

March 18, 1941.

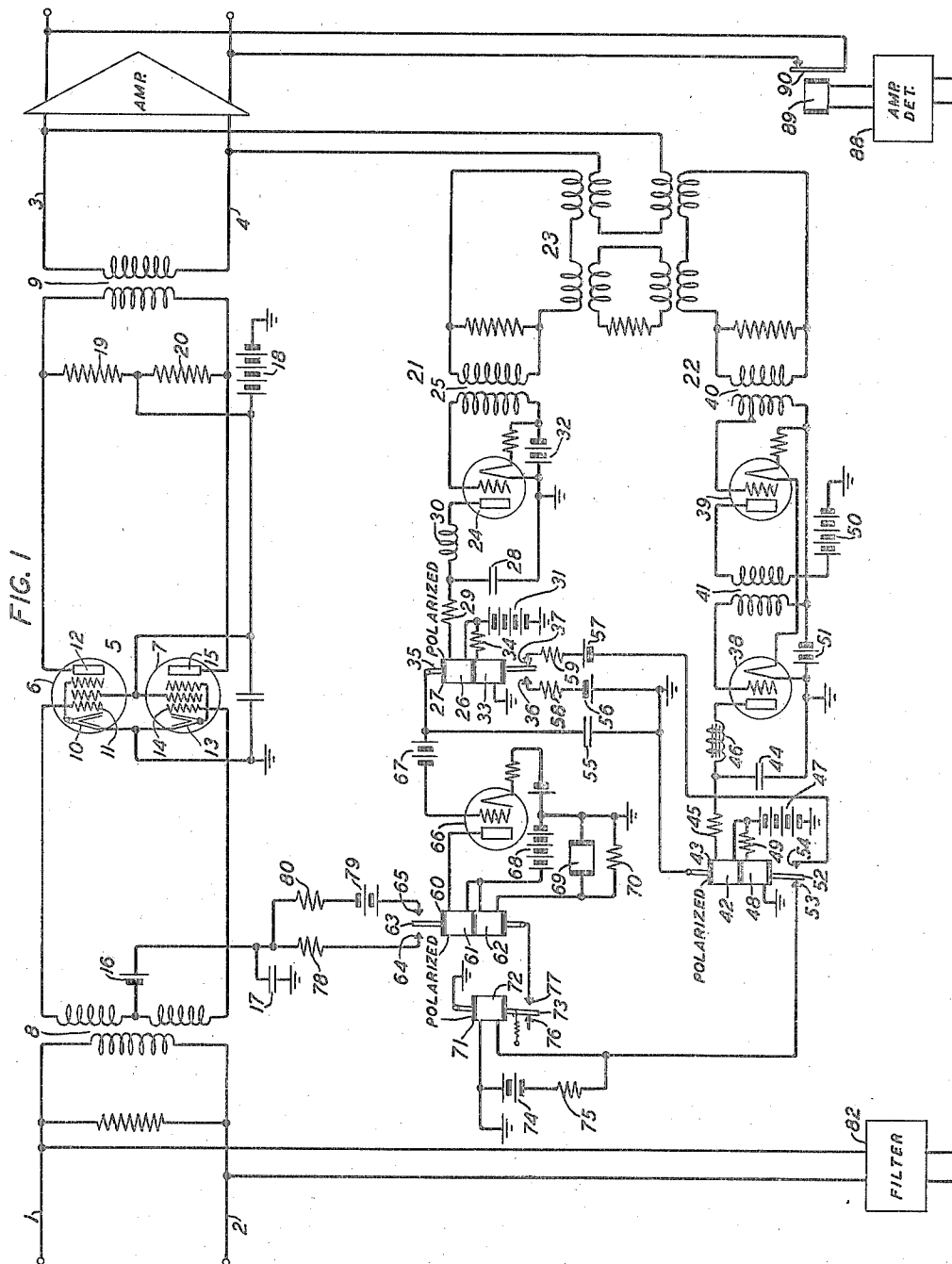
B. G. BJORNSON

2,235,007

SIGNAL TRANSMISSION SYSTEM

Filed Jan. 26, 1940

2 Sheets-Sheet 1



INVENTOR
B.G. BJORNSON
BY *Wayne B Wells*
ATTORNEY

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B. G. BJORNSON

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2 Sheets-Sheet 2

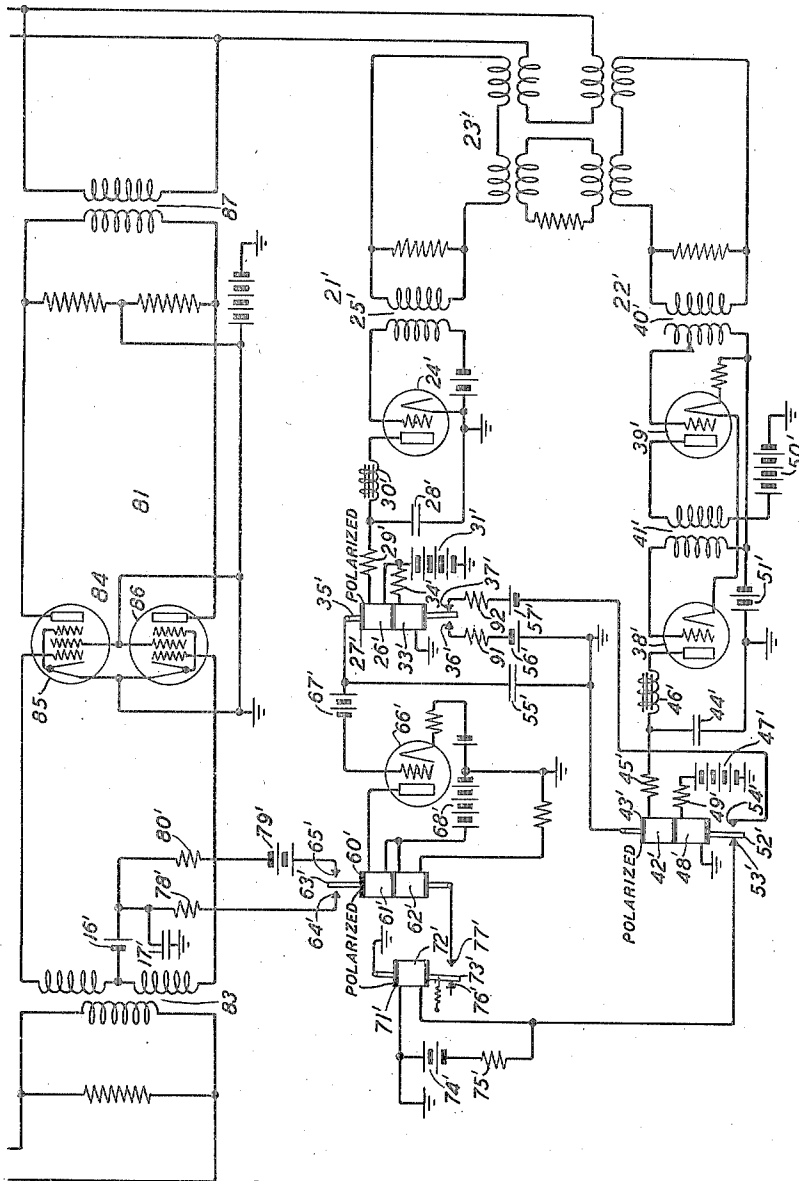


FIG. 2

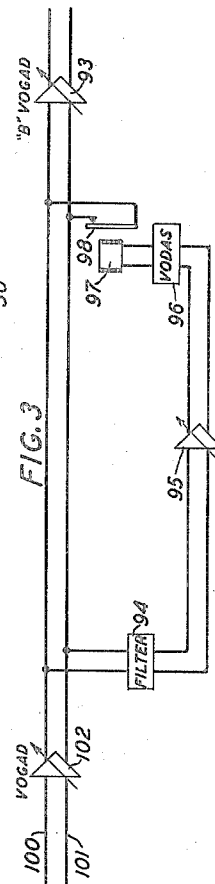


FIG. 3

INVENTOR
B.G. BJORNSON
BY
Wayne B Wells
ATTORNEY

UNITED STATES PATENT OFFICE

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SIGNAL TRANSMISSION SYSTEM

Bjorn G. Bjornson, New York, N. Y., assignor to
Bell Telephone Laboratories, Incorporated, New
York, N. Y., a corporation of New York

Application January 26, 1940, Serial No. 315,679

13 Claims. (Cl. 178—44)

This invention relates to signal transmission systems and particularly to signal transmission systems having switching circuits governed by the signal energy.

