amplifier tube 40. A battery 52 supplies filament heat current and grid biasing to the detector tube 39 and the amplifier tube 40.

The relay 44 is provided with an armature 53 which is adapted to engage contact members 54 and 55. When the operating coil 43 of the relay 44 is deenergized the armature 53 is held in engagement with the contact member 54. The relay 44 in combination with the relay 28, controls the charge impressed on a balancing condenser 56. Charges of opposite polarity are impressed on the balancing condenser 56 from batteries 57 and 58 through resistance elements 59 and 60. The batteries 57 and 58 are preferably of the same voltage and are of the order of $1\frac{1}{2}$ volts. The resistance elements 59 and 60 may be of the order of 50,000 ohms and 130,000 ohms respectively. With the relay 28 in release position, and the relay 44 in operative position, the balancing condenser 56 will be charged with potential from the battery 58 in circuit with the relatively large resistance 60. When the relay 28 is in operative position the balancing condenser 56 is charged from the battery 57 in circuit with the relatively small resistance 59.

The detector circuits 22 and 23 are operated when different energy levels of speech current are on the transmission line. The detector circuit 23 is assumed to be operated at a lower level for example, minus 12½ decibels and the detector 22 is assumed to be operated at a higher level, for example, plus 10 decibels. The difference in sensitivity therefore between the two detector circuits is 22.5 decibels.

A transfer relay 61 which is controlled by the balancing condenser 56 serves to control the charge on the control condenser 18. The transfer relay 61 comprises an operating winding 62, a biasing winding 63 and an armature 64 which is adapted to engage contact members 65 and 66. The operating winding 62 of the relay 61 is connected in the output circuit of an amplifier 67. The amplifier 67 is preferably in the form of a three-element space discharge device.

Biasing potential for the grid of the amplifier 67 is supplied by the battery 97 and the balancing condenser 56. A battery 68 is provided for supplying anode potential to the amplifier 67 and for energizing the neutralizing winding 63 of the relay 61. The circuit for the winding 63 extends from one terminal of the battery 68 through the winding 63 and two resistance elements 69 and 70 in parallel to the other terminal of the battery 68. The resistance element 69 has a non-linear coefficient of resistance and preferably is composed of silicon carbide crystals and a binder material. Resistance elements of this type are disclosed in the patent to K. B. McEachron 1,822,742, September 8, 1931.

Normally with no charge of either polarity on the balancing condenser 56 the effect of the operating winding 62 and the neutralizing winding 63 for the relay 61 are neutralized and the armature 64 is held midway between the contact members 65 and 66. When the relay 28 is operated by the detector circuit 22 the condenser 56 is charged with potential of negative polarity from the battery 57. When the negative charge on the balancing condenser 56 is raised to a predetermined point the negative bias of the grid of the amplifier tube 67 reduces the plate current flow through the winding 62 of the relay 61 to move the armature 64 into engagement with the contact member 66. When the relay 44 is operated by the detector circuit 23 and the relay 28 is in released position the balancing condenser 56 is charged with potential of positive polarity from the battery 58. Upon charging of the condenser 56 to a predetermined point by the battery 58 the positive potential bias on the grid of the amplifier device 67 increases the plate current flow through the winding 62 of the relay 61 to move the armature 64 into engagement with the contact member 65. If the charge on the balancing condenser 56 is initially zero the armature 36 of the relay 28 will have to be left on the contact member 37 a definite length of time, for example .06 of a second to allow the transfer relay 61 to move the armature 64 into engagement with the contact member 66. When the armature 64 engages the contact member 66 the gain on the transmission line 1 is reduced as will be explained hereinafter. If the charge on the balancing condenser 56 is zero and the armature 53 of the relay 44 is moved into engagement with the contact member 55 it will take a definite length of time, for example, .156 second before the transfer relay armature 64 can be moved into engagement with contact member 65. When the armature 64 of the transfer relay 61 is moved into engagement with the contact member 65 the gain on the transmission line 1 is raised as will be explained later.

