Nov. 2, 1937. H. L. BARNEY 2,097,507

CONTROL CIRCUIT

Filed Feb. 28, 1936 2 Sheets-Sheet 1

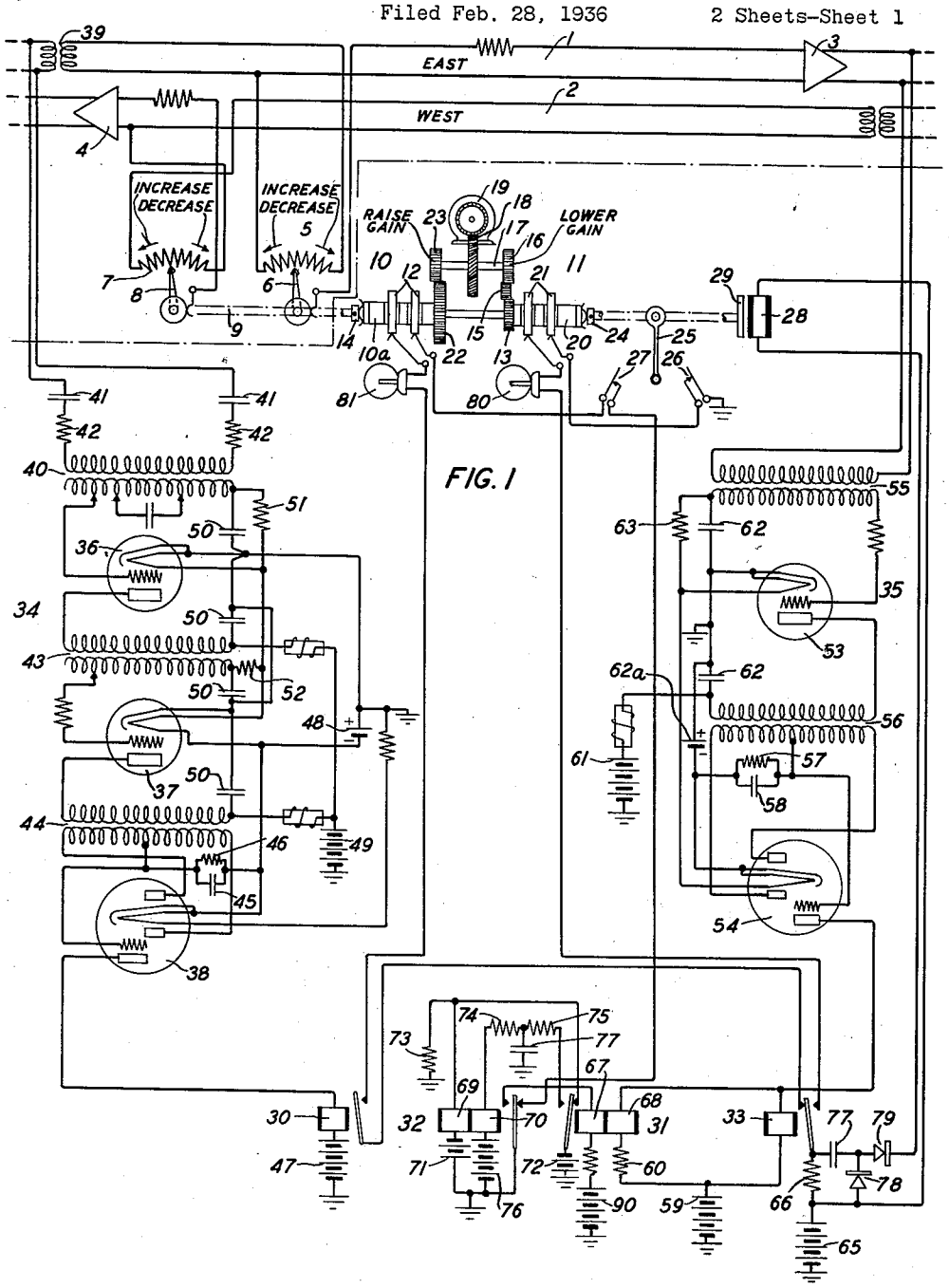


FIG. 1

INVENTOR
H. L. BARNEY
BY Wayne B Wells
ATTORNEY

Nov. 2, 1937. H. L. BARNEY 2,097,507

CONTROL CIRCUIT

Filed Feb. 28, 1936 2 Sheets-Sheet 2

FIG. 2

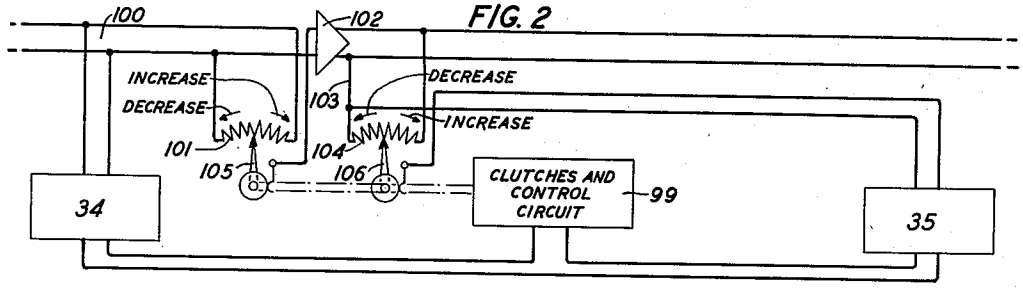


FIG. 3

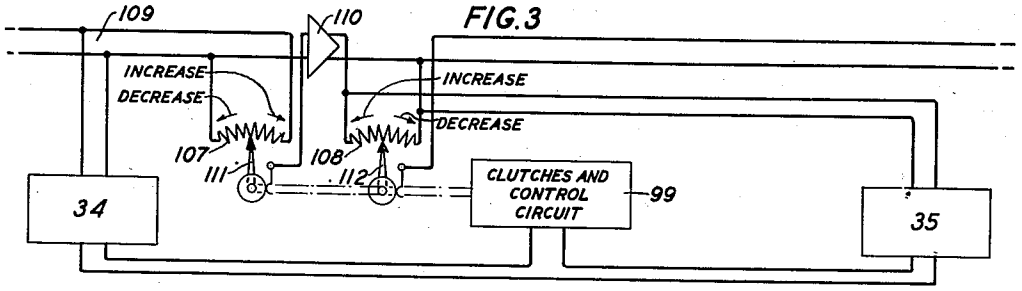


FIG. 4

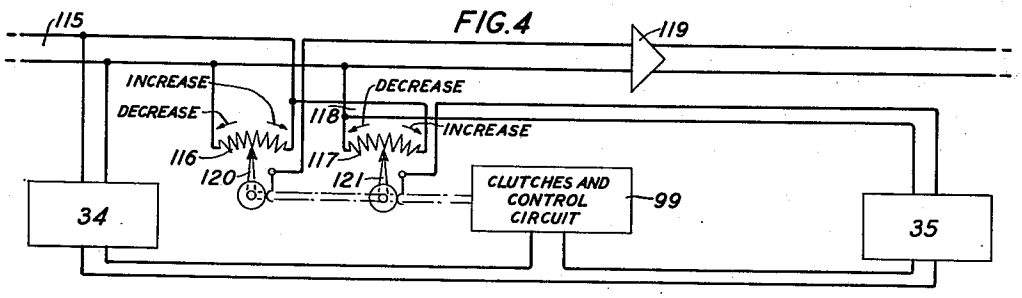
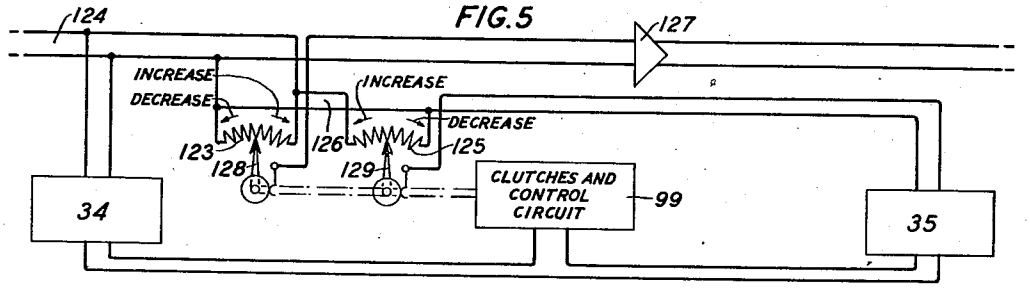


FIG. 5



INVENTOR
H.L. BARNEY
BY Wayne B Wells
ATTORNEY

Patented Nov. 2, 1937 2,097,507

UNITED STATES PATENT OFFICE

2,097,507

CONTROL CIRCUIT

Harold L. Barney, St. Louis, Mo., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application February 28, 1936, Serial No. 66,229

16 Claims. (Cl. 178—44)

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

One object of the invention is to provide a signal transmission system with control circuits for adjusting the gain on a line in an improved manner to maintain the volume substantially constant.

Another object of the invention is to provide a signal transmission line with control circuits that shall control a potentiometer to raise and to lower the gain on the line at different rates and maintain the volume on the line substantially constant.

Another object of the invention is to provide a signal transmission line with control circuits that shall control two potentiometers for raising and lowering the gain on the line to reduce the range of volume on the line.

Another object of the invention is to provide a signal transmission line with control circuits that shall control two potentiometers for raising and lowering the gain on the line to increase the range of volume on the line.

A further object of the invention is to provide a four-wire transmission line having a potentiometer in the east line and in the west line with control circuits that shall operate the potentiometers in the east and the west lines oppositively according to the volume of the signals on one of the lines and that shall raise and lower the gain in each line at different rates.