5 One object of the invention is to provide a signal transmission line with switching circuits that shall operate without signal clipping to control the line when signals are impressed on the line.

10 Another object of the invention is to provide a signal transmission line with control circuits to maintain constant volume on the line and switching circuits that shall operate without signal clipping to clear the line when signals are im-

15 A further object of the invention is to provide a signal transmission line having a gain control device therein with control circuits for governing the device to maintain constant volume on the line and with switching circuits operated by the signals on the line before said device without signal clipping to clear the line when signals are

20 In a signal transmission system provided with singing suppressor circuits the transmission path or line is provided with switching circuits for blocking the transmission line when no signals are impressed on the line and for removing the blocking means when signals are impressed on the transmission line. Under certain conditions a sudden change in the strength of the signals transmitted over the transmission line may cause the so-called clipping. In a signal system having a gain adjusting device on a transmission line operated to hold the signal volume constant, it is desirable to have a comparatively fast gain decrease in case of high amplitude signals to lessen the probability of overloading apparatus on the transmission line. If high amplitude signals are followed by low amplitude signals and the high amplitude signals are quickly reduced by the gain adjusting device then there is danger of signal clipping by the switching circuits which control the blocking of the transmission line.

45 According to the present invention, the signal currents which operate the switching circuits to clear a normally blocked transmission line are controlled to insure against any signal clipping. The signal currents which operate the switching circuits are adjusted to energy levels which insure against clipping.

50 In one form of the invention a gain varying device on a signal transmission line is controlled to maintain substantial constant volume in the manner disclosed in the patent to B. G. Bjornson 2,173,816, September 26, 1939. According to the

Bjornson Patent 2,173,816, it has been discovered 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. Moreover, the volume of a speaker may be measured within certain limits by determining the durations of two different energy levels in speech. 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.

15 In practicing the invention disclosed in the Bjornson Patent 2,173,816, the gain control device in the transmission line is governed so that the two energy levels in speech E_1 and E_2 are exceeded only t_1 and t_2 per cent of the time respectively. 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 20,000 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 160,000 ohms.

45 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 20,000 ohm resistance is r and 160,000 ohm resistance is R .

Then the relation between r and R is

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

and

$$\frac{T_B}{T_A} = \frac{r + R}{r} = 9$$

Thus, if the detector device operated by the voltage V_1 is operated 8 per cent of the time, the detector device operated by the voltage V_2 may be operated 72 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. 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.

The switching circuits employed to describe the invention comprise an amplifier detector connected to the transmission line before the gain varying device therein. The amplifier detector controls a relay which serves to block the transmission line beyond the gain varying device when no signals are on the transmission line. The signal currents which operate the amplifier detector are governed by auxiliary circuits similar to those shown in the Bjornson Patent No. 2,173,816 wherein the resistance elements r and R are changed to insure against any clipping of the signals on the transmission line by the relay operated by the amplifier detector. In one arrangement the resistance r is 60,000 ohms and the resistance R is 160,000 ohms. In this case the relation between T_A and T_B is

$$T_A = \frac{r + R}{r} = 3.66$$

In the arrangement under consideration for controlling the signal currents on the switching circuits the detector device operated by the voltage V_1 may be operated 20 per cent of the time and then the detector device operated by the voltage V_2 may be operated 73.2 per cent of the time. The lower amplitude signal currents will be raised so that control of the blocking relay can be effected at all times when signals are on the transmission line. In the example under consideration, the value of the resistance r was increased. A similar result could be effected by reducing the value of the resistance element R .

In the accompanying drawings,

Figs. 1 and 2 taken together with Fig. 1 above Fig. 2 disclose transmission circuits constructed in accordance with the invention; and

Fig. 3 is a diagrammatic view of a modification of the circuits shown in Figs. 1 and 2.

