May 23, 1939.

L. G. ABRAHAM

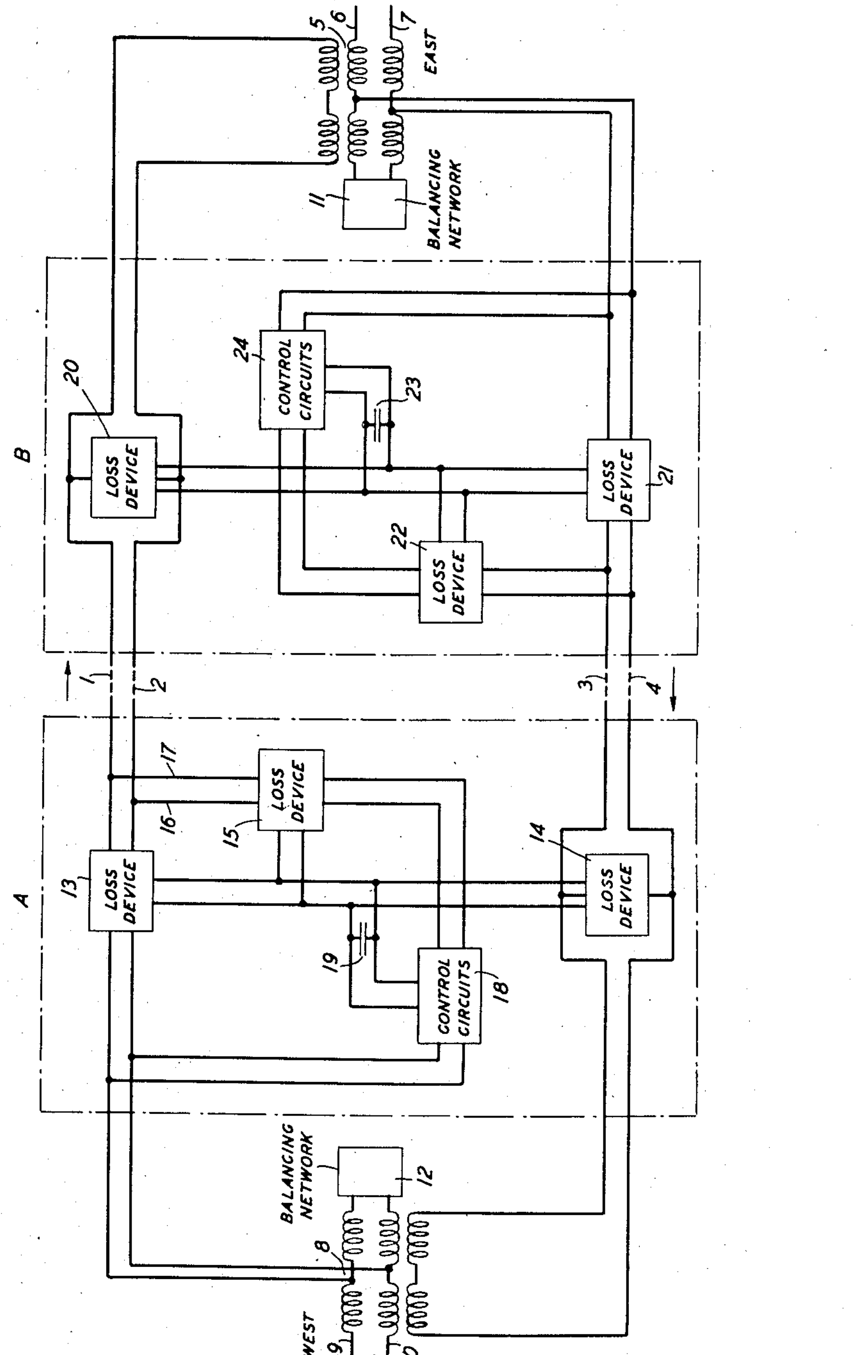
2,158,993

SIGNAL TRANSMISSION SYSTEM

Filed July 9, 1937

2 Sheets-Sheet 1

FIG. 1

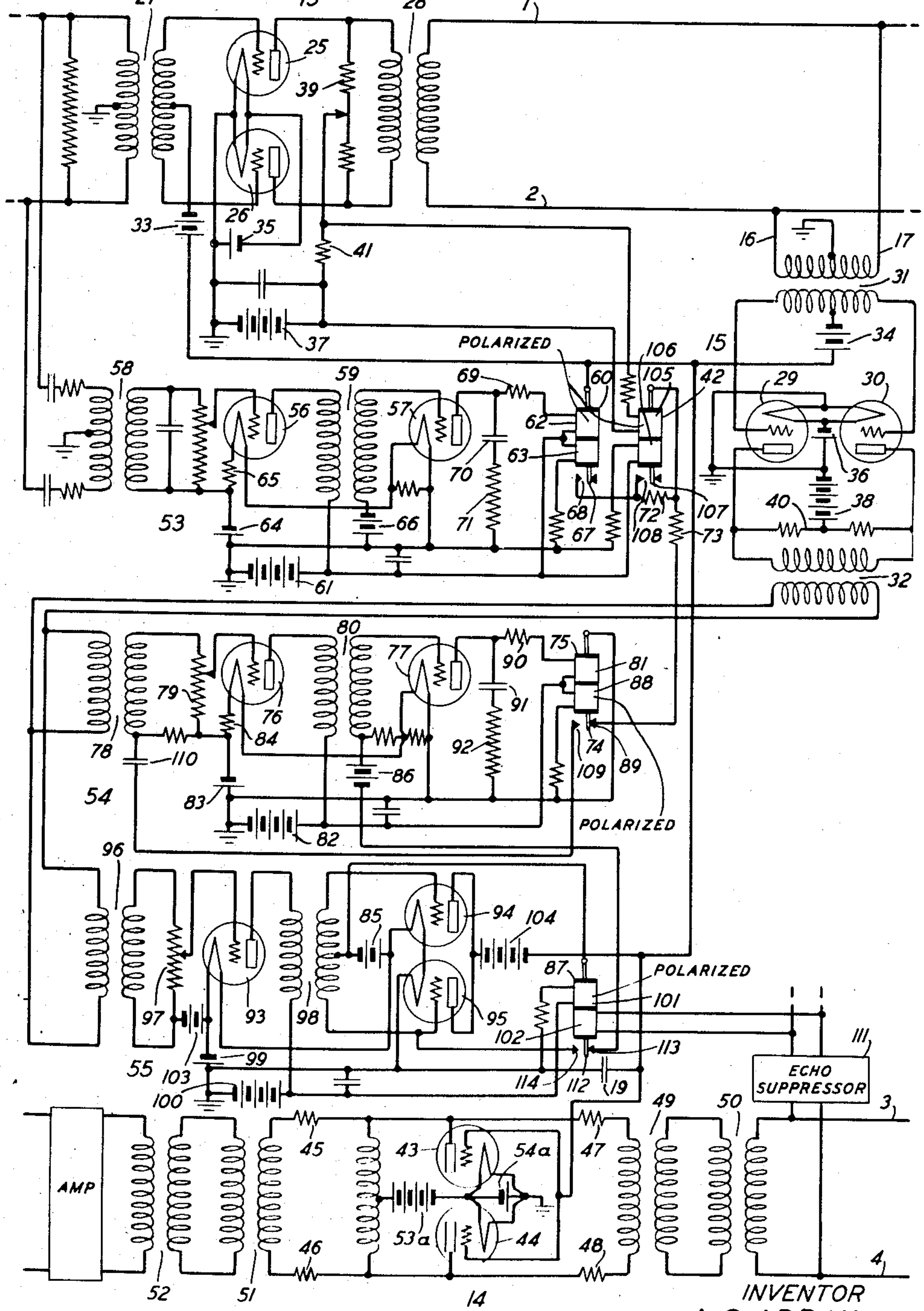


INVENTOR
L. G. ABRAHAM
BY Wayne B Wells
ATTORNEY

SIGNAL TRANSMISSION SYSTEM

Filed July 9, 1937 2 Sheets-Sheet 2

FIG. 2



INVENTOR
L. G. ABRAHAM
BY Wayne B Wells
ATTORNEY

Patented May 23, 1939

2,158,993

UNITED STATES PATENT OFFICE

2,158,993

SIGNAL TRANSMISSION SYSTEM

Leonard G. Abraham, Madison, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application July 9, 1937, Serial No. 152,701

12 Claims. (Cl. 179—170)

This invention relates to signal transmission systems and particularly to circuits for controlling the volume range of signals on signal transmission systems.

One object of the invention is to provide a four-wire signal transmission system that shall reduce by one-half the volume range of the signal transmitted from a station.

Another object of the invention is to provide a station on a four-wire signal transmission system having a loss controlling device in the transmitting and receiving paths that shall control the loss devices to reduce the volume range on the transmission path by a fixed amount and extend the volume range of the signals on the receiving path by a fixed amount.

A further object of the invention is to provide a four-wire signal transmission system that shall control the volume range of the signals at the terminal stations to reduce the volume range of the transmitted signals one-half and double the volume range of the received signals.

In long transmission systems it is very often desirable to reduce the volume range of the transmitted signals in order to permit increasing the gain so that the noise level may be safely overridden. In this manner a satisfactory noise-to-signal ratio may be obtained. In four-wire transmission systems it is also necessary to insure against singing action.

In a four-wire transmission system constructed in accordance with the invention, the transmitted signals have the range thereof reduced at a terminal station a fixed per cent which is preferably fifty per cent. At the same time the volume range of the signals received at the station is extended the same fixed amount. In a specific example, the volume range of the signals transmitted from a terminal station is reduced one-half whereas the volume range of the signals received at the terminal station is doubled. This operation takes place at both terminal stations so that the over-all net loss for the complete circuit is held constant and the so-called singing action is prevented. Moreover, the system permits the talker at each station to have partial control of the volume of the speech currents transmitted to the distant station and allows higher volumes of signals to be received when higher volumes are applied.