A relay 71 comprising an operating coil 72 and an armature 73 is provided for insuring against change in the charge of the control condenser 18 except when speech currents are on the transmission line 1. The coil 72 of the relay 71 is normally short-circuited by the armature 53 of relay 44 and the armature 73 is held in engagement with the back contact member 76. Upon operation of relay 44 the coil 72 of relay 71 is energized from battery 74 and the armature 73 is moved to engage a contact member 77 for placing a ground on the armature 64 of the transfer relay 61. Normally a shunt circuit is maintained around the battery 74 and the resistance element 75 to insure the release of the relay 71. The shunt circuit around the battery 74 and the

resistance element 75 may be traced from one terminal of the resistance element 75 through contact member 54, armature 53 and ground to a terminal of the battery 74. Upon operation of the relay 44 the shunt connection around the battery 74 is opened so that the relay 71 is operated whenever the relay 44 is operated. The relay 44 is operated by the detector circuit 23 of higher sensitivity.

When the armature 64 of the transfer relay 61 is moved into engagement with contact member 65 the control condenser is discharged through a resistance 78. The circuit may be traced from one terminal of the control condenser 18 through the resistance element 78, contact member 65, armature 64, contact member 77, armature 73 and ground return to the other terminal of the control condenser. When the armature 64 is moved into engagement with the contact member 66 the control condenser 18 is charged with potential of negative polarity from a battery 79. The charging circuit for the control condenser may be traced from one terminal of the condenser 18 through a resistance element 80, battery 79, contact member 66, armature 64, contact member 77, armature 73 and ground return to the other terminal of the condenser 18. The size of the resistance elements 78 and 80 may be varied as desired. The rate of gain increase depends upon the value of the condenser 18 and the resistance 78. The rate of gain decrease depends upon the condenser 18, resistance element 80 and the battery 79.

Assume that a weak talker transmits speech current over the transmission line 1 with a low gain, under this circumstance, the relay 44 will be operated by the detector circuit 23 and the relay 28 will not be operated. After two or more syllables, depending upon the previous condition of the system and the input amplitude, the relay 61 will move the armature 64 into engagement with the contact member 65. When the relay 44 is operated the balancing condenser 56 is charged with potential of positive polarity from the battery 58. The circuit for charging the balancing condenser 56 may be traced from one terminal of the condenser through the armature 36 of the relay 28, contact member 38, resistance 60, battery 58, contact member 55 and armature 53 of the relay 44 to the other terminal of the condenser 56. The charge on the balancing condenser 56 impresses positive potential on the grid of the device 67 to increase the current flow through the device. This effects operation of the transfer relay 61 to move the armature 64 into engagement with the contact member 65. The negative charge on the control condenser 18 is reduced by a circuit including the resistance element 78. The relay 71 is operated at this time, inasmuch as this relay is operated whenever the relay 44 is operated. A reduction in the negative bias upon the control grids 10 and 13 of the pentodes 7 and 8 increases the gain upon the transmission line 1. It may be noted that the relay 71 which is operated only when the relay 44 is operated insures that change in the charge upon the control condenser 18 can only take place when speech currents are on the transmission line.

The circuits controlled by the relays 28 and 44 are timed so that when operated the balancing condenser 56 is charged with potential of opposite polarity and inversely proportional to the times of operation of the relays. The gain on the transmission line will be increased gradually

until the relay 28 is operated. The relay 28 is operated when the energy level on the detector circuit 22 is raised above the higher predetermined energy level. Upon operation of the relay 28 the charging circuit of the balancing condenser 56 from the battery 58 is broken and a circuit is completed from battery 57 for reducing the positive charge on the condenser 56. When the condenser 56 is charged with potential of negative polarity to the critical point negative bias is impressed on the grid of the device 67 to reduce the current flow through the winding 62 of the relay 61 sufficient to move the armature 64 into engagement with the contact member 66. At this time the relay 71 is in operation because the relay 44 is in operation. The relay 44 is always in operation when the relay 28 is operated. The control condenser 18 is charged with potential of negative polarity from the battery 79 through the resistance element 80. Increase in the negative charge on the control condenser 18 increases the negative bias on the grids 10 and 13 of the pentode tubes 7 and 8 to lower the gain on the transmission line 1.