Referring to Fig. 1 of the drawings, a transmission line is connected to an attenuation con-

trol station by input conductors 1 and 2 and output conductors 3 and 4. A vario-repeater 5 in the form of two space discharge devices 6 and 7 is connected to the input conductors 1 and 2 by a transformer 8 and to the output conductors 3 and 4 by transformer 9. The device 6 is shown in the form of a pentode and is provided with a cathode 10, a control grid 11 and an anode 12. The device 7 is in the form of a pentode having a cathode 13, a control grid 14 and an anode 15. The vario-repeater 5 is effectively connected in series with the transmission line and is governed to control the gain so as to maintain substantially constant volume on the output conductors 3 and 4. A fixed minimum biasing potential for the grids 11 and 14 of the devices 6 and 7 is supplied by a battery 16. A variable biasing potential for the control grids 11 and 14 of the devices 6 and 7 is supplied by a control condenser 17. The charge on the control condenser 17 is governed in a manner to be hereinafter set forth for controlling the vario-repeater 5 to govern the volume of the signals on the transmission line. A battery 18 is connected to the anodes 12 and 15 of the devices 6 and 7 through resistance elements 19 and 20.

Two detector circuits 21 and 22 are connected to the output conductors 3 and 4 of the transmission line by a hybrid coil 23. The detector circuit 22 comprises a three-element gas-filled tube 24. The input circuit of the tube 24 is connected to the hybrid coil 23 by means of a transformer 25. The output circuit of the tube 25 is connected in series with a coil 26 of a polarized relay 27. A condenser 28 associated with a resistance element 29 and an inductance element 30 is provided to insure a hang-over in the operation of the relay 27 by the tube 24. The hang-over effected by the condenser resistance arrangement is preferably of the order of .02 second. A battery 31 is provided for supplying anode potential to the anode of the tube 24. A battery 32 is provided for supplying filament heating current and grid bias to the tube 24.

The relay 27 is provided with a biasing winding 33 which is connected through a resistance element 34 to the battery 31. An armature 35 of the relay 27 which is operated by the coil 26 engages contact members 36 and 37. In the released position of the relay 27 when the coil 26 is not energized the armature 35 engages the contact member 37.

The detector circuit 22 comprises a three-element gas-filled tube 38 which is marginal in operation and an amplifier 39 of any suitable type. The input circuit of the amplifier tube 39 is connected by a transformer 40 to the hybrid coil 23. The output circuit of the amplifier tube 39 is connected by transformer 41 to the input circuit of the detector tube 38. The output circuit of the detector tube 38 is connected in series with the operating winding 42 of a polarized relay 43. A condenser 44 associated with a resistance element 45 and an inductance element 46 is provided for insuring a hang-over in the operation of the relay 43 of the detector tube 38. The hang-over time in the operation of the relay 43 is of the order of .02 second. A battery 47 is provided for supplying anode potential to the detector tube 38 and for energizing a biasing winding 48 on the relay 43. The biasing winding 48 is connected to the battery 47 in series with a resistance element 49. A battery 75

50 supplies anode potential to the amplifier tube 39. A battery 51 supplies filament heating current and grid biasing potential to the detector tube 38 and the amplifier tube 39. The relay 43 is provided with an armature 52 which is adapted to engage contact members 53 and 54. When the operating coil 42 of the relay 43 is deenergized the armature 52 is held engaged with the contact member 53.

10 The relay 43 in combination with the relay 27 controls the charge impressed on a balancing condenser 55. Charges of opposite polarity are impressed on the balancing condenser 55 from batteries 56 and 57 through resistance elements 58 and 59. The batteries 56 and 57 are preferably of the same voltage and are of the order of one and one-half volts. The resistance elements 58 and 59 may be of the order of 20,000 ohms and 160,000 ohms, respectively. With the relay 27 in released position and the relay 43 in operated position the balancing condenser 55 will be charged with potential from the battery 57 in circuit with the relatively large resistance 59. When the relay 27 is in operated position the balancing condenser 55 is charged from the battery 56 in circuit with the relatively small resistance 58.

The detector circuits 21 and 22 are operated by different energy levels of speech currents on the transmission line. The detector circuit 22 is assumed to be operated at a lower level, for example, $-12\frac{1}{2}$ decibels and the detector circuit 21 is assumed to be operated at a higher level, for example, $+10$ decibels. The difference in sensitivity between the two detector circuits is 22.5 decibels.

