April 19, 1932. S. DOBA 1,854,828

TRANSMISSION SYSTEM

Filed April 12, 1930 3 Sheets-Sheet 1

FIG. 1

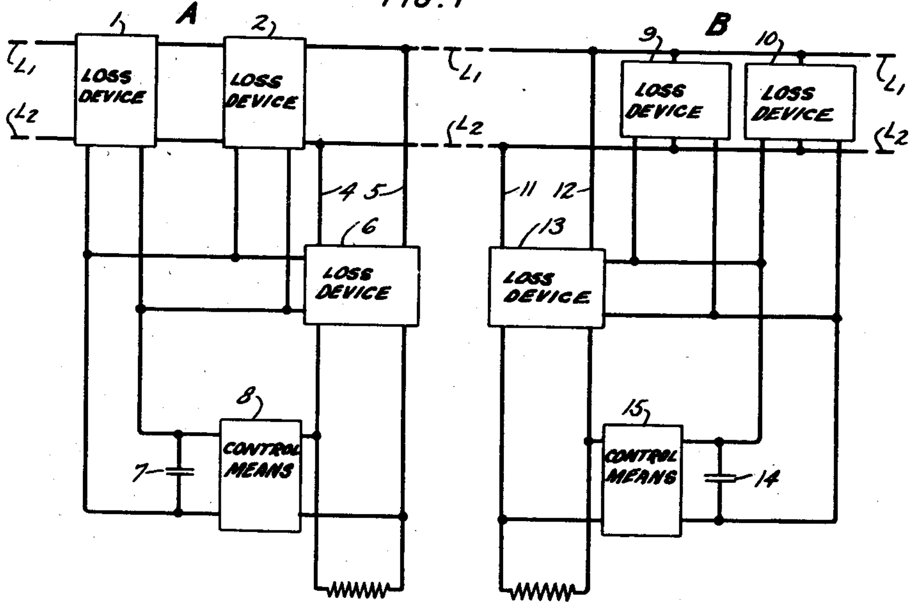
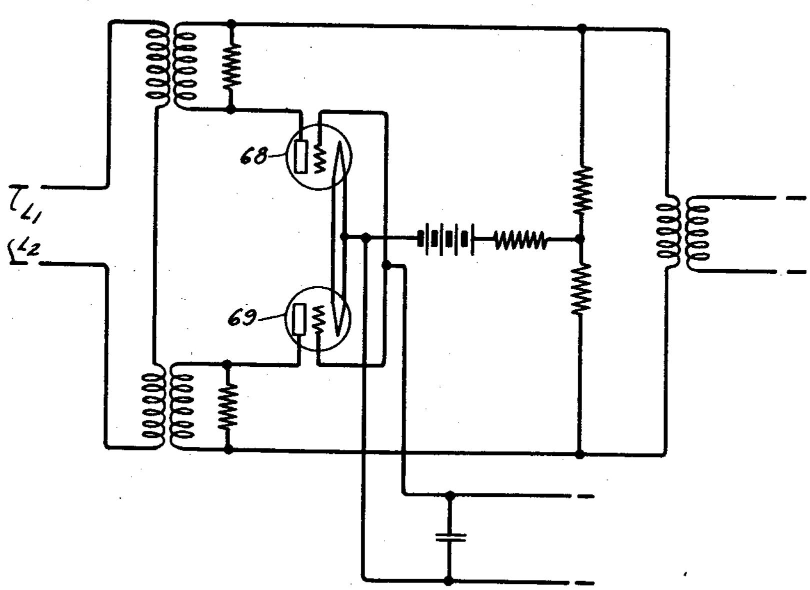