The invention has been illustrated by means of a four-wire circuit having a separate pair of conductors for transmission in opposite directions. At a terminal station a loss device of any suitable type is connected effectively in series with the conductors transmitting signals to the distant station. A second loss device similar to the first-mentioned loss device is effectively connected across the conductors transmitting signals from the distant station. A third loss device which is similar to the above-mentioned loss devices is connected effectively in series with a branch circuit joined to the conductors transmitting signals to the distant station at a point beyond the first-mentioned loss device therein. Preferably the loss devices are of the thermionic type which are controlled according to the negative bias impressed on the grids thereof. The negative bias impressed on the grids of the three loss devices is controlled according to the charge on a control condenser. A gain increase disabler circuit and a gain decreaser circuit are connected to the branch line beyond the loss device therein and a gain increaser circuit is connected to the conductors transmitting signals to the distant station at a point before the loss device therein.

The gain increaser circuit tends to increase the gain at the commencement of communication when the energy level of signals on the conductors transmitting signals to the distant station before the loss device therein exceeds a predetermined level which corresponds to the average peaks of the weakest talkers. The gain increaser disabler circuit nullifies the action of the gain increaser circuit when the signals on the branch line beyond the loss device therein are above a predetermined lower limit. The gain decreaser circuit serves to prevent the signals on the branch line beyond the loss device therein from going above a predetermined upper limit of value.

The gain increaser circuit consists essentially of a detector controlling a relay and a circuit controlled by the relay for discharging the control condenser to lower the negative bias on the grids of the three loss devices. The control condenser is discharged through resistance elements at a relatively slow rate. The relay which completes the circuit for discharging the condenser is quick-acting and slow-releasing. The release of the relay is comparatively slow in order to permit a commensurable discharge of the control condenser for each operation of the relay. The function of the gain increaser circuit is to prepare a circuit for discharging the control condenser to increase the gain if the incoming signals are above a predetermined value. Whether or not the gain is incerased depends on the operative portion of the gain increaser disabler circuit which is controlled by the volume of the signals on the branch circuit beyond the loss device therein.

The gain increaser disabler circuit consists essentially of a detector which controls a relay in the discharge circuit for the control condenser. The relay in the gain increaser disabler circuit normally closes contact members in the control condenser discharge circuit. When this relay is operated, the discharge circuit for the control condenser is opened and no increase in gain can be effected regardless of the operation of the gain increaser circuit. The relay in the gain increaser disabler circuit is quick-acting and slow-releasing. The relay in the gain increaser disabler circuit is also controlled by the echo suppressor circuits to prevent change in the gain when the receiving circuit is in operation.

The gain decreaser circuit comprises a highly biased detector whose output circuit is connected across the control condenser. Whenever the volume on the branch circuit beyond the loss device therein exceeds a predetermined upper limit, the bias on the detector is overcome to charge the control condenser. The charging of the control condenser is effected at a relatively rapid rate as compared to the discharge thereof by the gain increaser circuit.

In the system employed to describe the invention constant volume is obtained on the branch circuit beyond the loss device therein. The volume range on the conductors transmitting signals to the distant station at a point beyond the loss device therein is reduced one-half with respect to the volume range before the loss device. The volume range on the receiving conductors beyond the loss device therein is doubled as compared with the volume range before the loss device. The amount of contraction of the volume range on the transmitting conductors and the amount of expansion of the volume range on the receiving conductors may be varied by varying the number of the loss devices in the transmitting conductors and the branch circuit. If two loss devices were placed in the branch circuit and one loss device were placed in the transmission conductors, the volume range would be contracted one-third on the transmission conductors and the volume range would be three times larger on the receiving conductors. If two loss devices were placed in the transmission conductors and one loss device were placed in the branch circuit, the volume range on the transmission conductors would be two-thirds the original volume range and the volume range on the receiving conductors beyond the loss device would be three-halves the received volume range.

The invention has been illustrated by means of similar stations at opposite ends of a four-wire system. In such a system, like reduction and extension of the volume range of the signals is effected by the stations at opposite ends of the four-wire system. If so desired, the reduction in the volume range effected by the stations at opposite ends of the four-wire system may differ. Moreover, if so desired the volume may be maintained constant at one of the stations. In any of the above cases there will be no tendency to sing because the complete system is maintained balanced at all times.

In the accompanying drawings:

Fig. 1 is a diagrammatic view of a volume control system constructed in accordance with the invention.

Fig. 2 is a diagrammatic view of one of the terminal stations shown in Fig. 1.

Referring to Fig. 1 of the drawings, a four-wire system comprising west-to-east conductors 1 and 2 and east-to-west conductors 3 and 4 is shown connected by a hybrid coil 5 to a two-wire system comprising conductors 6 and 7 and by a hybrid coil 8 to a two-wire system comprising conductors 9 and 10. A balancing network 11 is associated with the hybrid coil 5 and a balancing network 12 is associated with the hybrid coil 8. Two terminal stations A and B are connected to the four-wire system. The station A located at the west end of the four-wire system comprises a loss device 13 effectively connected in series with the conductors 1 and 2 and a loss device 14 connected across the east-to-west conductors 3 and 4. A third loss device 15 which is similar to the loss devices 13 and 14 is connected effectively in series with a branch circuit comprising conductors 16 and 17.