If the talker is talking at substantially constant volume it is possible to select the time constants of the circuits so that the critical charge on the balancing condenser 56 is never exceeded. If a critical charge of positive or negative polarity is never exceeded on the balancing condenser 56 the transfer relay 61 will not be operated and no change will take place in the gain of the transmission line.

Referring to Fig. 2 of the drawings, a modification of the invention is shown for increasing the speed of gain changes under certain circumstances and for preventing over-compensation of gain changes under certain circumstances. The circuit shown in Fig. 2 is very similar to the circuit shown in Fig. 1 and like parts will be indicated by similar reference characters. A relay 82 is connected in series with the relay 61 and a relay 83 is connected in series with relay 28. The relay 82 comprises an operating winding 84 connected in series with the operating winding 62 of the relay 61. A neutralizing winding 85 connected in series with the neutralizing winding 63 and an armature 86 is adapted to engage contact members 87 and 88. The relay 83 comprises an operating winding 89 connected in series with the operating winding 27 of the relay 28, a neutralizing winding 89a in series with the neutralizing winding 34 and an armature 90 which engages contact members 91 and 92. The relay 83 is operated whenever the relay 28 is operated. The relay 82 is less sensitive than the relay 61 and is operated only when the charge on the balancing condenser 56 is above a second critical value. One critical value for the charge of either polarity on the balancing condenser 56 is necessary to operate the relay 61 and change the gain on the transmission line and a second higher critical value of the charge on the balancing condenser 56 is necessary to effect operation of the relay 82. The relay 82 changes the rate at which the gain is changed on the transmission line 1 under control of the transfer relay 61.

An additional resistance element 93 is connected in the charge and discharge circuit for the control condenser 18 and two resistance elements 94 and 95 are connected in shunt to the resistance element 93 under control of the relay 82. The armature 90 of the relay 83 is included in the charge and discharge circuit of the control condenser 18 and serves to prevent any in-

crease in the gain or reduction of the negative charge on the condenser 18 when the relay 28 is operated. In brief the relay 83 serves to prevent any increase in the gain on the transmission line when the detector circuit 22 is operated by the higher predetermined potential. The voltages of the batteries 57 and 58 in the balancing circuit are limited to a value just a little higher than that required to operate the relay 82. Otherwise when a talker requiring a large gain adjustment begins talking the balancing condenser 56 would receive excessive charge in one direction or another which could only be annulled when the gain had passed its correct value. A battery 97 is provided for impressing a fixed negative bias on the grid of the amplifier tube 67.

Assume the relay 28 and the relay 83 are operated under control of the detector circuit 22 and that energy level above the upper predetermined point is on the transmission line. The balancing condenser 56 is charged with potential of negative polarity above the first critical point. The relay 61 is then operated to move armature 64 into engagement with the contact member 66. The relay 82 is not operated at this time. The control condenser 18 is charged with potential of negative polarity by a circuit extending from one terminal of condenser 18 through the resistance element 93, armature 90 of the relay 83, contact member 91, resistance element 80, battery 79, contact member 66, armature 64 of the relay 61, contact member 77, armature 73 of the relay 71 and ground return to the other terminal of the condenser 18. If the charge of negative polarity on the balancing condenser 56 is raised above the second critical value the relay 82 is operated to move the armature 86 into engagement with the contact member 88. The resistance element 95 is now connected in shunt to the resistance element 93 to increase the rate at which the condenser 18 is charged. This increases the rate at which the gain is lowered on the transmission line.

If a weak talker is transmitting over the transmission line 1 the relay 44 will be operated by the detector circuit 23 and the relays 28 and 83 will not be operated. The armature 90 of the relay 83 is held in engagement with the contact member 92. Operation of the relay 44 charges the condenser 56 with potential of positive polarity from the battery 58. When the balancing condenser 56 is charged above the first critical point the relay 61 is operated to move the armature 64 into engagement with the contact member 66. A discharge circuit for the control condenser is then completed which may be traced from one terminal of the condenser 18 through the resistance element 93, armature 90 of the relay 83, contact member 92, resistance element 78, contact member 65, armature 64 of the relay 61, contact member 77, armature 73 of the relay 71 and ground return to the other terminal of the condenser 18. The condenser 18 has the negative charge thereon lowered to decrease the gain on the transmission line. If the charge on the balancing condenser 56 is raised to the second critical point under control of the relay 44 then the relay 82 is operated to move the armature 86 into engagement with the contact member 87. The resistance element 94 is now connected in shunt to the resistance element 93 for increasing the rate at which the gain is increased. The resistance elements 94 and 95 are made of different sizes. The resistance 95 may