FIG. 4



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TRANSMISSION SYSTEM

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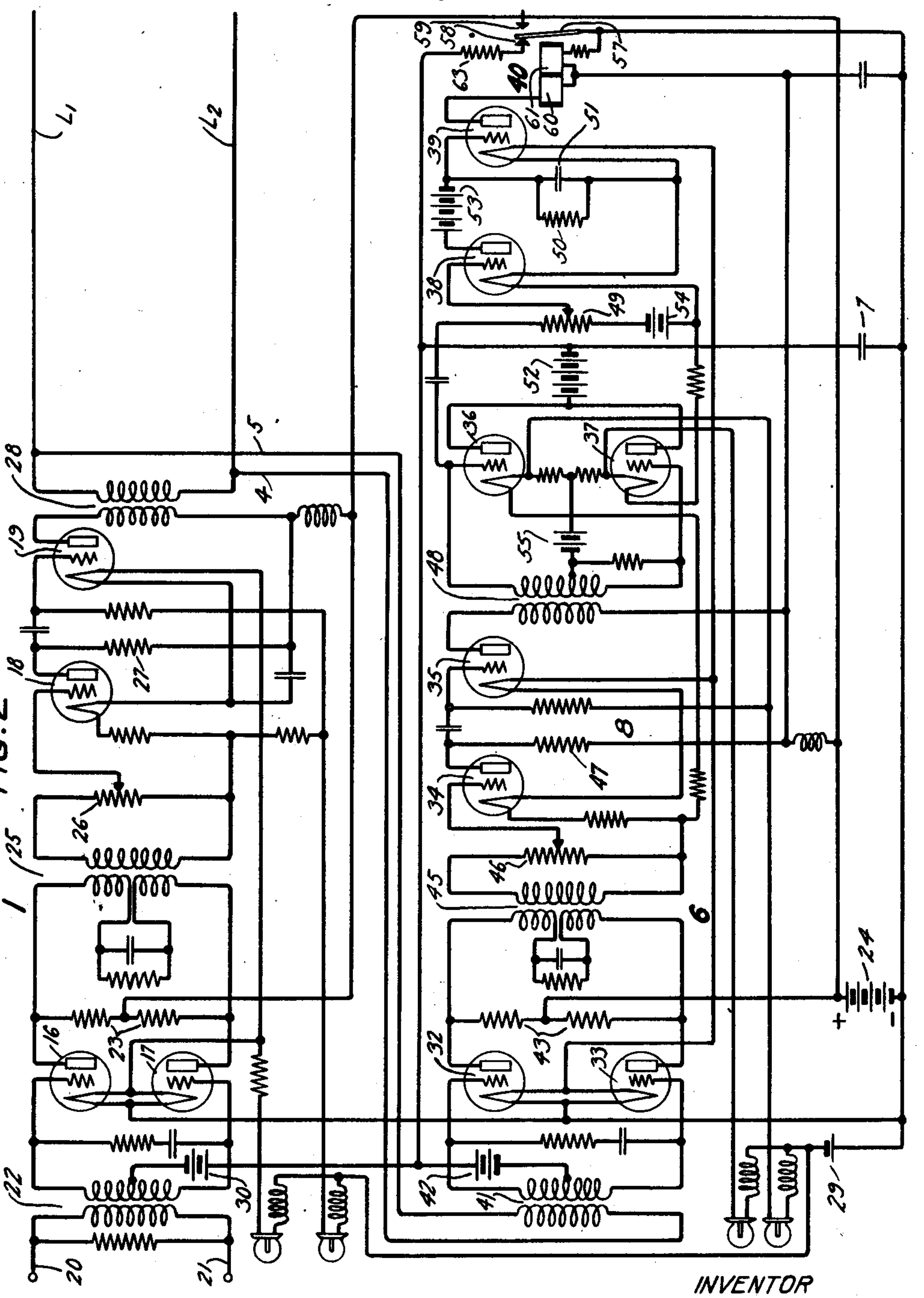