The branch circuit beyond the loss device 15 is connected to control circuits 18 which control the charge on a control condenser 19. The charge on the control condenser 19 governs the loss devices 13, 14 and 15. The loss devices 13 and 15 are so controlled by the charge on the condenser 19 that constant volume range is held on the branch circuit beyond the loss device 15 therein. The volume range on the conductors 1 and 2 beyond the loss device 13 is held at one-half the volume range of the signals on the west-to-east circuit before the loss device 13. The charge on the condenser 19 also serves to control the loss device 14 connected across conductors 3 and 4 to double the volume range of the signals received over the conductors 3 and 4. The control circuits 18 are not only controlled by the branch circuit, but are also controlled according to the volume range of the signals on the west-to-east circuit before the loss device 13. The control circuits 18 govern the charge on the condenser 19 to insure against any operation or change in the loss devices until the average level of the volume on the west-to-east circuit before the loss device 13 is above a predetermined level corresponding to the average peaks of the weakest talkers.

The station B at the east end of the four-wire circuit is provided with loss devices 20, 21 and 22 which respectively correspond to the loss devices 13, 14 and 15 at station A. The loss devices 20, 21 and 22 are governed by a control condenser 23 and control circuits 24. The condenser 23 corresponds to the control condenser 19 at station A and the control circuits 24 correspond to the control circuits 18 at station A.

At station A the volume range of the signals transmitted over the transmission conductors 1 and 2 is reduced one-half and the volume range of the signals received over the conductors 3 and 4 is doubled. At station B the volume range of the signals transmitted over the conductors 3 and 4 is reduced one-half and the volume range of the signals received over the conductors 1 and 2 is doubled. By such means it is apparent that the average loss over the complete four-wire circuit is held constant and there is no tendency to produce a singing action. In Fig. 1 of the drawings no amplifiers have been shown in order to simplify the system. It is to be understood that any suitable amplifiers may be employed with the loss devices shown.

Referring to Fig. 2 of the drawings a detailed showing is made of the terminal station A on the four-wire system shown in Fig. 1. It is of course understood that the terminal station B is similar in construction and operation to station A. The loss device 13 comprises two space discharge devices 25 and 26 which are effectively connected in series with the transmission conductors 1 and 2 connected to station A. The space discharge devices 25 and 26 are shown as three-element devices connected in push-pull relation. A transformer 27 is connected to the input circuit and a transformer 28 is connected to the output circuit.

The loss device 15 which is connected in the branch circuit comprises two space discharge devices 29 and 30. The devices 29 and 30 are connected in push-pull relationship. A transformer 31 is connected to the input circuit of the devices 29 and 30 and a transformer 32 is connected to the output circuit of the devices 29 and 30. A battery 33 is provided for impressing negative bias on the grids of the devices 25 and 26 and battery 34 is provided for impressing negative bias on the grids of the devices 29 and 30. A battery 35 is provided for heating the filaments of the devices 25 and 26 and a battery 36 is provided for heating the filaments of the devices 29 and 30. A battery 37 supplies a plate current to the devices 25 and 26 and a battery 38 supplies plate current to the devices 29 and 30. A divided impedance means 39 is connected across the primary winding of the transformer 28 and a divided impedance means 40 is connected across the primary winding of a transformer 32. A resistance 41 in the plate circuit of the devices 25 and 26 is provided for controlling the operation of a gain rate relay 42 in a manner to be later set forth.

The loss device 14 comprises two space discharge devices 43 and 44 of the three-element type which are connected across the receiving conductors at the station A. The space discharge devices 43 and 44 are connected across the receiving channel between resistance elements 45, 46, 47 and 48. Two transformers 49 and 50 are provided in the receiving channel before the loss device 14. Two transformers 51 and 52 are provided in the receiving channel beyond the loss device 14. A battery 53*a* is provided for supplying plate current to the devices 43 and 44. A battery 54*a* is provided for heating the filaments of the devices. The bias on the grids of the devices 43 and 44 is controlled according to the charge on the control condenser 19.

The charge on the condenser 19 is controlled by a gain increaser circuit 53, a gain increase disabler circuit 54 and a gain decreaser circuit 55. The gain increaser circuit serves to complete a circuit for discharging the condenser 19 to lower the negative bias impressed on the grids of the devices 25, 26, 29, 30, 43 and 44. The gain increase disabler circuit 54 when operated, serves to render the gain increaser circuit inactive. The gain decreaser circuit 55 serves, when operated, to increase the charge on the condenser 19 and therefore to increase the negative bias impressed on the grids of the space discharge devices in the loss devices 13, 15 and 14.