A transfer relay 60, which is controlled by the balancing condenser 55, serves to control the charge on the control condenser 17. The transfer relay 60 comprises an operating winding 61, a biasing winding 62 and an armature 63 which is adapted to engage contact members 64 and 65. The operating winding 61 of the relay 60 is connected to the output circuit of an amplifier tube 66. The amplifier tube 66 is preferably in the form of a three-element space discharge device. Biasing potential for the grid of the amplifier tube 66 is supplied by a battery 67 and the balancing condenser 55. A battery 68 is provided for supplying anode potential to the amplifier tube 66 and for energizing the neutralizing winding 62 of the relay 60. The circuit for the winding 62 extends from one terminal of the battery 68 through the winding 62 and 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 or copper-oxide rectifier elements. 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 55 the effects of the operated winding 61 and the neutralizing winding 62 of the relay 60 are neutralized and the armature 63 is held midway between the contact members 64 and 65. When the relay 27 is operated by the detector circuit 21 the balancing condenser 55 is charged with potential of negative polarity from the battery 56. When the negative charge on the balancing condenser 55 is raised to a predetermined point the negative bias on the grid of the amplifier tube 66 reduces the plate current flow through the winding 61 of the relay 60

to move the armature 63 into engagement with the contact member 65. When the relay 43 is operated by the detector circuit 22 and the relay 27 is in released position, the balancing condenser 55 is charged with potential of positive polarity from the battery 57. Upon charging of the condenser 55 to a predetermined point by the battery 57, the positive potential bias on the grid of the amplifier 66 increases the plate current flow through the winding 61 of the relay 60 to move the armature 63 into engagement with the contact member 64. If the charge on the balancing condenser 55 is initially zero, the armature 63 of the relay 27 will have to be left on the contact member 36 a definite length of time, for example .06 second, to allow the transfer relay 60 to move the armature 63 into engagement with the contact member 65. When the armature 63 engages the contact member 65 the gain on the transmission line is reduced, as will be explained hereinafter.

If the charge on the balancing condenser 55 is zero and the armature 52 of the relay 43 is moved into engagement with the contact member 54, it will take a definite length of time, for example, .15 second, before the armature 63 of the transfer relay 60 may be moved into engagement with the contact member 64. When the armature 63 of the transfer relay 60 is moved into engagement with the contact member 64, the gain on the transmission line is raised, as will be explained hereinafter.

A relay 71 comprising an operating coil 72 and an armature 73 is provided for insuring against change in the charge on the control condenser 17 except when speech currents are on the transmission line. The coil 72 of the relay 71 is normally short-circuited by the armature 52 of the relay 43 and the armature 73 is held in engagement with a back contact member 76. Upon operation of the relay 43 the coil 72 of relay 71 is energized from a battery 74 and the armature 73 is moved into engagement with the contact member 77 for placing a ground on the armature 63 of the transfer relay 60. Normally a shunt circuit is maintained around the battery 74 and a 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 53, armature 52 and ground return to a terminal of the battery 74. Upon operation of the relay 43, the shunt connection around the battery 74 is opened so that the relay 71 is operated whenever the relay 43 is operated. The relay 43 is operated by the detector circuit 22 of higher sensitivity.

When the armature 63 of the transfer relay 60 is moved into engagement with contact member 64 the control condenser 17 is discharged through a resistance element 78. The discharge circuit for the control condenser may be traced from one terminal of the condenser 17 through the resistance element 78, contact member 64, armature 63, contact member 77, armature 73 and ground return to the other terminal of the condenser 17. When the armature 63 is moved into engagement with the contact member 65 the control condenser 17 is charged with potential of negative polarity from a battery 79. The charging circuit for the control condenser 17 may be traced from one terminal of the condenser 17 through a resistance element 80, battery 79, contact member 65, armature 63, contact member 77, armature 73 and ground return to the other terminal of the con-

denser 17. The sizes of the resistance elements 72 and 80 may be varied as desired. The rate of gain increase depends upon the value of the condenser 17 and the resistance 78. The rate of gain decrease depends upon the condenser 17, resistance element 80 and the battery 79.