FIG. 2

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TRANSMISSION SYSTEM

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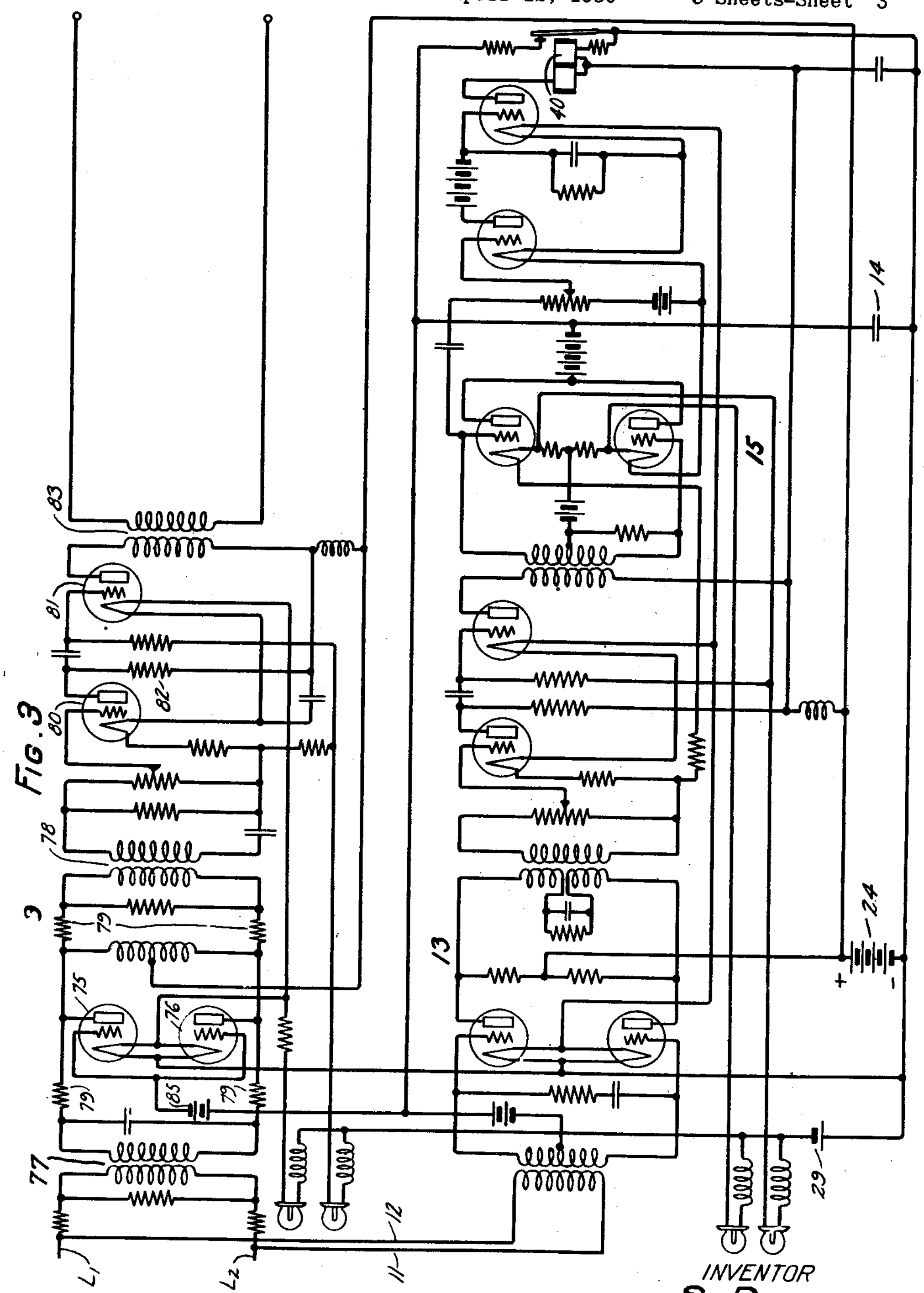

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Patented Apr. 19, 1932

1,854,828

UNITED STATES PATENT OFFICE

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TRANSMISSION SYSTEM

Application filed April 12, 1930. Serial No. 443,640.

This invention relates to signal transmission systems and particularly to volume control circuits for governing the energy volume range at different points on signal transmission systems.

One object of the invention is to provide a transmission system with volume control circuits that shall reduce the energy volume range transmitted over the system a fixed per cent of the energy volume range received for transmission.

Another object of the invention is to provide a transmission system with volume control circuits that shall reduce at the transmitting end of the system the energy volume range transmitted over the system a fixed per cent of the energy volume range received for transmission and that shall restore the volume range transmitted over the system to the original energy volume range at the receiving end of the system.

A further object of the invention is to provide a transmission line with a vacuum tube loss device connected in series with the line at the transmitting end thereof that shall reduce the energy volume range transmitted over the line a fixed per cent of the energy volume range received for transmission and a vacuum tube loss device connected across the line at the receiving end thereof that restores the transmitted energy volume range to the original volume range.

In radio broadcasting programs of speech or music, the program is very often transmitted for some distance over transmission lines before broadcasting. This is true where the broadcasting station and the studio are widely separated. The energy volume range or the speech or music may be such as to overload the apparatus on the transmission line.

The present invention provides means for reducing the energy volume range of speech or music at the transmitting end of a line and for restoring the original energy volume range at the receiving end of the line. Thus in broadcasting operations, where the studio is at a distance from the broadcasting station, the volume range of the program may be reduced when being transmitted from the studio to the broadcasting station and then restored to the original range at the broadcasting station. The present invention also provides for reducing very wide energy volume ranges of speech or music to enable recording on films or phonograph records and for restoring the original range upon reproduction from the film or phonograph record.

In accordance with the present invention one or more vacuum tube loss devices are connected in series with a transmission line at the transmitting end thereof for reducing the volume range of the signals transmitted over the line. At the receiving end of the line one or more vacuum tube loss devices are connected across the line and are so controlled as to restore the volume range of the signals to their original range. At the transmitting end of the line the signals which are received for transmission are assumed to have a relatively wide energy volume range. Such signals at the transmitting station are reduced so that the volume range transmitted over the line has a certain per cent of fraction of the volume range of the signals as received for transmission. At the receiving end of the line the volume range of the signals is restored to the original range received for transmission at the transmitting end of the line.