In signal transmission systems it is desirable to control the volume of transmitted signals in order to prevent overload of the various apparatus on the line. In a radio broadcasting station it is desirable to hold the volume before the radio transmitter within predetermined limits in order not to overload the transmitter.

According to the present invention a potentiometer which is located in a signal transmission line adjacent to an amplifier is controlled according to the volume of the signals to maintain the volume of the signals on the line beyond the amplifier within predetermined limits. The potentiometer cannot be operated to raise the gain until the volume of the signals received over the line is above the peaks of the weakest talker. If the volume of the signals on the line beyond the amplifier is below a predetermined lower limit, the potentiometer is operated to raise the gain and if the volume of the signals on the line beyond the amplifier is above a predetermined upper limit, the potentiometer is operated to lower the volume of the signals.

In a four-wire circuit constructed in accordance with the invention two potentiometers which are respectively placed in the east line and the west line of the four-wire circuit are controlled by two magnetic clutch mechanisms. The magnetic clutch mechanisms are rotated by a constantly rotating motor. The clutch mechanism which is adapted to operate a potentiometer in one line, for example, the east line, to raise the gain, is operated at a relatively slow speed, whereas the other clutch mechanism which serves to lower the gain in the east line is operated at a relatively high speed. The two potentiometers are connected to the east and the west lines to operate in opposite directions, so that if the gain is raised in the east line, the gain is lowered in the west line.