be of the order of 1,000,000 ohms and the resistance 94 may be of the order of 50,000. The values of these resistance elements may be varied according to the rate at which gain changes are desired.

Modifications in the circuits and arrangement and location of parts may be made within the spirit and scope of the invention and such modifications are intended to be covered by the appended claims.

What is claimed is:

1. A signal transmission line having a gain varying device therein, a balancing condenser, means for charging said condenser with potentials of different polarity according to the respective durations of two different energy levels in the signals on said line, and means controlled according to the polarity of the charge on said condenser only when charged above a predetermined level for governing said device to maintain the signals on the line at substantially constant volume.

2. A signal transmission line having a gain varying device therein, a balancing condenser, backward acting control means connected to said line beyond said device, means for charging said condenser with potentials of different polarity according to the respective durations of two energy levels on said control means, and means controlled according to the polarity of the charge on said condenser only when charged above a predetermined level for governing said device to maintain a predetermined constant ratio of the times said energy levels obtain on said control means.

3. A signal transmission line having a gain varying device therein, a balancing condenser, means for charging said balancing condenser with potential of one polarity at a relatively fast rate when the energy on said line goes above a predetermined upper limit and for charging the balancing condenser with potential of opposite polarity at a relatively slow rate when the energy on said line is above a predetermined lower limit and below said upper limit, and means controlled according to the polarity of the charge on said condenser when charged above a predetermined level for governing said device to maintain the signals on said line at substantially constant volume.

4. A signal transmission line having a gain varying device therein, a balancing condenser, means for charging said balancing condenser with potential of one polarity at a relatively fast rate when the energy on said line goes above a predetermined upper limit and for charging the balancing condenser with potential of opposite polarity at a relatively slow rate when the energy on said line is above a predetermined lower limit and below said upper limit, control means governed according to the polarity of the charge on said condenser when charged above a predetermined level for governing said device to maintain the signals on said line at substantially constant volume, and means for preventing operation of said control means to govern said device when signals are off said line.

5. A signal transmission line having a gain varying device therein, a balancing condenser, means for charging said balancing condenser with potential of one polarity at a relatively fast rate when the energy on said line goes above a predetermined upper limit and for charging the balancing condenser with potential of opposite polarity at a relatively slow rate when the en-

ergy on said line is above a predetermined lower limit and below said upper limit, means comprising a control condenser for varying the gain effected by said device according to the charge thereon, means comprising a transfer relay for controlling the charge on said control condenser, means for operating said relay when the balancing condenser is charged above a predetermined value and according to the polarity of the charge on the balancing condenser to maintain constant signal volume on said line and means for preventing operation of said transfer relay to change the charge on the control condenser when signals are off said line.

6. In a voice operated gain adjusting device, a variorepeater in a transmission line, a control condenser for controlling the gain of the variorepeater according to the charge on the condenser, a balancing condenser, means for charging said balancing condenser with potential of one polarity when the energy level on said line beyond the variorepeater is above a predetermined upper level and for charging said balancing condenser with a potential of the opposite polarity when the energy level on said line beyond the variorepeater is above a predetermined lower level and below the predetermined upper level, and means comprising a transfer circuit for reducing the charge on the control condenser when the charge of one polarity on the balancing condenser is above a predetermined value and for increasing the charge on the control condenser when a charge of an opposite polarity on the balancing condenser is above a predetermined value.