In a volume control system constructed in accordance with the invention one or more impedances which are in the form of vacuum tube loss devices are connected in series with the transmission line and one or more vacuum tube loss devices are connected in series with a branch circuit joined to the transmission line adjacent to and beyond the last impedance device in series therewith. A condenser is provided for controlling the potential on the grids of the vacuum tube loss devices in series with the line and the grids of the vacuum tube loss devices in the branch circuit. Means are provided for controlling the charge on the condenser to insure a constant volume beyond the impedance device in the branch circuit. When constant volume is maintained beyond the impedance device in the branch circuit, each of the impedance devices in series with the main line reduces the volume range of the transmitted signals a fraction of or a per cent of the range of the signals received for transmission over the line.

At the receiving end of the transmission line one or more vacuum tube loss devices are connected across the line and a branch circuit having a vacuum tube loss device connected in series therewith is joined to the line adjacent to and before the first impedance device at the receiving end of the line. The vacuum tube loss device in series with the branch circuit and the devices connected across the line have their impedances controlled in accordance with the charge on a condenser. The condenser varies the potential impressed on the grids of the impedance devices. The charge on the condenser is controlled by means joined to the branch circuit beyond the vacuum tube loss device in series therewith. The charge on the condenser is so varied as to maintain constant energy volume on the branch circuit beyond the vacuum tube loss device therein, and to control the vacuum tube loss devices connected across the line so as to restore the transmitted volume range to the original volume range of the signals received for transmission at the transmitting end of the line.

In the application of J. L. Hogg and S. Doba Serial No. 445,543, filed April 19, 1930, is disclosed a volume control system having vacuum tube impedance devices connected in series and across the line which are controlled by a condenser very much in the same manner as the control of vacuum tube impedance devices by condensers as hereinafter disclosed.

In the accompanying drawings Figure 1 is a diagrammatic view of a volume control system constructed in accordance with the invention.

Fig. 2 is a diagrammatic view of the volume control circuits at the transmitting end of the system.

Fig. 3 is a diagrammatic view of the circuits at the receiving end of the volume control system.

Fig. 4 is a modification of the vacuum tube loss device which may be inserted in series with the line at the transmitting end thereof, and in series with the branch circuits connected to the line.

Referring to Fig. 1 of the drawings, a transmission line comprising conductors L_1 and L_2 is shown provided with a transmitting station A and a receiving station B. At the transmitting station two vacuum tube loss devices 1 and 2 are connected in series with the line. A branch circuit, comprising conductors 4 and 5 and having a vacuum tube loss device 6 connected in series therewith, is joined to the line beyond and adjacent to the impedance device 2. The potential impressed on the grids of the vacuum tube loss devices 1, 2 and 6 is governed in accordance with the charge on a condenser 7. The charge on the condenser 7 is governed by control means 8 in accordance with the energy volume on the branch circuit beyond the impedance device 6 connected in series therewith.

If three impedance devices are provided at the transmitting end of a line, as is illustrated in Fig. 1 of the drawings, each of said impedance devices will reduce the volume range one-third so that constant volume will be maintained on the branch circuit beyond the vacuum tube impedance device therein. The volume range beyond the first impedance device connected in series with the transmission line will be reduced one-third of the range of the signals received for transmission. The volume range beyond the second vacuum tube device in series with a line will be reduced two-thirds of the volume range of the signals received for transmission over the line. Although only two vacuum tube loss devices are shown in series with the transmission line it is to be understood that only one vacuum tube loss device may be provided or a number of such devices may be connected in series with the transmission line. A detailed description of the loss devices 1, 2 and 6 will be given when reference is made to Figs. 2 and 4 of the drawings. The term "volume" or "energy volume" used in the specification and claims is assumed to be measured in transmission units or decibels.

At the receiving end of the transmission line two vacuum tube loss devices 9 and 10 are assumed to be connected across the conductors L_1 and L_2 of the transmission line. A branch circuit comprising conductors 11 and 12 and having a vacuum tube loss device 13 connected in series therewith is joined to the transmission line adjacent to and before the loss device 9. The loss devices 9, 10 and 13 are controlled in accordance with the potential impressed upon the grids thereof by means of a condenser 14. The charge on the condenser 14 is governed by control circuits 15 which are joined to the branch circuit beyond and adjacent to the vacuum tube loss device 13. The charge on the condenser 14 is controlled to maintain a constant volume range on the branch circuit beyond the vacuum tube loss device 13 and to control the loss devices 9 and 10 so as to restore the transmitted signals to their original volume range. The vacuum tube loss devices 9 and 10 operate in a manner opposite to the vacuum tube loss devices 1 and 2 so as to restore the volume range in a similar manner to the reduction of the range at the transmitting end of a line.