A forward-acting circuit which is connected to the east line before the potentiometer and an amplifier, controls a gain increaser relay. A backward-acting circuit which is connected to the east line beyond the potentiometer and the amplifier controls a gain decreaser relay and a gain increaser disabler relay. If the peaks of speech waves on the east line before the potentiometer and the amplifier are above the peaks of the weakest talker and the volume beyond the potentiometer and amplifier in the east line is below a predetermined lower limit, one of the clutch mechanisms is controlled to operate the two potentiometers so as to raise the gain in the east line and lower the gain in the west line. When the volume of the signals beyond the potentiometer and amplifier in the east line is raised above the predetermined lower limit, the clutch mechanism which serves to raise the gain in the east line is released. If the volume on the east line beyond the potentiometer and amplifier is above a predetermined upper limit, the second clutch mechanism is controlled to operate the two potentiometers so as to lower the gain in the east line and raise the gain in the west line. A magnetic brake is provided for quickly stopping the operation of the potentiometers when either of the clutch mechanisms is released.

In the accompanying drawings:

Figure 1 is a diagrammatic view of gain control circuits constructed in accordance with the invention;

Fig. 2 is a diagrammatic view of a modification of the control circuits shown in Fig. 1, wherein the volume of the signals on the transmission line may be compressed any desired per cent;

Fig. 3 is a diagrammatic view of a modifica-

tion of the control circuits shown in Fig. 1, wherein the volume of the signals on the transmission line may be expanded any desired per cent; and

Figs. 4 and 5 are diagrammatic views of modifications of the circuits shown in Figs. 2 and 3.

Referring to Fig. 1 of the drawings, a four-wire circuit comprising an east line 1 and a west line 2 is controlled to maintain the volume on the east line substantially constant. An amplifier 3 of any suitable type is provided in the east line 1 and an amplifier 4 is provided in the west line 2. A potentiometer 5 having a control arm 6 is provided in the east line 1 ahead of the amplifier 3 and a potentiometer 7 having a control arm 8 is provided in the west line 2 ahead of the amplifier 4. The potentiometer arms 6 and 8 are mounted on a shaft 9 which is controlled by the clutch mechanisms 10 and 11. Rotation of the potentiometer arms 6 and 8 in a clockwise direction, as viewed in Fig. 1 of the drawings, serves to increase the gain on the east line and decrease the gain on the west line. Rotation of the arms 6 and 8 in a counter-clockwise direction serves to decrease the gain on the east line and increase the gain on the west line.

The clutch mechanism 10 which serves to rotate the potentiometer arms 6 and 8 in a clockwise direction comprises a clutch magnet 10*a* having the terminals thereof connected to slip rings 12 and a gear wheel 22. The clutch magnet 10*a*, the slip rings 12 and gear wheel 22 are rotatably mounted on the shaft 9. A disc 14 which is fixedly mounted on the shaft 9 is engaged by the electromagnet 10*a* when energized to connect the shaft 9 to the gear wheel 22. The gear wheel 22 is connected to a gear wheel 23 on a shaft 17. The shaft 17 is connected by worm gearing 18 to a constantly rotating motor 19. The motor 19 effects constant rotation of the electromagnet 10*a* and upon energization of the electromagnet effects rotation of the shaft 9 and the potentiometer arms 6 and 8.

The clutch mechanism 11 comprises electromagnet 20 having the terminals thereof connected to slip rings 21. The electromagnet 20, the slip rings 21 and a gear wheel 13 are rotatably mounted on the shaft 9. The gear wheel 13 meshes with a pinion 15 with a gear wheel 16 mounted on the shaft 17. The motor 19 by means of the worm gearing 18, shaft 17 and gear wheels 16 and 13 rotates the electromagnet 20 constantly in a direction opposite to the direction of rotation of the electromagnet 10*a* by the motor 19. A magnetic disc 24 is fixedly mounted on the shaft 9 adjacent to the electromagnet 20. Upon energization of the electromagnet 20, the magnetic disc 24 is connected to the electromagnet so that the disc 24 and shaft 9 having the potentiometer arms 6 and 8 mounted thereon are rotated in accordance with the rotation of the electromagnet. In the above construction it will be noted the potentiometer arms 6 and 8 when controlled by the electromagnet 20 are operated at a faster rate than when controlled by the electromagnet 10*a*.

A control arm 25 is mounted on the shaft 9 for controlling two limit switches 26 and 27. When the arm 6 of the potentiometer 5 has been operated to its extreme position for increasing the gain on the east line, the limit switch 27 is opened by the arm 25. When the potentiometer 5 has reached its extreme lower position for decreasing the gain on the line, the limit switch 26 is opened by the arm 25. A stationary brake electromagnet 28 is positioned adjacent to a magnetic disc 29 which is fixedly mounted on the shaft 9. Upon energization of the brake magnet 28 the disc 29 is engaged to effect a relatively quick stopping of the rotation of the shaft 9.

A gain increaser relay 30 is provided for completing a circuit through the clutch electromagnet 10*a* and a gain increase disabler relay 31 is provided for controlling a relay 32 to open the circuit of the clutch electromagnet 10*a* when the volume of the signals on the east line beyond the amplifier 3 is above a predetermined lower limit. A gain decreaser relay 33 is provided for completing a circuit through the clutch electromagnet 20 when the volume of the signals on the east line beyond the amplifier 3 is above a predetermined upper limit. The gain increaser relay 30 is controlled by a forward-acting circuit 34 and the gain decreaser relay 33 and the gain increase disabler relay 31 are controlled by a backward-acting control circuit 35.