The gain increaser circuit 53 is connected to the transmitting channel at a point before the loss device 13 and it is operated when the average value of the signal peaks is above that of the weakest talkers. The gain increaser circuit comprises an amplifier space discharge device 56 of the three-element type and a three-element gas-filled detector tube 57. The input circuit of the amplifier 56 is connected to the transmitting conductors by means of a transformer 58. Capacity and resistance elements are preferably connected to the windings of the transformer 58 for tuning the circuit to audio frequency currents. The output circuit of the amplifier 56 is connected by a transformer 59 to the input circuit of the gas-filled tube 57. The gas-filled tube 57 is filled with an inert gas or vapor and operates as a marginal device to effect operation of a relay 60 when the level of the signals from the transmission conductors before the loss device 13 is above that of the weakest talkers. A battery 61 is provided for supplying plate potential to the amplifier 56 and the gas-filled tube 57. The battery 61 also supplies current for energizing the two windings 62 and 63 of the relay 60. A battery 64 is provided for heating the filaments of the amplifier 56 and the gas-filled tube 57. Biasing potential for the grid of the amplifier tube 56 is provided by the drop across a resistance element 65. A battery 66 supplies biasing potential for the grid of the gas-filled tube 57.

The winding 63 of the relay 60 is connected across the battery 61 for biasing the armature 67 of the relay 60 away from contact member 68 and to the position shown in Fig. 2 of the drawings. The winding 62 of the relay 60 is connected across the battery 61 in circuit with a resistance element 69 and the gas-filled tube 57. Accordingly the winding 62 of the relay 60 which moves the armature 67 into engagement with the contact member 68 is controlled in accordance with the impedance of the gas-filled tube 57. The gas-filled tube 57 is marginal in operation and triggers off when predetermined peaks of energy are impressed on the transmitting conductors. A hangover circuit comprising a condenser 70 and a resistance element 71 is connected across the gas-filled tube 57 in order to provide a hangover in the operation of the relay 60 by the gas-filled tube. The condenser 70 is charged from the battery 61 by the circuit including the winding 62. Upon operation of the gas-filled tube 57 the condenser 70 is discharged through the space discharge path provided by the tube. When the impedance of the gas-filled tube is raised and current flow therethrough is stopped the relay 60 is not immediately released but a hangover in the operation thereof is provided according to the time required to charge the condenser 70. Relay 60, when operated, completes a circuit for discharging the control condenser 19. The circuit completed by the relay 60 may be traced from one terminal of the control condenser 19 through the armature 67 of the relay 60, contact member 68, resistance elements 72 and 73, armature 74 over relay 75 and ground return to the other terminal of the control condenser 19.

The gain increase disabler circuit 54 comprises a three-element space discharge amplifier 76, a gas-filled tube 77 which is preferably of the three-element type and a relay 75. The amplifier 76 is connected to the branch circuit at a point beyond the loss device 15 therein by means of a transformer 78. A potentiometer 79 is provided in the input circuit of the amplifier 76 for adjusting the operation of a gain increase disabler circuit 54. The output circuit of amplifier 76 is connected to the input circuit of the gas-filled tube 77 by means of a transformer 80. The output circuit of the gas-filled tube 77 is connected to a winding 81 of the relay 75. A battery 82 is provided to supply plate potential to the amplifier 76 and to the gas-filled tube 77. A battery 83 is provided for supplying heating current to the filaments of the amplifier 76 of the gas-filled tube 77. Biasing potential for the grid of the amplifier 76 is provided by the drop across the resistance element 84 of the filament heating circuit.

Biasing potential for the grid of the gas-filled tube 77 is provided by a battery 85 in the decreaser circuit 55 opposed by the battery 86. The battery 85 is assumed to supply negative potential of approximately 67 volts, and the battery 86 is assumed to supply a positive potential of approximately 22 volts so that substantially negative biasing potential of 45 volts is impressed on the grid of the gas-filled tube 77. The circuit of the batteries 85 and 86 for supplying biasing potential to the grid of the gas-filled tube 77 is controlled by a receiving relay 87 in a manner to be hereinafter disclosed.

The relay 75 comprises not only the operating winding 81 but also a biasing winding 88. The biasing winding 88 is connected across the terminals of the battery 82 and serves to hold the armature 74 in engagement with a contact member 89. When the operating winding 81 is energized the armature 74 is moved into engagement with the contact member 109. The operating winding 81 is connected across the batteries 82 in circuit with a resistance element 90 and a gas-filled tube 77. The gas-filled tube 77 is marginal in its operation the same as the gas-filled tube 57 in the gain increaser circuit 53. The gas-filled tube 77 in the gain increase disabler circuit 54 is assumed to operate or trigger off when the peaks of the currents in the branch circuit beyond the loss device 15 are above the lower limiting value. The gas-filled tube 57 in the gain increaser circuit is assumed to operate or trigger off when the peaks of speech in the transmitting channel before the loss device 13 are above those of the weakest talkers. A hangover circuit comprising a condenser 91 and a resistance element 92 is provided in the output circuit of the gas-filled tube 77 for effecting a hangover in the operation of the relay 75. This hangover circuit operates in a manner similar to the hangover circuit described when reference was made to the gas-filled tube 57.

The gas-filled tube 77 in the gain increase disabler circuit 74 is operated not only according to the peaks of energy on the branch circuit beyond the loss device 15 but may be operated by the relay 87 which is controlled from the receiving channel. When the relay 87 is operated the circuit from the batteries 85 and 86 for supplying potential to the grid of the gas-filled tube 77 is open. Accordingly the strong negative bias on the grid of the gas-filled tube 77 is removed to permit operation of the gas-filled tube 77 which in turn operates the relay 75.