Referring to Fig. 2 of the drawings, a transmitting station, similar to that shown in Fig. 1 of the drawings, is shown connected to the line conductors L_1 and L_2 except that only one vacuum tube loss device is connected in series with the line in place of two loss devices as shown in Fig. 1 of the drawings. Similar parts in Fig. 2 of the drawings to those shown in Fig. 1 of the drawings will be indicated by like reference characters.

The vacuum tube loss device 1, which is connected in series with the line conductors L_1 and L_2, comprises two three-element thermionic tubes 16 and 17. The two tubes are connected in push-pull relationship, and the output circuits thereof are connected to the input circuit of an amplifier tube 18. The amplifier tube 18 is connected to a second amplifier tube 19 which is connected to the line conductors L_1 and L_2 connecting the transmitting station shown in Fig. 2 with the receiving station shown in Fig. 3 of the drawings.

The signals, which are to be transmitted over the line conductors L_1 and L_2, are received over conductors 20 and 21. Conductors 20 and 21 are connected to the input circuits of the impedance tubes 16 and 17 by means of a transformer 22. Resistance and capacity elements are connected across the secondary winding of the transformer 22 for improving the frequency characteristic of the transmitted signals. In the output circuits of the impedance tubes 16 and 17 are connected resistance elements 23 which are joined to a battery 24 supplying plate potential to the tubes. The battery 24 also supplies plate potential to the amplifier tubes 18 and 19. The impedance tubes 16 and 17 are jointed to the input circuit of the amplifier tube 18 by means of a transformer 25 and a coupling resistance 26. The output circuit of the amplifier tube 18 is connected to the input circuit of the amplifier tube 19 by means of a coupling resistance 27. The output circuit of the amplifier tube 19 is connected to the line conductors L_1 and L_2 by means of a transformer 28.

A battery 29 is provided for supplying heating current to the impedance tubes 16 and 17 and the amplifier tubes 18 and 19. Grid biasing potential for the impedance tubes 16 and 17 is provided by the battery 30 and grid biasing potential for the amplifier tubes 18 and 19 is provided by the drop across resistance elements in the heating circuit for the filaments of the tubes.

A branch circuit comprising conductors 4 and 5 is connected to the transmission line beyond the impedance device 1 in series with the line and has an impedance device 6 connected in series therewith. The impedance device 6 comprises two three-element thermionic tubes 32 and 33. The grid potential impressed on the impedance devices 32 and 33 in the branch conductors 4 and 5 and upon the impedance devices 16 and 17 in the main transmission line is controlled according to the charge impressed on a condenser 7. The charge impressed on the condenser 7 is governed by control circuits 8 comprising two amplifier tubes 34 and 35, two rectifier tubes 36 and 37 and two rectifier tubes 38 and 39. The condenser 7 is directly charged by the circuit including the battery 52 and the output circuits of the tubes 36 and 37. The rectifier tubes 38 and 39 control the operation of a relay 40 which governs the discharge of the condenser 7.

A transformer 41 inserted in the branch conductors 4 and 5 is connected to the input circuit of the impedance tubes 32 and 33. Resistance and capacity elements are connected across the secondary winding of the transformer 41 to improve the frequency characteristic of the transmitted signals. A battery 42 is provided for supplying grid biasing potential to the tubes 32 and 33. Resistance elements 43 in the output circuits of impedance tubes 32 and 33 are connected to the battery 24 for supplying plate potential to the tubes. The amplifier tubes 34 and 35 and the rectifier tube 39 are also supplied with plate potential by the battery 24. A transformer 45 and coupling resistance element 46 are provided for connecting the output circuits of the impedance tubes 32 and 33 to the amplifier tube 34. A capacity element and a resistance element are connected in series with the primary winding of transformer 45 for improving the frequency characteristic of the amplifying system. Similar resistance and capacity elements are connected in series with the primary winding of the transformer 25 in the transmission line for a like purpose. A coupling resistance 47 is provided between the output circuit of the amplifier tube 34 and amplifier tube 35. The amplifier tube 35 is connected to the rectifier tubes 36 and 37 by means of the transformer 48. The input circuit of the rectifier tube 38 is connected to the transformer 48 by means of a coupling resistance 49. The output circuit of the rectifier tube 38 is connected to the input circuit of the rectifier tube 39 by means of a coupling resistance 50 and a condenser 51.