The forward-acting control circuit 34 comprises two space discharge amplifier tubes 36 and 37 and a diode-triode tube 38. The input circuit of the amplifier 36 is connected to the east line 1 before a transformer 39 by means of transformer 40. Condensers 41 and resistance elements 42 are inserted in the connection between the transformer 40 and the east line 1. The output circuit of amplifier 36 is connected to the input circuit of the amplifier 37 by means of a transformer 43. The output circuit of the amplifier 37 is connected by a transformer 44 to the diode portion of the tube 38. A mid-tap from the secondary winding of the transformer 44 is connected to the grid of the tube 38 and to the cathode of the tube 38 through a capacity element 45 and resistance element 46. The capacity element 45 and the resistance element 46 are connected in parallel to each other. The plate cathode circuit of the triode portion of the tube 38 is connected in series with the gain increaser relay 30 and a plate battery 47. Battery 48 is provided for heating the filaments of tubes 36, 37 and 38. A battery 49 is provided for supplying plate potential to the tubes 36 and 37. Condensers 50 serve as blocking condensers. The resistance elements 51 and 52 connect the grids of the tubes 36 and 37 to points effectively negative with respect to the cathodes of the tubes 36 and 37. The resistance elements 51 and 52 in combination with the condensers 50 filter out disturbances in the filament battery 48 to provide a constant effective grid bias.

Normally, the gain increaser relay 30 is operated by the current from the battery 47 flowing through the triode portion of the tube 38. When the relay 30 is operated, the circuit of the clutch electromagnet 10*a* is held open. When the signals on the east line 1 are above the peaks of the weakest talker, the diode portion of the tube 38 rectifies sufficient current for impressing a negative bias on the grid of the triode portion of the tube 38 to release the relay 30. The two electrodes of the diode portion of the tube 38 are respectively connected to the terminals of the secondary winding of the transformer 44. The mid-tap of the secondary winding of the transformer 44 is connected through the capacity 45 in parallel with the resistance 46 to the cathode of the tube 38. In such connection, potential is built up on the capacity 45 for impressing negative bias on the grid of the triode portion of the tube 38. When the negative bias on the grid of the tube 38 is raised to a predetermined point, the space current flow through the triode portion of the tube 38

is reduced to a point for releasing the relay 30. The relay 30 is released when the voltage on the line before the transformer 39 is above the peaks of the weakest talker.

The backward-acting circuit 35 comprises an amplifier space discharge tube 53 and a diode-triode space discharge device 54. The input circuit of the amplifier tube 53 is connected by a transformer 55 to the east line 1 beyond the amplifier 3. The output circuit of the amplifier 53 is connected by a transformer 56 to the diode portion of the diode-triode tube 54. The output terminals of the secondary winding of the transformer 56 are connected to the electrodes of the diode portion of the tube 54. A central tap from the secondary winding of the transformer 56 is connected to the grid of the triode portion of the tube 54 and to the cathode of the tube 54 through a resistance element 57 and a capacity element 58. The diode-triode tube 54 is controlled by the signals beyond the amplifier 3 on the east line 1 in the same manner as the tube 38 is controlled by the signals on the east line 1 before the transformer 39. A battery 59 is provided for supplying plate potential to the triode portion of the tube 54. The winding of the gain decreaser relay 33 is connected in the plate circuit of the tube 54 in parallel with a winding of the gain increase disabler relay 31. A resistance element 60 is included in series with the winding of the gain increase disabler relay 31. A battery 61 supplies plate potential to the amplifier 53 and a battery 62a supplies heating current to the filaments of the tubes 53 and 54. Condensers 62 serve as blocking condensers. The resistance element 63 connects the grid of the tube 53 to a point effectively negative with respect to the cathode of the tube 53. The resistance element 63 in combination with the condenser 62 filters out disturbances in the filament battery 62a to provide a constant effective grid bias.

If the voltage on the east line 1 before the transformer 39 is above the peaks of the weakest talker and the volume on the east line beyond the amplifier 3 is below a predetermined lower limit, the relay 30 will be released by the forward-acting control circuit 34. The gain decreaser relay 33 and the gain increase disabler relay 31 are held in operative position by means of the backward-acting circuit 35 and the relay 32 is held in released position as shown in the drawings by the gain increase disabler relay 31. A circuit is completed by release of the relay 30 for operating the electromagnet 10a which may be traced from battery 65 through a resistance element 66, armature of the gain decreaser relay 33 in operative position, armature of the gain increaser relay 30 in released position, slip rings 12, electromagnet 10a, limit switch 27, armature of the relay 32 in released position and ground return to the battery 65. The clutch magnet 10a attracts the disc 14 and by means of the motor 19, effects rotation of the potentiometer arms 6 and 8 in a clockwise direction as shown on Fig. 1 of the drawings to increase the gain on the east line 1 and decrease the gain on the west line 2. The gearing comprising gears 22 and 23 serves to effect raising of the gain at a relatively slow rate.