7. A signal transmission line having a gain varying device therein, a balancing condenser, means for charging said balancing condenser with potential of one polarity at a relatively fast rate when the energy on said line goes above a predetermined upper limit and for charging the balancing condenser with potential of opposite polarity at a relatively slow rate when the energy on said line is above a predetermined lower limit and below said upper limit, means comprising a control condenser for varying the gain effected by said device according to the charge thereon, means comprising a transfer relay for controlling the charge on said control condenser, and means for operating said relay when the balancing condenser is charged above a predetermined value and according to the polarity of the charge on the balancing condenser to maintain substantially constant signal volume on said line.

8. A signal transmission line having a gain varying device therein, a balancing condenser, means for charging said balancing condenser with potential of one polarity at a relatively fast rate when the energy on said line goes above a predetermined upper limit and for charging the balancing condenser with potential of opposite polarity at a relatively slow rate when the energy on said line is above a predetermined lower limit and below said upper limit, means comprising a control condenser for varying the gain effected by said device according to the charge thereon, and means for varying the charge on the control condenser according to the polarity of the charge on the balancing condenser when the charge on the balancing condenser is above a predetermined point to maintain substantially constant volume on said line.

9. A signal transmission line having a variorepeater therein for maintaining substantially constant volume on the line, a gain increase relay, a gain decrease relay, means comprising a detec-

tor circuit for operating said gain decrease relay when the energy on the transmission line beyond said variorepeater is above a predetermined upper limit, means comprising a detector circuit for
 5 operating said gain increase relay when the energy on the transmission line beyond said variorepeater is above a predetermined lower limit, a balancing condenser, means controlled
 10 by said gain decrease relay when operated for charging said balancing relay with potential of one polarity at a relatively fast rate, means controlled by said gain increase relay when operated
 15 with the gain decrease relay in released position for charging said balancing condenser at a relatively slow rate with potential of an opposite polarity, a control condenser for governing said
 20 variorepeater according to the charge on the condenser, and means comprising a transfer relay controlled by said balancing condenser when charged above a predetermined point for varying
 the charge on the control condenser according to the polarity of the charge on the balancing condenser.

10. A signal transmission line having a gain
 25 varying device therein, a balancing condenser, means for charging said balancing condenser with potential of one polarity at one rate when the energy on said line goes above a predetermined
 30 upper limit and for charging the balancing condenser with potential of opposite polarity at a different rate when the energy on said line is above a predetermined lower limit and below said
 35 upper limit, control means governed according to the polarity of the charge on said condenser when charged above a predetermined level for governing said device to maintain the signals on
 40 said line at substantially constant volume, and means operative in case the charge on said condenser goes above a second predetermined limit for governing said control means to increase the
 rate of gain change effected by said device.

11. A signal transmission line having a gain
 45 varying device therein, a balancing condenser, means for charging said balancing condenser with potential of one polarity at one rate when the energy on said line goes above a predeter-

mined upper limit and for charging the balancing
 condenser with potential of opposite polarity at a
 different rate when the energy on said line is
 above a predetermined lower limit and below
 5 said upper limit, control means governed according to the polarity of the charge on said condenser
 when charged above a predetermined level for governing said device to control the volume of
 the signals on said line, and means operated when
 10 the energy on said line goes above said upper limit for governing said control means to prevent operation of said device to increase the gain on the
 line.

12. A signal transmission line having a gain
 15 varying device therein, a balancing condenser, means for charging said balancing condenser with potential of one polarity at one rate when the energy on said line goes above a predetermined
 20 upper limit and for charging the balancing condenser with potential of opposite polarity at a different rate when the energy on said line is above a predetermined lower limit and below said
 25 upper limit, control means governed according to the polarity of the charge on said condenser when charged above a predetermined level for governing said device to control the volume of
 the signals on said line, means operative in case
 30 the charge on said condenser goes above a second predetermined limit for governing said control means to increase the rate of gain change effected by said device and means operated when
 the energy on said line goes above said upper limit
 for governing said control means to prevent operation of said device to raise the gain on the
 35 line.

13. A signal transmission line having a gain
 40 varying device therein, two detector circuits connected to the line beyond said device and respectively operated by two different energy levels on the transmission line, and means controlled by
 45 said detector circuits for governing said device to hold the ratio between the durations of the two energy levels on the detector circuits approximately constant.

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