The gain decreaser circuit 55 comprises an amplifier 93, preferably of a three-element thermionic type, and two detector tubes 94 and 95. A transformer 96 is provided for connecting the input circuit of the amplifier 93 to the branch circuit at a point beyond the loss devices 15 therein. A potentiometer 97 is provided in the input circuit of the amplifier 93 for adjusting the operation of the gain decreaser circuit 55. The output circuit of the amplifier 93 is connected to the input circuit of the detector tubes 94 and 95 by means of a transformer 98. Heating current for the filaments of the amplifier 93 and the detector tubes 94 and 95 is provided by means of a battery 99. A battery 100 is provided for supplying plate potential to the amplifier 93 and for supplying current to the biasing winding 101 of the relay 87. The operating winding 102 of the relay 87 is controlled from the receiving channel in a manner to be hereinafter set forth. Biasing potential for the grid of the amplifier 93 is supplied by the battery 103. Biasing potential for the grids of the detector tubes 94 and 95 is supplied by the battery 85 which also controls the biasing potential for the grid of the gas-filled tube 77 in the gain increase disabler circuit 54. Plate potential for the detector tubes 94 and 95 is supplied by a battery 104. The output circuit of the detector tubes 94 and 95 is directly connected to the control condenser 19 for impressing a charge on the condenser in accordance with the operation of the detector tubes 94 and 95.

The gain rate relay 42 which is controlled according to the potential drop across the resistance element 41 in the plate circuit of the space discharge devices 25 and 26 comprises an operating winding 105 and a biasing winding 106. The biasing winding is energized from the battery 61 and normally holds the armature in engagement with a stop member 107 and away from a contact member 108. The operating winding 105 which is energized according to the drop across the resistance 41 serves to move the armature of the relay into engagement with the contact member 108. When the armature of the gain rate relay is in engagement with the contact member 108 the resistance element 72 is excluded from the discharge circuit of the control condenser 19 as will be set forth hereinafter.

Assume a charge on the condenser 19 and conversation to be started on the transmitting channel so that the average level of the volume before the loss device 13 is above that of the weakest talkers and the energy level beyond the loss device 15 in the branch circuit is below the lower limiting value. Under these circumstances the gas-filled tube 57 in the gain increaser circuit 53 is triggered off for completing a circuit through the operating winding 62 of the relay 60, the condenser 70 in the hangover circuit is discharged, the relay 60 is operated and the armature 67 is moved into engagement with the contact member 68. The engagement between the armature 67 and the contact member 68 serves to complete a discharge circuit for the control condenser through the resistance elements 72 and 73. The circuit of the control condenser 19 for impressing potential on the grids of the space discharge devices 25 and 26 may be traced from the grids of the devices 25 and 26 through the secondary winding of the transformer 27, battery 33, control condenser 19 and ground to the filaments of the space discharge devices 25 and 26. Similar control circuits may be traced for the space discharge devices 29 and 30 and 43 and 44.

The circuit completed by the relay 60 extends from one terminal of the control condenser 19 to the armature 67, contact member 68, resistance elements 72 and 73, contact member 89, armature 74 and ground return to the other terminal of condenser 19. It is thus apparent that the resistance elements 72 and 73 are connected across the condenser 19 for effecting a discharge of the condenser. The time rate of the discharge may be controlled as desired. The discharge action on the condenser 19 serves to reduce the negative biasing potential on the grids of the devices in the loss element 13 in the transmitting channel and to reduce the negative biasing potential on the grids of the space discharge element in the loss device 15 of the branch circuit. At the same time the potential impressed on the grids of the space discharge devices 43 and 44 of the loss element 14 is reduced.

When the space current for the space discharge devices **25** and **26** is raised to a predetermined point the gain rate relay **42** is operated to exclude the resistance element **72** from the discharge circuit of the condenser **19**. The relay **42** is provided in order to effect a more uniform gain of energy in the transmitting channel. If the relay **42** were not provided the gain in the transmitting channel would be very rapid at the beginning of the discharge of the condenser **19** and then would become relatively slow. The excluding of the resistance element **72** from the discharge circuit for the control condenser **19** serves to increase the rate at which the discharge of the condenser takes place and the gain of energy upon the transmitting channel.

When the level of the volume in the branch circuit beyond the loss device **15** is above the lower limiting value, then the gas-filled tube **77** in the gain increase disabler circuit **54** is operated or triggered off. The operation of the gas-filled tube **77** effects operation of the relay **75**. The relay **75** moves the armature **74** from engagement with the contact member **89** into engagement with the contact member **109**. This breaks the discharge circuit for the control condenser **19** and prevents further increase in the gain on the branch circuit beyond the loss device **15**. When the armature **74** of the relay **75** engages the contact member **109** the condenser **110** effectively shunts a portion of the impedance in the input circuit of the amplifier **76** to increase the sensitivity of the gain increase disabler circuit **54**. When the gas-filled tube **77** of the gain increase disabler circuit **54** ceases to operate by reason of the energy level beyond the loss device **15** in the branch circuit below the lower limiting value the relay **75** is held operated for a limited period by reason of the hangover action produced by the condenser **91** and the resistance element **92**.