Assume that a weak talker transmits speech current over the transmission line with a low volume. Under this circumstance, the relay 43 will be operated by the detector circuit 22 and the relay 27 will not be operated. After two or more syllables, depending on the previous condition of the system and the input amplitude, the relay 60 will move the armature 63 into engagement with the contact member 64. When the relay 43 is operated the balancing condenser 55 is charged with potential of positive polarity from the battery 57. The circuit for charging the balancing condenser 55 may be traced from one terminal of the condenser through the armature 35 of the relay 27, contact member 37, resistance element 59, battery 57, contact member 54 and armature 52 of the relay 43 to the other terminal of the balancing condenser 55. The charge on the balancing condenser 55 impresses positive potential on the grid of the amplifier device 66 to increase the current flow through the device. This effects operation of the transfer relay 60 to move the armature 63 into engagement with the contact member 64. The negative charge on the control condenser 17 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 43 is operated. A reduction in the negative bias on the control grids 11 and 14 of the tubes 6 and 7 increases the gain on the transmission line. It may be noted that the relay 71, which is operated only when the relay 43 is operated insures that change in the charge on the control condenser 17 can only take place when speech currents are on the transmission line.

The circuits controlled by the relays 27 and 43 are timed so that when operated the balancing condenser 55 is charged with potentials of opposite polarity and approximately inversely proportional to the durations of the operations of the relays. The gain on the transmission line will be increased gradually until the relay 27 is operated. The relay 27 is operated when the energy level on the detector circuit 21 is raised above the high predetermined level. Upon operation of the relay 27 the charging circuit of the balancing condenser 55 from the battery 57 is broken and a circuit is completed from the battery 56 for reducing the positive charge on the condenser 55. When the condenser 55 is charged with potential of negative polarity to the critical point, negative bias is impressed on the grid of the device 66 to reduce the current flow through the winding 61 of the relay 60 sufficiently to move the armature 63 into engagement with the contact member 65. At this time the relay 71 is in operation because the relay 43 is in operation. The relay 43 is always in operation when the relay 27 is operated. The control condenser 17 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 17 increases in negative bias on the grids 11 and 14 of the tubes 6 and 7 to lower the gain on the transmission line. If the talker is speaking at substantially constant volume it is possible to select the time constants of the circuit so that the critical charge on the balancing condenser 55 is never exceeded. If a

critical charge of positive and negative polarity is never exceeded on the balancing condenser 55, the relay 60 will not be operated and no change will take place in the gain on the transmission line.

Switching circuits 81, shown in Figs. 1 and 2, are connected between the input conductors 1 and 2 and the output conductors 3 and 4 for blocking the output conductors 3 and 4 whenever speech currents are off the transmission line and for removing the line blocking when speech currents are impressed on the transmission line. The switching circuits 81 comprise a filter 82 which selects suitable frequencies within the voice frequency range and a transformer 83 which connects the filter 82 to a vario-repeater 84 similar in construction to the vario-repeater 5 connected to the transmission line. The vario-repeater 84 comprises two space discharge devices 85 and 86 which are preferably in the form of pentodes. The devices 85 and 86 are controlled in a manner to be hereinafter set forth for governing the level of the speech currents employed to operate the switching circuits. The output circuits of the devices 85 and 86 are connected by a transformer 87 to an amplifier-detector 88. The amplifier-detector 88 is connected to a relay 89 which controls the blocking of the output conductors 3 and 4. The relay 89 is provided with an armature 90 which in released position places a short circuit across the conductors 3 and 4. The relay 89 is operated by currents supplied from the amplifier-detector 88 for operating the armature 90 to remove the blocking of the transmission line when speech currents are being transmitted.

At times it may happen that the speech currents on the transmission line may fall below amplitudes sufficient to effect operation of the relay 89 which controls the blocking of the transmission line. It has been customary heretofore to connect the switching circuits to the transmission line beyond the apparatus which maintains constant volume on the transmission line. The apparatus which maintains constant volume on the transmission line reduces high amplitudes rather quickly and raises low amplitudes slowly. Thus, if high amplitude signals are followed by low amplitude signals it is apparent that the switching circuits under such conditions may block the line while signals are still being impressed thereon. This will cause the so-called clipping of portions of the signals. Such conditions may also take place even if no volume control apparatus is employed.