When the volume on the east line 1 beyond the amplifier 3 is raised above the predetermined lower limit, the gain increase disabler relay 31 is released to effect operation of the relay 32. The relay 32 upon operation breaks the energizing circuit for the clutch electromagnet 10a to prevent any further increase in the gain on the east line 1. The gain increase disabler relay 31 is provided with two windings 67 and 68 and the relay 32 is provided with two windings 69 and 70. When the relay 31 is in operative position, winding 69 is connected to two opposing batteries 71 and 72 so that no operation of the relay 32 can take place. Upon release of the relay 31, the battery 72 is disconnected from the winding 69 of the relay 32 so that the relay 32 is operated by the battery 71 through a circuit including a resistance element 73. When the armature of the gain increase disabler relay 31 engages its back contact, a circuit is completed through resistance elements 74 and 75 for energizing the winding 70 of the relay 32 from the batteries 72 and 76. A condenser 77 is charged to effect a hangover in the operation of the relay 32 when the gain increase disabler relay 31 is again operated. A circuit is completed through the winding 67 of relay 31 from battery 99 when relay 32 operates. The winding 67 opposes the winding 68 and tends to hold relay 31 in released position. This action of winding 67 causes an increase in the effective sensitivity of relay 31 to signals at the output of the amplifier 3 when relay 32 is operated. Thus, succeeding peaks of speech several decibels weaker will release relay 31 and renew the hangover on the relay 32.

A resistance element 66 in the energizing circuit of the clutch electromagnet 10a is shunted by a condenser 77 and a rectifier 78. During the operation of the clutch electromagnet 10a, condenser 77 is charged and upon opening of the circuit through the clutch electromagnet 10a the charge on the condenser 77 is discharged through a rectifier 79 for energizing the brake electromagnet 28. The brake electromagnet 28, upon energization, engages the disc 29 on the shaft 9 for effecting a relatively quick stopping of the rotatable element of the potentiometer arms 6 and 8.

When the volume on the east line 1 beyond the amplifier 3 is above a predetermined upper limit, the gain decreaser relay 33 is released by the backward-acting control circuit 35. Upon release of the relay 33, a circuit is completed for energizing the clutch electromagnet 20. The circuit for energizing the clutch electromagnet 20 may be traced from the grounded battery 65 through the resistance element 66, armature of the relay 33 in released position, lamp 80, slip rings 21 and electromagnet 20, limit switch 26 and ground return to the battery 65. The clutch electromagnet 20 upon operation attracts the disc 24 for effecting rotation of the shaft 9 and the potentiometer arms 6 and 8 in a counter-clockwise direction. Counter-clockwise rotation of the potentiometer arms 6 and 8 serves to decrease the gain on the east line 1 and to increase the gain on the west line 2. A lamp 80 is included in the circuit of the electromagnet 20 in order to indicate when the electromagnet is in operation. A similar lamp 81 is provided in the circuit of the clutch electromagnet 10a.

When the volume on the east line 1 beyond amplifier 3 is reduced below the predetermined upper limit, the gain decreaser relay 33 is operated by the backward-acting control circuit 35 to open the circuit of the clutch electromagnet 20 and prevent further decrease in the gain on the east line and increase in the gain on the west line. At this time the charge on the condenser 77 energizes the brake electromagnet 28 to effect quick stopping of the rotative movement of the poten-

tiometer arms 6 and 8. If the volume on the east line 1 beyond the amplifier 3 falls below the predetermined lower limit, the gain increase disabler relay 31 is released to again effect operation of the clutch electromagnet 10a. The operation of potentiometer arms 6 and 8 by the clutch electromagnet 10a has been described heretofore. The gain increase disabler relay 31 is made more sensitive than the gain decreaser relay 33 in order to effect operation of the relays at different volume levels.

Referring to Fig. 2 of the drawings, a modification of the invention is shown wherein the volume of the signals on the line may be compressed any desired per cent. A signal line 100 has a potentiometer 101 connected across it and an amplifier 102 is positioned on the line beyond the potentiometer. A branch line 103 is connected to the transmission line 100 beyond the amplifier 102 and a potentiometer 104 is connected across the branch line. The two potentiometers 101 and 104 are provided with control arms 105 and 106 which are governed in the same manner as the control arms 6 and 8 shown in Fig. 1 of the drawings. The changes in decibel loss effected by the two potentiometers 101 and 104 vary in accordance with the compression in volume that is desired on the transmission line beyond the amplifier 102. If the volume of the signals on the transmission line beyond the amplifier 102 is to be compressed one-half with respect to the volume of the signals before the potentiometer 101, then the change in loss effect by the potentiometer 104 is made the same as the change in loss effected by the potentiometer 101. A backward-acting control circuit 35 is connected to the branch line 103 beyond the potentiometer 104 for controlling the movement of the potentiometer arms 105 and 106 in the same manner as the backward-acting control circuit 35 in Fig. 1 of the drawings controls the operation of the potentiometer arms 6 and 8. A forward-acting control circuit 34 which is similar to the forward-acting control circuit 34 shown in Fig. 1 of the drawings is provided for preventing any control of the potentiometer arms 105 and 106 until the peaks of the speech on the line 100 before the potentiometer 101 are above those of the weakest talker. The backward-acting control circuit 35, the forward-acting control circuit 34 and the clutch mechanisms and control circuits 99 governed thereby are similar in construction and operation to the same parts shown in Fig. 1 of the drawings. Accordingly, a detailed description of the operation of these parts with respect to Fig. 2 is deemed unnecessary.