Plate potential for the rectifier tubes 36 and 37 is supplied by a battery 52 and plate potential for the rectifier tube 38 is supplied by a battery 53. Heating current for the impedance tubes 32 and 33, the amplifier tubes 34 and 35 and the rectifier tubes 36 to 39, inclusive, is supplied by the battery 29. Grid biasing potential for the rectifier tube 38 is supplied by the battery 54. The battery 55 is provided for supplying grid biasing potential to the tubes 36 and 37. Grid biasing potential is supplied to the tubes 34 and 35 by the drop across resistance elements in the filament heating circuit.

The relay 40 comprises an armature 57 which is adapted to engage a contact member 58 or a stop member 59, an operating coil 60 and a biasing coil 61. The operating coil

60 is included in the output circuit of the rectifier tube 39. The biasing coil 61 is connected across the battery 24. The coil 61 serves to hold the armature 57 in engagement with the stop member 59 when the winding 60 is deenergized. Normally, the current from rectifier 39 through coil 60 overcomes the effect of the current through 61 so that armature 57 is held in engagement with contact member 58. In this position of the armature 57 the condenser 7 is discharged through a resistance element 63. The coil 60 is only deenergized when the signals transmitted over the line conductors L_1 and L_2 and received through transformer 41 and tubes 32 and 33 are above a lower limiting value. When the signals transmitted over the line conductors L_1 and L_2 and received through transformer 41 and tubes 32 and 33 are below the lower limiting value, the battery 54 impresses a strong negative potential on the grid of the rectifier tube 38. This prevents any current flow through the tube 38 and coupling resistance 50 between the tube 38 and the tube 39 so that maximum current flows through the winding 60. The winding 60, as heretofore set forth, moves the armature 57 into engagement with the contact member 58.

If the signals transmitted over the line conductors L_1 and L_2 are above the lower limiting value a potential is impressed on the grid of the rectifier tube 38 from the secondary circuit of the transformer 48 which permits current flow through the tube 38 and the coupling resistance 50. The potential across the coupling resistance 50 controls the grid of the rectifier tube 39 to prevent current flow through the operating winding 60. The winding 61 operates the armature into engagement with the stop member 59 to insure against any discharge of the condenser 7.

The impedance device 1 in series with the line conductors and impedance device 6 in series with the branch conductors 4 and 5, as shown in Fig. 2 of the drawings, are controlled according to the charge on the condenser 7. The charge on the condenser 7 is controlled according to the output from the impedance tubes 32 and 33 in the branch conductors 4 and 5. Inasmuch as only one impedance device is connected in series with the line conductors such impedance device will reduce the volume range of the transmitted signals one-half the range of said signals as received for transmission. The volume beyond the impedance device 6 in the branch conductors 4 and 5 is held constant when the volume range beyond the impedance device 1 on the line is held one-half the volume range of the signals before the impedance device in the transmission circuit.

The control circuit for the tube 16 from the condenser 7 extends from the grid of the tube 16 through a portion of the secondary winding of the transformer 22, grid biasing battery 30, condenser 7 and ground to the filament of the tube 16. A like circuit is traced for the tube 17 of impedance device 1. The grid control circuits for the tubes 32 and 33 of the impedance device 6 in the branch circuit are traced in like manner through the grid biasing battery 42 and the secondary winding of the transformer 41.

If so desired the impedance device 1 in the transmission line and the impedance device 6 in the branch circuit may be connected, as shown in Fig. 4 of the drawings. In Fig. 4 of the drawings two impedance tubes 68 and 69 are shown with their anode-cathode circuits directly connected in series with the line, which may be the transmission line or the branch circuit. A similar impedance device is disclosed in the above mentioned application of J. L. Hogg and S. Doba, Serial No. 445,543.

Referring to the Fig. 3 of the drawings, a receiving station is illustrated which is provided with only one impedance device connected across the line conductors in place of two impedance devices as shown in Fig. 1 of the drawings. Similar parts in Fig. 3 of the drawings to those shown in Figs. 1 and 2 of the drawings will be referred to by like reference characters.

The impedance device 9 comprises two three-element thermionic tubes 75 and 76. The anode-cathode circuits of the tubes 75 and 76 are connected across the line conductors L_1 and L_2 between two transformers 77 and 78. Four resistance elements 79 are connected in the line adjacent to the connection of the anode-cathode circuits of the tubes 75 and 76 across the line. The resistance elements have a relatively high impedance as compared to the impedance of the tubes. The secondary winding of the transformer 78 is connected to the input circuit of an amplifier tube 80. The amplifier tube 80 is joined to a second amplifier tube 81 by coupling resistance 82. The output circuit of the amplifier tube 81 is connected to the transformer 83.