If the volume level on the branch circuit beyond the loss device **15** rises above an upper limiting value then the negative potential impressed upon the grids of the detector tubes **94** and **95** in the gain decreaser circuit **55** is overcome to permit current flow through the detector tubes to charge the control condenser **19**. The charge on the control condenser **19** serves to impress negative biasing potential on the space discharge devices **25, 26, 29, 30, 43** and **44**.

In case the receiving channel is in operation and the transmitting channel is idle it is desirable to have the charge held on the control condenser **19** and to permit no change in the setting of the loss devices in the transmitting channel. The echo suppressor circuits **111** serve to effect energization of the winding **102** of the relay **87** whenever the receiving channel is in use. Thus the armature **112** of the relay **87** is moved from engagement with the contact member **113** into engagement with the contact member **114** whenever the receiving channel is in use. Such movement of the armature **112** serves first to break the circuit of the biasing batteries **85** and **86** for controlling the potential impressed on the grid of the gas-filled tube **77** in the gain increase disabler circuit **54**. The gas-filled tube **77** is operated to effect operation of the relay **75**. The relay **75** opens the discharge circuit for the control condenser **19** and prevents any discharge from the control condenser. The engagement of the armature **112** of the relay **87** with the contact member **114** serves to short-circuit one-half of the secondary winding of the transformer **98** connected to the detector tubes **94** and **95** in the gain decreaser circuit **55**. This action serves to prevent any operation of the detector tubes **94** and **95** and accordingly to prevent any increase in the charge on the control condenser **19** when the receiving channel is in use.

Briefly reviewing the operation of the loss devices at the terminal stations on a four-wire system, constant volume is maintained on the branch circuit beyond the loss device **15**. In maintaining constant volume on the branch circuit the volume range on the transmitting channel beyond the loss device **13** will have the volume range reduced one-half. At the same time the volume range of the signals on the receiving channel will be doubled. It will be noted that whatever action is taken by the loss device **13** in the transmitting channel, an opposite action is taken by the loss element **14** in the receiving channel so that there will be no tendency for a singing action.

Modifications in the system 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 a four-wire signal transmission system, a station having a transmitting pair of conductors and a receiving pair of conductors connected thereto, and means controlled only from the transmitting pair of conductors for reducing the volume range of the signals on the transmitting conductors by a certain fraction with the signal volume partially determining the transmitted signal volume, for extending the volume range of the signals on the receiving conductors by a reciprocal of said fraction and for holding the loss devices at fixed values during pauses in the transmission of signals.

2. In a four-wire telephone signal transmission system having a station with a transmitting pair of conductors and a receiving pair of conductors, a loss controlling device connected to each pair of conductors at said station, and means for controlling the loss device in the transmitting pair of conductors to reduce the volume range beyond the device to a fixed fraction of the volume range before the device, for controlling the loss device in the receiving pair of conductors to extend the volume range beyond the loss device in the receiving conductors a reciprocal of a fraction of the volume range before the device in the receiving conductors and for holding the loss devices at fixed values during pauses in the transmission of signals while enabling the speaker at the station to partially control the volume of his transmitted speech currents and the volume of the received speech currents according to the volume of his speech.

3. In a four-wire signal transmission system having a station with a transmitting pair of conductors and a receiving pair of conductors, a loss controlling device connected to each pair of conductors at said station, and means for controlling the loss device in the transmitting pair of conductors to reduce the volume range beyond the device one-half the volume range before the device so that the signal volume partially determines the transmitted signal volume, for controlling the loss device in the receiving pair of conductors to extend the volume range beyond the loss device in the receiving conductors to double the volume range before the loss device and for

holding the loss devices at fixed values during pauses in the transmission of signals.

4. In a four-wire signal transmission system having a station with a receiving pair of conductors and a transmitting pair of conductors connected thereto, a loss device connected to each of said pairs of conductors, and means governed solely according to the volume on the transmitting pair of conductors at said station for controlling the loss device connected to the transmitting conductors to reduce the volume range beyond the device a fixed fraction of the volume range before the loss device so that the transmitted volume is partially controlled according to the signal volume, for controlling the loss device connected to the receiving conductors to expand the volume range of the signal beyond the device a reciprocal of a fixed fraction of the volume range of the signals before the loss device and for holding the loss devices at fixed values during pauses in the transmission of signals over the transmitting pair of conductors.

5. In a four-wire signal transmission system having east and west terminal stations and separate pairs of conductors for transmission of signals in opposite directions, a loss controlling device connected to each pair of conductors at each end of the system, and means at each of said stations controlled only by the energy level of the signals on the pair of conductors transmitting signals from a station for reducing the volume range of the signal volume beyond the loss device on the conductors transmitting signals from the station a fixed fraction of the signal volume before the loss device on the conductors transmitting signals and for increasing the signal volume range beyond the loss device in the pair of conductors receiving signals at the station a reciprocal of a fixed fraction of the signal volume before the loss device in the conductors receiving signals.