If the volume of the signals on the transmission line before the potentiometer 101 is above the volume of the weakest talker, then the control circuit 35 operates to maintain constant volume on the branch line 103 beyond the potentiometer 104. When constant volume is maintained on the branch line beyond the potentiometer 104, it will be noted that the volume range of the signals on the transmission line 101 beyond the amplifier 102 will be compressed one-half. This circuit operates somewhat in the manner of the circuit disclosed in the patent to S. Doba, No. 1,854,828 dated April 19, 1932. It will be noted that if the potentiometer arms 105 and 106 are both rotated in a clockwise direction, the gain on the transmission line and the branch line will be increased and that if each of the potentiometer arms 105 and 106 are rotated in a counter-clockwise direction, the gain on the transmission line and the branch line would be decreased.

Referring to Fig. 3 of the drawings, control circuits are shown for expanding the signals on the line any desired per cent. In Fig. 3 of the drawings, two potentiometers 107 and 108 are connected in tandem across the transmission line 109 and are separated by an amplifier 110 of any desired type. The potentiometers 107 and 108 are respectively provided with contact arms 111 and 112 and are so connected to the transmission line that rotation of the contact arms 111 and 112 in a clockwise direction will increase the gain effected by the potentiometer 107 and decrease the gain effected by the potentiometer 108. An opposite effect takes place if the two potentiometer arms 111 and 112 are rotated in a counter-clockwise direction. The changes in decibel loss effected by the two potentiometers 107 and 108 are varied in accordance with the expansion of the signals which is desired. If the volume of the signals on the transmission line 109 beyond the potentiometer 108 is to be double the volume of the signals on the line 109 before the potentiometer 107, then the change in decibel loss effected by the potentiometer 108 is double the change in decibel loss effected by the potentiometer 107. The impedance values of the two potentiometers 107 and 108 are varied in accordance with the expansion desired of the signals on the transmission line 109 beyond the potentiometer 108 with respect to the signals on the transmission line 109 before the potentiometer 107.

A forward-acting control circuit 34 which is similar in construction and operation to the control circuit 34 as shown in Figs. 1 and 2 of the drawings is provided for preventing any operation of the potentiometer arms 111 and 112 until the volume of the signals on the line 109 before the potentiometer 107 is above that of the weakest talker. A backward-acting control circuit 35 similar in construction and in operation to the backward-acting control circuit shown in Figs. 1 and 2 of the drawings is provided for controlling the operation of the potentiometer arms 111 and 112. The control circuits 34 and 35 govern clutches and control circuits 99 in the same manner as the potentiometer arms 6 and 8 are controlled by the clutch mechanisms shown in Fig. 1 of the drawings.

The backward-acting control circuit 35 is connected to the transmission line 109 between the amplifier 110 and the potentiometer 108. When the backward-acting control circuit 35 is so connected, it will be noted that constant volume is maintained on the line 109 between the amplifier 110 and the potentiometer 108, and the volume of the signals on the line 109 beyond the potentiometer 108 will be expanded according to the difference in the changes in decibel loss effected by the potentiometers 107 and 108. If the impedance value of the potentiometer 108 is double the impedance value of the potentiometer 107, the volume of the signals beyond the potentiometer 108 will be doubled with respect to the volume of the signals on the line 109 before the potentiometer 107.

Referring to Fig. 4 of the drawings, a range reducer or compressor is shown which operates in a manner similar to the compressor shown in Fig. 2 of the drawings. A potentiometer 116 is connected across the transmission line 115 and a potentiometer 117 is connected across a branch line 118. The branch line 118 is connected to the transmission line 115 at a point before the poten-

tiometer 116. An amplifier 119 of any suitable type is connected to the transmission line 115 at a point beyond the potentiometer 116. The two potentiometers 116 and 117 are respectively provided with contact arms 120 and 121. The potentiometer 116 is so connected across the transmission line 115 and the potentiometer 117 is so connected across the branch line 118 that if the contact arms 120 and 121 are rotated in a clockwise direction, the gain on both the transmission line and the branch line will be increased. An opposite effect takes place if the two contact arms 120 and 121 are rotated in a counter-clockwise direction. A forward-acting control circuit 34 is connected to the transmission line 115 before the connection of the potentiometer 116 across the transmission line for preventing any control of the potentiometers until the volume on the transmission line before the potentiometer 116 is above that of the weakest talker.

The control circuit 34 in Fig. 4 of the drawings is similar in construction and operation to the control circuit 34 shown in Fig. 1 of the drawings. A backward-acting control circuit 35 is connected to the branch line 118 beyond the potentiometer 117. The control circuits 34 and 35 govern clutches and control circuits 99 for operating arms 120 and 121 in the same manner as the potentiometer contact arms 6 and 8 in Fig. 1 of the drawings are governed. The changes in decibel loss effected by the potentiometers 116 and 117 are varied according to the compression desired on the transmission line 115 beyond the amplifier 119. If the signals beyond the potentiometer 116 are to be compressed one-half with respect to the signals before the potentiometer, then the changes in decibel loss effected by the potentiometer 117 is twice the change in decibel loss effected by the potentiometer 116. In such an arrangement the potentiometer 117 is so operated as to maintain constant volume on the branch line 118 beyond the potentiometer 117. While the potentiometer contact arm 121 is being operated to maintain constant volume on the branch line, the potentiometer arm 120 is being operated to compress the signals on the transmission line 115 one-half.