A branch circuit comprising conductors 11 and 12, similar to the conductors shown in Fig. 1 of the drawings, is connected to the line conductors L_1 and L_2 adjacent to and before the impedance device 9. An impedance device 13, which is similar in construction and operation to the impedance device 6 shown in Fig. 2 of the drawings is connected in series with the branch conductors 11 and 12. Control circuits 15 are provided for governing the charge on a condenser 14 to restore the volume range of the signals transmitted over the line of their original volume range. The control circuits 15 are similar to the control circuit 8 shown in Fig. 2 of the drawings and a detailed description thereof is deemed unnecessary. A relay 40, similar to the relay 40 shown in Fig. 2 of the drawings is provided for controlling the discharge of the condenser 14. Condenser 14 is discharged in a manner similar to the discharge of condenser 7.

Filament heating current for all tubes, shown in Fig. 3 of the drawings is supplied from the battery 29. Plate potential for the impedance tubes 75 and 76 and the amplifier tubes 80 and 81 is supplied by the battery 24. Grid biasing potential for the impedance tubes 75 and 76 is supplied by a battery 85. The control circuit for the grids of the impedance tubes 75 and 76 extends from the grids of the tubes 75 and 76 through the grid biasing battery 85, condenser 14 and ground to the filaments of the tubes. The condenser 14 simultaneously controls the potential impressed upon the grids of the impedance tubes 75 and 76 connected across the line conductors and the impedance tubes connected in series with the branch conductors 11 and 12. The impedance tubes in the branch conductors 11 and 12 are so controlled by the condenser 14 as to maintain a constant volume in the branch circuit beyond the impedance tubes. Inasmuch as the impedance tubes 75 and 76 have their anode-cathode circuits connected across the line conductors, an increase of the charge on the condenser will tend to increase the negative potential of the grids of the tubes 75 and 76 and reduce the impedance in the line caused by such tubes. The impedance device 9 will restore the volume range of the transmitted signals to their original range before reduction by the impedance device in series with the line at the transmitting end thereof.

Modification in the system and in the arrangement and location 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 transmission line, a variable loss device connected in series with said line at the transmitting end thereof, and means connected to said line beyond the loss device for governing the device to reduce the energy volume range beyond the loss device a fixed fraction of the energy volume range before the loss device.

2. In combination, a transmission line, a variable loss device connected across said line at the receiving end thereof, and means connected to said line before and adjacent to the loss device therein for governing the device to expand the energy volume range beyond the device a fixed amount of the energy volume range before the impedance device.

3. In combination, a transmission line, a variable loss device connected in series with said line at the transmitting end thereof, means connected to said line beyond the loss device for governing the device to reduce the energy volume range beyond the loss device a fixed fraction of the energy volume range before the device, a second impedance device connected across the line at the receiving end thereof, and means connected to said line before and adjacent to the second impedance device therein for governing the second impedance device to expand the energy volume range beyond the second impedance device a fixed amount of the energy volume range before the second impedance device.

4. In a signal transmission line, means comprising a vacuum tube loss device at the transmitting end of the line for reducing the volume range transmitted over the line a fixed fraction of the energy volume range before the loss device and means comprising a vacuum tube loss device at the receiving end of the line for restoring the volume range of the received signals.

5. In a signal transmission system having signals of relatively wide volume range delivered thereto for transmission over a line, means comprising a vacuum tube loss device at the transmitting end of the line for reducing the volume range a fixed per cent of the range of the signals received for transmission and means comprising a vacuum tube loss device at the receiving end of the line for restoring the volume range of the signal to the original range received at the transmitting end of the line.

6. In a signal transmission system having signals of relatively wide volume range delivered thereto for transmission over a line, means comprising a vacuum tube loss device connected in series with the line at the transmitting end thereof for reducing the volume range of the signals transmitted over the line and means comprising a vacuum tube loss device connected across the line at the receiving end thereof for restoring the volume range of the signals.

7. In combination, a transmission line, a vacuum tube loss device connected in series with the line at the transmitting end thereof, means for controlling the potential impressed on the grid of said device for reducing the range of the transmitted signals, a vacuum tube loss device at the receiving end of the line connected across the line, and means for controlling the potential impressed on the grid of the device at the receiving end of the line for restoring the volume range of the signals.