6. In a four-wire transmission system having a station with a receiving pair of conductors and a transmitting pair of conductors, a loss device connected in series with the transmitting conductors at said station, a branch circuit connected to the transmitting pair of conductors beyond the loss device therein, a loss device connected in series with said branch circuit, a loss device connected across the receiving conductors at said station, and means for controlling said loss devices to maintain constant volume on the branch circuit beyond the loss device therein, to reduce the volume range on the transmitting conductors one-half and to double the volume range on the receiving conductors.

7. In a four-wire transmission system having a station with a receiving pair of conductors and a transmitting pair of conductors, a loss device connected in series with said transmitting conductors, a branch circuit connected to the transmitting pair of conductors beyond the loss device therein, a loss device connected in series with said branch circuit, a loss device connected across said receiving conductors, and means controlled according to the volume range on the transmitting conductors for maintaining constant volume on the branch circuit beyond the loss device therein, for reducing the volume range of the signals beyond the loss device in the transmission conductors one-half with respect to the signal volume range before the loss device and for expanding the volume range of the signals on the receiving conductors beyond the loss device therein to twice the volume range before the loss device.

8. In a four-wire transmission system having a station with a receiving pair of conductors and a transmitting pair of conductors, a loss device connected in series with the transmitting conductors at said station, a loss device connected across the receiver conductors at said station, means controlled solely from said transmitting conductors and remaining in adjusted position between pauses in speech and when signals are being sent over the receiving pair of conductors for governing the loss device connected to the transmitting conductors to reduce the volume range on the transmitting conductors beyond the loss device one-half the volume range of the signals before the loss device and for governing the loss device connected to the receiving conductors to double the volume range beyond the loss device on the receiving conductors with respect to the volume range before the loss device.

9. In a four-wire signal transmission system having separate pairs of conductors for transmitting signals in opposite directions between a west station and an east station, a loss device connected in series with the first pair of conductors at the west station, a loss device connected across the second pair of conductors at the west station, a loss device connected across the first pair of conductors at the east station, a loss device connected in series with the second pair of conductors at the east station, means at the west station controlled only according to the energy volume on the first pair of conductors for controlling the loss device in the first pair of conductors to reduce the volume range according to a fixed fraction and for controlling the loss device in the second pair of conductors to expand the volume range according to a reciprocal of a fixed fraction, said means retaining its setting to hold the values of said loss devices constant during pauses in speech and when signals are transmitted from the east station to the west station, and means at the east station controlled only according to the energy volume on the second pair of conductors for controlling the loss device in the second pair of conductors to reduce the volume range a fixed fraction and for controlling the loss device in the first pair of conductors to expand the volume range a reciprocal of a fixed fraction, said second mentioned means remaining in adjusted position to hold the values of the loss devices at the east station constant during pauses in speech and when signals are transmitted from the west station to the east station.

10. In a four-wire two-way signal transmission system, a loss device connected to each pair of conductors at the west and east ends of said system, means controlled only according to the energy volume on the first pair of conductors at the west end of the system when the signals are transmitted from the west to the east for controlling the loss device in the first pair of conductors at the west end to reduce the volume range one-half beyond the loss device with respect to the volume range before the device and for controlling the loss device in the second pair of conductors at the west end to expand the volume range beyond the loss device to double the volume range before the device, said means retaining its setting between pauses in speech and when signals are transmitted from the east to the west station, and means controlled only according to the energy volume on the second pair of con-

ductors at the east end of the system when signals are transmited from the east to the west for controlling the loss device in the second pair of conductors at the east end to reduce the volume range one-half beyond the loss device with respect to the volume range before the device and for controlling the loss device in the first pair of conductors at the east end to expand the volume range to double the volume range before the device, said second mentioned means retaining its setting between pauses in speech and when signals are transmitted from the west to the east.

11. In a four-wire transmission system having a station with a receiving pair of conductors and a transmitting pair of conductors, a loss device connected in series with the transmitting conductors at said station, a branch circuit connected to the transmitting conductors beyond said loss device, a second loss device connected in series with the branch circuit, a third loss device connected across said receiving conductors, and means controlled by the energy volume on the branch conductors beyond the loss device therein for governing the three loss devices to reduce the volume range on the transmitting conductors beyond the loss device therein one-half the volume range before the loss device, and to extend the volume range on the receiving conductors beyond the loss device therein to double the volume range before the loss device.

12. In a four-wire transmission system having a station with a receiving pair of conductors and a transmitting pair of conductors, a loss device connected to said transmitting conductors, a loss device connected to said receiving conductors, a branch circuit connected to the transmitting conductors at a point beyond the loss device therein, a loss device connected to said branch circuit, and means controlled according to the volume range on the branch line beyond the loss device therein for governing the loss device on the transmitting conductors to reduce the volume range on the transmitting conductors one-half, for governing the loss device on the receiving conductors to double the volume range on the receiving conductors, and for governing the loss device on the branch line to maintain constant volume on the branch line beyond the loss device.

LEONARD G. ABRAHAM.