Referring to Fig. 5 of the drawings, a range expander is shown which operates in a manner similar to the range expander shown in Fig. 3 of the drawings. A potentiometer 123 is connected across a transmission line 124 and a potentiometer 125 is connected across a branch line 126. The branch line 126 is connected to the transmission line 124 at a point before the connection of the potentiometer 123 to the transmission line. An amplifier 127 is connected to the transmission line 124 at a point beyond the potentiometer 123. The potentiometer 123 is provided with a contact arm 128 and the potentiometer 125 is provided with a contact arm 129. The potentiometer 123 effects a larger change in decibel loss than the change in decibel loss effected by the potentiometer 125. Furthermore, the potentiometers 123 and 125 are operated in opposite directions. If the contact arms 128 and 129 are operated in a clockwise direction, the gain effected by the potentiometer 123 is increased and the gain on the branch circuit 126 is decreased by the potentiometer 125. An opposite effect takes place if the contact arms 128 and 129 are rotated in a counter-clockwise direction.

A control circuit 34, similar in construction and operation to the control circuit 34 shown in Fig. 1 of the drawings, is connected to the transmission line 124 at a point before the potentiometer 123 for preventing operation of the contact arms 128 and 129 until the volume on the transmission line 124 before potentiometer 123 is above that of the weakest talker. A control circuit 35 is connected to the branch circuit 126 at a point beyond the potentiometer 125. The control circuits 34 and 35 govern clutches and control circuits 99 for operating the potentiometer arms 128 and 129 in the same manner as the potentiometer arms 6 and 8 in Fig. 1 of the drawings are governed. The potentiometer 125 is so operated as to maintain constant volume on the branch line 126 beyond the potentiometer 125. At the same time the potentiometer 123 is operated to expand the volume of the signals of the transmission line 124. If the changes in decibel loss effected by the potentiometer 123 are twice the changes in decibel loss effected by the potentiometer 125, the range of the signals beyond the potentiometer 123 will be double that of the range of the signals on the transmission line 124 before the potentiometer 123.

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 gain adjusting circuits for a transmission line, an amplifier on said line, a potentiometer having a movable contact arm for controlling the gain of said amplifier, and means controlled according to the volume of the signals on the line for operating said contact arm at one fixed rate to raise the volume and for operating said contact arm at another fixed rate to lower the volume.

2. In gain adjusting circuits for a transmission line, a potentiometer having an adjustable contact arm for controlling the gain on the transmission line, means operated when the volume on the line beyond said potentiometer is below a predetermined limit for operating said contact arm at one fixed rate to raise the volume on the line and means operated when the volume on the line beyond said potentiometer is above a predetermined level for operating said contact arm at a different fixed rate to lower the volume on the line.

3. In gain adjusting circuits for a transmission line, an amplifier on said line, a potentiometer having a movable contact arm for controlling the gain of said amplifier, means operated when the volume of the signals on the line beyond said amplifier falls below a predetermined lower limit for operating said arm at a relatively slow rate to raise the volume of the signals and means operated when the volume of the signals on the line beyond said amplifier rises above a predetermined upper limit for operating said arm at a relatively fast rate to lower the volume of the signals.

4. In a signal system, a transmission line, an amplifier on said transmission line, a potentiometer having a movable contact arm for controlling the gain effected by said amplifier, means comprising clutch mechanism operated when the volume of the signal on the line before the potentiometer is above the volume of the weakest talker and the volume on the line beyond said amplifier is below a predetermined lower volume limit for operating said arm at a relatively slow rate to raise the volume and means comprising clutch mechanism operated when the volume of the signals on the line beyond said amplifier is above a

predetermined upper limit for operating said arm at a relatively fast rate to lower the signal volume.

5. In a signal system, a four-wire circuit having a receiving line and a transmitting line, an amplifier and a potentiometer having a controlling arm in each of said lines, means comprising clutch mechanism controlled in accordance with the signal volume on the transmitting line beyond the potentiometer and amplifier therein for operating the arms of said potentiometers to vary the two potentiometers oppositely and means for preventing operation of the clutch mechanism in a direction to raise the gain on the transmitting line when the volume of the signals on the transmitting line before the potentiometer therein is below the peaks of the weakest talker.

6. In a signal system, a four-wire circuit having a receiving line and a transmitting line, an amplifier and a potentiometer having a controlling arm in each of said lines, means comprising clutch mechanism for operating the arm of the potentiometer in the transmitting line to raise the gain and for operating the arm of the potentiometer in the receiving line to lower the gain when the volume of the signals on the transmitting line before the potentiometer and amplifier therein is above the volume of the weakest talker and the signal volume on the transmitting line beyond the potentiometer and amplifier is below a predetermined lower limit, and means comprising clutch mechanism for operating the arm of the potentiometer in the transmitting line to lower the gain and for operating the arm of the potentiometer in the receiving line to raise the gain when the volume of the signals on the transmitting line beyond the potentiometer and amplifier therein raises above a predetermined upper limit.

7. In a signal system, a transmission line, an amplifier on said line, a potentiometer having a movable contact arm for controlling the gain effected by said amplifier, gain raise clutch mechanism for controlling said contact arm to raise the gain on the line at one rate, gain lower clutch mechanism for controlling said contact arm to lower the gain on the line at a different rate, means for selectively operating said clutch mechanisms according to the energy volume on the line beyond the potentiometer and amplifier to maintain the volume on the line substantially constant.

8. In a signal system, a transmission line, an amplifier on said line, a potentiometer having a movable contact arm for controlling the gain effected by said amplifier, gain raise clutch mechanism for controlling said arm to raise the gain effected by said amplifier, gain lower clutch mechanism for controlling said arm to lower the gain effected by said amplifier, means operated when the volume on the line beyond said amplifier falls below a predetermined lower limit for operating said gain raise clutch mechanism to raise the volume on the line beyond the amplifier, means operated when the volume on the line beyond the amplifier rises above a predetermined upper limit for operating said gain lower clutch mechanism to lower the volume on the line beyond the amplifier, and breaking means operated upon return of the volume on the line to normal value between the upper and lower limits and release of the clutch mechanisms for quickly stopping movement of the contact arm.