In order to prevent any clipping of the signals by sudden changes in amplitudes of the signals being transmitted, the vario-repeater 84 is controlled by apparatus similar to the apparatus controlling the vario-repeater 5, to insure that the relay 89 will always be operated when signals are being impressed on the transmission line. The circuits operating the vario-repeater 84 are similar in construction and operation to the circuits operating the vario-repeater 5 and accordingly like parts have been indicated by similar reference characters with the addition of prime marks.

In the circuits shown in Fig. 1 of the drawings the resistance elements 58 and 59 have resistance values of 20,000 and 160,000 ohms, respectively. In the circuit shown in Fig. 2 of the drawings the resistance elements 58 and 59, shown in Fig. 1, have been replaced by resistance elements 91 and 92 which have resistance values of 60,000 ohms and 160,000 ohms, respectively. By changing the resistance values of the resistance elements in the

circuits controlled by the relay 27' it is possible to change the energy values of the control currents beyond the vario-repeater 84 which were supplied to the amplifier-detector 88 for operating the relay 89. A resistance value of 60,000 ohms for the resistance 88 is selected in place of the 20,000 ohms in order to effect elevation of the lower signal energies which are selected for operating the switching circuits 81. The circuits shown in Fig. 2 for operating the vario-repeater 84 are operated in exactly the same manner as the circuits shown in Fig. 1 for operating the vario-repeater 5. A detailed description of these circuits is deemed unnecessary. The detector circuits 21' and 22' shown in Fig. 2 of the drawings may be operated by the same energy levels of speech current as the detector circuits 21 and 22 shown in Fig. 1 of the drawings. The detector circuit 22' in Fig. 2 may be assumed to be operated at a lower level, for example, $-12\frac{1}{2}$ decibels, and the detector circuit 21' may be assumed to be operated at a higher level, for example, 10 decibels.

Referring to Fig. 3 of the drawings, a modification of the circuits shown in Figs. 1 and 2 is illustrated wherein two volume control arrangements are employed in combination with one set of switching circuits. A transmission line comprising conductors 100 and 101 is illustrated having two volume control arrangements 102 and 93 thereon. The volume control arrangements 102 and 93 may be similar to the volume control arrangements shown in Fig. 1 of the drawings. The volume control arrangement 102 may effect constant volume rather roughly whereas the volume control arrangement 93 effects substantially constant volume on the transmission line. The switching circuits which control the blocking of the transmission line when no signals are impressed thereupon comprise a filter 94, which is similar to the filter 82 shown in Fig. 1 of the drawings and which is connected to the transmission line beyond the volume control apparatus 102. The filter 94 is connected to gain adjusting apparatus 95 similar to the apparatus shown in Fig. 2 for controlling the energy of the signals supplied to the detector-amplifier 83 for operating the relay 89. The gain control apparatus 95 is connected to a detector-amplifier 96 which in turn is connected to a relay 97. The relay 97 operates an armature 98 for blocking the transmission line when no signals are impressed thereupon. The gain control apparatus 95 shown in Fig. 3 of the drawings serves to insure that no block on the transmission line will take place when signals are impressed thereon so that no clipping of speech syllables can take place.

Modifications in the circuits and in the 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. In combination a signal line, means controlled by the signals on the line to hold the signals at substantially constant volume, control means governed by signals on the line for clearing and blocking said line, and means controlled according to the energy levels of the signals on the line for selectively governing the energy level of the signals operating said control means to minimize clipping.

2. In combination a signal line, a gain varying device on said line, means controlled by the signals on the line for governing said device to main-

tain the volume of the signals on the line beyond said device substantially constant, normally operated blocking means on said line beyond said device, control means for removing said blocking means when signals are impressed on the line, and means governed by the signals on the line before said device for maintaining the energy of the signals operating said control means between levels to insure against clipping.