8. In combination, a transmission line, two three-element vacuum tube loss devices connected in push-pull relationship and in series with said line at the transmitting end thereof, a branch circuit connected to the line at the transmitting end thereof, two three-element vacuum tube loss devices connected in push-pull relationship and in series with said branch circuit, a condenser for controlling the potential on the grids of said devices according to the charge thereon, and means for con-

trolling the charge on said condenser according to the energy volume on the branch circuit beyond the loss device therein to reduce the energy volume range beyond the loss device in the line a fixed fraction of the energy volume range before the loss device in the line.

9. In combination, a transmission line, two three-element vacuum tube loss devices connected in push-pull relationship and across the line at the receiving end thereof, a branch circuit connected to the line before and adjacent to said loss device, two three-element vacuum tube loss devices connected in push-pull relationship and in series with said branch circuit, a condenser for controlling the potential on the grids of said devices according to the charge thereon, and means for controlling the charge on said condenser according to the energy volume on the branch circuit beyond the loss devices therein to expand the energy volume range beyond the loss devices in the line a fixed amount of the energy volume range before the loss devices in the line.

10. In combination, a transmission line, an impedance device connected in series with said line at the transmitting end thereof, a branch circuit connected to the line beyond the impedance device therein, a second impedance device connected in series with the branch circuit, and means governed according to the energy volume in the branch circuit beyond the impedance device therein for controlling the impedance devices to reduce the volume range on the line beyond the impedance device therein and to maintain constant volume range on the branch circuit beyond the impedance device therein.

11. In combination, a transmission line, an impedance device connected across the line at the receiving end thereof, a branch circuit joined to the line before and adjacent to said impedance device, a second impedance device connected in series with said branch circuit, and means governed according to the energy volume in the branch circuit beyond the impedance device therein for controlling the impedance devices to expand the volume range on the line beyond the impedance device therein and to maintain constant volume on the branch circuit beyond the impedance device therein.

12. In combination, a transmission line, a vacuum tube loss device connected in series with the line at the transmitting end thereof, a branch circuit connected to the line beyond the loss device therein, a second vacuum tube loss device connected in series with said branch circuit, a condenser for controlling the impedance of said devices according to the charge thereon, and means joined to said branch circuit beyond the device therein for controlling the charge on said condenser to maintain the volume range constant in the branch circuit beyond the loss device therein and to reduce the volume range on the line.

13. In combination, a transmission line, a vacuum tube loss device connected across the line at the receiving end thereof, a branch circuit joined to the line before and adjacent to said loss device therein, a second vacuum tube loss device connected in series with said branch circuit, a condenser for varying the impedance of said loss devices according to the charge thereon, and means joined to said branch circuit beyond the loss device therein for controlling the charge on said condenser to maintain constant volume range in the branch circuit beyond the loss device therein and to extend the volume range in the line beyond the loss device therein.

14. In combination, a transmission line, a vacuum tube loss device connected in series with the line at the transmitting end thereof, a second vacuum tube loss device connected in series with a branch circuit joined to the line beyond said first mentioned loss device, a condenser for varying the impedance of said devices according to the charge thereon, means joined to said branch line beyond the loss device therein for varying the charge on the condenser to maintain the volume in the branch line beyond the loss device constant and to reduce the volume range in the line beyond the first mentioned loss device, a third vacuum tube loss device connected across the line at the receiving end thereof, a second branch circuit joined to the line before and adjacent to said third device therein, a fourth vacuum tube loss device connected in series with said second branch circuit, a second condenser for varying the impedance of said third and fourth loss devices according to the charge thereon and means joined to said second branch circuit beyond the loss device therein for controlling the charge on the second condenser to maintain constant volume in the second branch circuit beyond the loss device therein and to restore the volume in the line at the receiving end thereof to its original range.

15. In combination, a transmission line, an impedance device connected in series with the line at the transmitting end thereof, a branch circuit connected to the line beyond the impedance device therein, a second impedance device connected in series with the branch circuit, means governed according to the energy volume in the branch circuit beyond the impedance device therein for controlling the impedance devices to reduce the volume range on the line beyond the impedance device therein and to maintain constant volume on the branch circuit beyond the impedance device therein, a third impedance device connected across the line at the receiving end thereof, a second branch circuit joined to the line before and adjacent to said third impedance device, a fourth impedance device connected in series with said second branch circuit, and means governed according to the

energy volume in the second branch circuit beyond the fourth impedance device for controlling the third and fourth impedance devices to expand the volume range on the line beyond the third impedance device therein and to maintain constant volume on the second branch circuit beyond the impedance device therein.

In witness whereof, I hereunto subscribe my name this 11th day of April, 1930.

STEPHEN DOBA.