9. In gain adjusting circuits for a transmission line, a constantly operating motor, two electromagnetic clutches each having one member adapted to be rotated by said motor, another member normally stationary and adapted to be connected to the rotating member, and an electromagnet for connecting the two members together when energized, gearing for connecting the two rotating clutch members to the motor to effect rotation at different speeds, a potentiometer having a contact arm controlled by said normally stationary clutch members, means operative when the volume on the line beyond said potentiometer is below a predetermined lower level for energizing one of said clutch magnets to operate the contact arm and raise the gain, and means operative when the volume on the line beyond said potentiometer is above a predetermined upper level for energizing the other clutch magnet to operate the contact arm and lower the gain.

10. In a signal system, a transmission line, an amplifier on said line, a potentiometer having a movable contact arm for controlling the gain effected by said amplifier, a circuit comprising a diode triode tube connected to said line before said potentiometer and amplifier, means for supplying negative bias to the grid of said tube by the diode portion thereof connected to said circuit, a gain increase relay connected to the output circuit of said tube and normally operated by the space current flow through said tube, and means controlled by said relay for operating said contact arm to increase the gain effected by said amplifier when the volume on the line before the potentiometer and amplifier is above the volume of the weakest talker and the volume on the line beyond the potentiometer and amplifier is below a predetermined lower limit.

11. In a signal system, a transmission line, an amplifier on said line, a potentiometer having a movable contact arm for controlling the gain effected by said amplifier, a circuit comprising a diode triode tube connected to said line beyond said potentiometer and amplifier, means for supplying negative bias to the grid of said tube by the diode portion thereof connected to said circuit, a gain decreaser relay connected to the plate and filament circuit of the triode portion of said tube and normally operated by the space current flow through the tube, and means controlled by said relay for operating said contact arm to lower the gain effected by said amplifier when the volume on the line beyond said potentiometer and the amplifier rises above a predetermined upper limit.

12. In a signal system, a transmission line, an amplifier on said line, a potentiometer having a movable contact arm for controlling the gain effected by said amplifier, a circuit comprising a diode triode tube connected to said line before said potentiometer and amplifier, means for supplying negative bias to the grid of said tube by the diode portion thereof connected to said circuit, a gain increaser relay connected to the output circuit of said tube and normally operated by the space current flow through the tube, a second circuit comprising a second diode triode tube connected to said line beyond said potentiometer and amplifier, means for supplying negative bias to the grid of the second tube by the diode portion thereof connected to the second circuit, a gain decreaser relay and a gain increase disabler relay connected to the plate and filament circuit of the triode portion of said second tube and each normally operated by the space current flow through the second tube, means controlled by said gain increaser relay for

operating said contact arm to increase the gain effected by said amplifier when the volume on the line before the potentiometer and the amplifier is above the volume of the weakest talker and the volume on the line beyond the potentiometer and the amplifier is below a predetermined lower limit, means controlled by said gain increase disabler relay for preventing increase of the volume on the line under control of the gain increaser relay when the volume on the line beyond the potentiometer and amplifier rises above a predetermined lower limit, and means controlled by said gain decreaser relay for operating said contact arm to lower the gain effected by said amplifier when the volume on the line beyond said potentiometer and amplifier rises above a predetermined upper limit.

13. In control circuits for a signal transmission line, a branch line directly connected to the transmission line to receive signals transmitted over the transmission line, two potentiometers respectively connected across the branch line and the transmission line and each having a movable contact arm, and means controlled according to the volume of the signals beyond the potentiometer connected across the branch line which are received from the transmission line for controlling the two potentiometer arms to vary the volume of the signals on the transmission line beyond the potentiometer therein with respect to the volume of the signals on the transmission line before the potentiometer therein.

14. In control circuits for compressing the volume of the signals on a transmission line, a potentiometer connected across said line and having a movable contact arm, a branch line directly connected to the transmission line to receive signals transmitted over the transmission line, a second potentiometer connected across said branch line and having a movable contact arm, and means controlled according to the volume of the signals on the branch line beyond the potentiometer therein which are received from the transmission line for operating said potentiometer arms to compress the volume of the signal on the transmission line beyond the potentiometer therein with respect to the volume of the signals on the transmission line before the potentiometer therein.

15. In control circuits for a transmission line, two potentiometers connected across said line and each having a control arm, said potentiometer effecting different changes in loss and the potentiometers being so connected to the line that the changes in loss effected by them are varied oppositely when the contact arms are moved in the same direction, and means controlled according to the volume of the signals on the line between said potentiometers for controlling said potentiometers to expand the volume of the signals on the line beyond said potentiometers according to a fixed ratio with respect to the volume of the signals on the line before the potentiometer.

16. In control circuits for a transmission line, two potentiometers connected across said line and each having a contact arm, one of said potentiometers effecting twice the change in loss effected by the other potentiometer and the two potentiometers being so connected to the line that the changes in loss effected by them are varied oppositely when the contact arms are moved in the same direction, and means controlled according to the volume of the signals on the line between said potentiometers for controlling said potentiometer arms to expand the volume of the signals on the line beyond said potentiometers.

HAROLD L. BARNEY.