3. In combination a signal line, a gain varying device on said line, means controlled by the signals on the line for governing said device to maintain the volume of the signals on the line beyond said device substantially constant, normally operated blocking means on said line beyond said device, control means operated by signals on said line for removing the blocking means from the line, and means governed by two energy levels of the signals for maintaining the energy of the signal currents operating said control means at levels to minimize clipping.

4. In combination a signal line, a gain varying device on said line, means for controlling said device according to two different energy levels on said line to reduce the volume spread beyond the device and hold the signals at constant volume, means comprising an auxiliary circuit controlled by the signals on the line before said devices and connected to said line beyond the device therein for blocking the line when no signals are being transmitted and for removing the blocking means when signals are being transmitted, and means on said auxiliary circuit controlled by the line signals for reducing the necessary sensitivity spread of the control currents on the auxiliary circuit to minimize clipping.

5. In combination a signal line, a gain varying device on said line, means controlled by the signals on the line for governing said device to maintain constant volume on the line beyond said device, control means governed by the signals on said line before said device for blocking the line beyond said device when no signals are on the line and for insuring the free transmission of signals when signals are impressed on the line, and means for governing the signal currents employed to operate the control means to insure a small sensitivity spread so as to prevent clipping.

6. In combination a signal line, a gain varying device on said line, means for controlling said device according to two different energy levels on said line to maintain constant volume on the line beyond said device, control means for blocking said line when no signals are on the line and for effecting free transmission of signals when signals are impressed on the line, and means governed according to two energy levels of the signals on the line for adjusting the strength of the signal currents governing the control means to prevent clipping when signals are on the line.

7. In combination a signal line, a gain varying device on said line, means controlled by the signals on the line for controlling said device to maintain constant volume on the line, control means for blocking the line when free from signals and for removing the blocking on the line when signals are on the line, means controlled by two energy levels of the signals on the line for holding the energy level of the signals operating said control means between two levels to prevent clipping.

8. In combination a signal line, a gain varying device on said line, means controlled according to two energy levels of the signals on the line beyond said device for governing the device to

- maintain constant volume on the line beyond said device, control means operated by line signals for blocking said line beyond said device when the line is free from signals and for removing the line blocking when signals are on the line, and means controlled by the signals on the line before said device for holding the signal currents operating said control means between levels to minimize clipping of the signals.
- 5 9. In combination a signal line, a gain varying device on said line, means controlled according to two energy levels of the signals on the line beyond said device for governing the device to maintain constant volume beyond said device,
- 10 15 control means operated by line signals for blocking said line beyond said device when the line is free from signals and for removing the line blocking when signals are on the line, and means controlled by two energy levels of the signals on the line before said device for governing the energy level of the signal currents operating said control means to minimize clipping of the signals on the line.
- 10 25 10. In combination a signal line, two gain adjusting devices on said line, means controlled by the signals on the line for controlling the first device to maintain roughly constant volume on the line beyond the first device, means controlled by the signals on the line for controlling the second device to maintain constant volume on the line beyond the second device, blocking means on the line between said devices for blocking the line when no signals are on the line, control means operated by signals on the line between said devices for removing the line blocking when signals are on the line, and means controlled by two energy levels of the signals on the line between said devices for governing the energy level of the signal currents operating said control means to minimize clipping of the signals on the line.
- 15 30 11. In combination a signal line, two gain adjusting devices on said line, means controlled by the signals on the line for controlling the first device to maintain roughly constant volume on the line beyond the first device, means controlled by the signals on the line for controlling the second device to maintain constant volume on the line beyond the second device, blocking means on the line between said devices for blocking the line when no signals are on the line, control means operated by signals on the line between said devices for removing the line blocking when signals are on the line, and means controlled by two energy levels of the signals on the line between said devices for governing the energy level of the signal currents operating said control means to minimize clipping of the signals on the line.
- 20 25 12. In combination a signal line, control means governed by signals on the line for blocking said line when no signals are on the line and for removing the blocking when signals are on the line, and means governed by the energy levels of the signals on the line for selectively controlling the energy level of the signals operating said control means to minimize signal clipping.
- 30 35 13. In combination a signal line, control means governed by signals on the line for clearing and blocking the line, and means governed by the energy levels of the signals on the line for selectively controlling the energy level of the signals operating said control means to minimize signal clipping.

BJORN G. BJORNSEN.