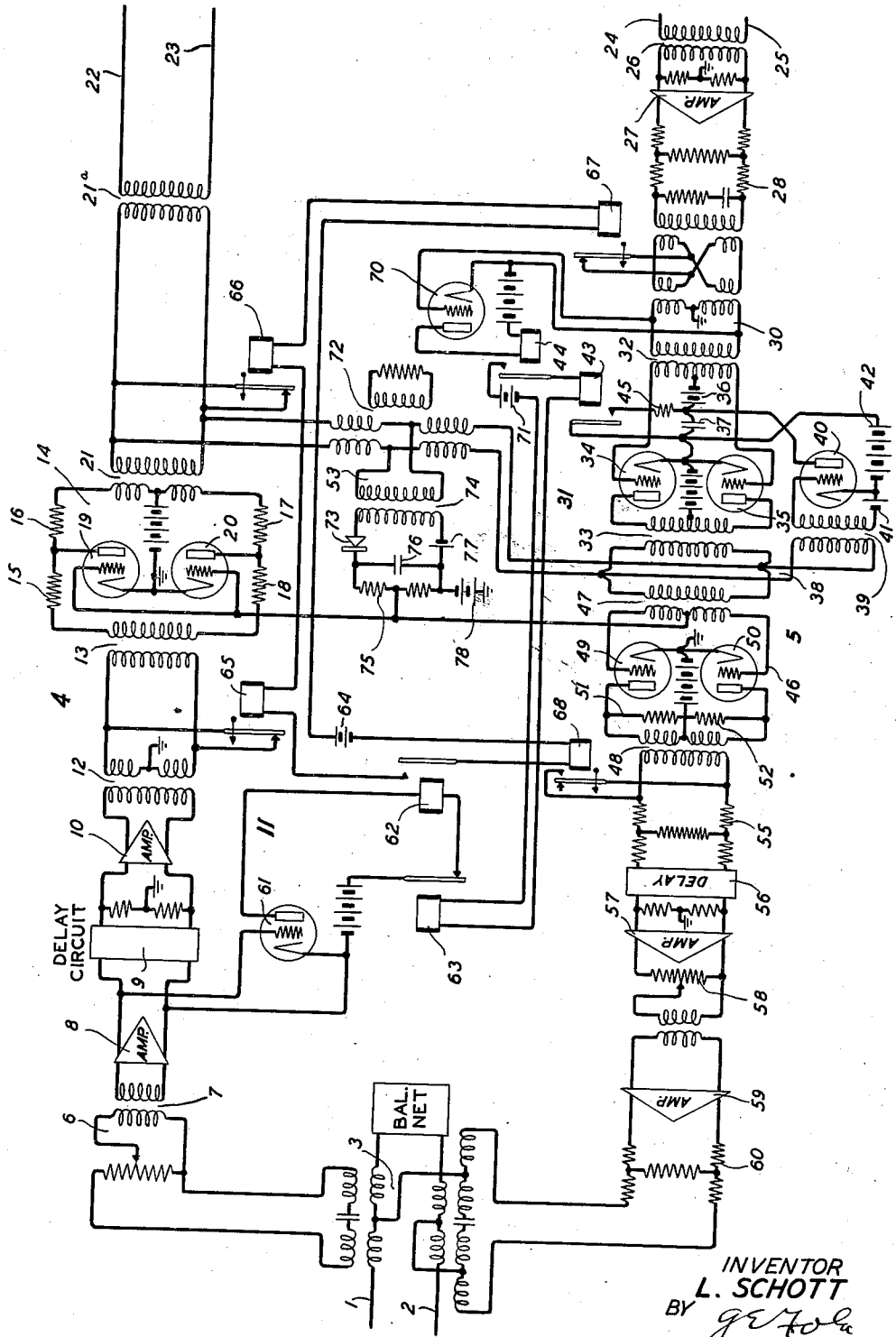
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TRANSMISSION SYSTEM

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TRANSMISSION SYSTEM

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

One object of the invention is to provide a four-wire section of a transmission system with a single control circuit that shall govern volume compression means in the transmitting line and volume expansion means in the receiving line.

Another object of the invention is to provide a four-wire section of a transmission system with a control circuit connected to the transmitting and receiving lines by a hybrid coil that shall govern volume compression means in the transmitting line and volume expansion means in the receiving line.

Another object of the invention is to provide a four-wire section of a transmission system with a control circuit connected to the transmitting and receiving lines that shall govern compression means in the transmitting line to effect compression of the volume range of the signals beyond the compression means with respect to the volume range of the signals before the compression means according to a fixed ratio and that shall govern expansion means in the receiving line to effect expansion of the volume range of the signals beyond the expansion means with respect to the volume range of signals before the expansion means according to a fixed ratio.

A further object of the invention is to provide a four-wire section of a transmission system with a control circuit of the above indicated type and with blocking means that shall block the output circuit of the compressor in the transmitting line when the receiving line is in use and that shall block the output circuit of the expandor in the receiving line when the transmitting line is in use.

The volume range of signals is, in many instances, larger than can be efficiently transmitted over a line. Satisfactory transmission of signals over a line has an upper limit to avoid overloading of line apparatus, such as repeaters, and has a lower limit by reason of interference from line noises. In order to transmit signals over a line with a volume range between the upper and lower limits, it is customary to compress the volume range of the signals at the sending end of the line and to expand the volume range of the signals at the receiving end of the line.

The present invention has been illustrated by means of the volume compression and the volume expansion circuits disclosed in the patent to Stephen Doba, Jr., No. 2,018,489, dated October 22, 1935. The present invention, which is applicable to a four-wire transmission line, is provided with a single rectifying control circuit for not only governing the volume range compressing means in the transmitting line but also for governing the volume range expanding means in the receiving line.

In the transmission system employed to describe the present invention, a two-wire transmission line is connected to one end of a four-wire transmission circuit by means of a hybrid coil. The transmitting line of the four-wire circuit is provided with a gain adjusting device of any suitable type. A gain adjusting device of any suitable type is also provided in the receiving line of the four-wire section. The four-wire section is also provided with echo suppressor circuits of the type disclosed in D. Mitchell Patent No. 1,986,515, dated January 1, 1935. A compressor of the type disclosed in the patent to Stephen Doba, Jr., No. 2,018,489, dated October 22, 1935, is provided in the transmitting line. This compressor preferably comprises an impedance pad having two space discharge devices in push-pull relation connected across it as the shunt member. The receiving line of the four-wire section is provided with an expandor of the type disclosed in the above mentioned patent to Stephen Doba, Jr. This expandor preferably comprises two space discharge devices in push-pull relation effectively connected in series with the receiving line.

A single rectifying control circuit is provided at each end of the four-wire section of the transmission system for controlling a volume compressor in one line and a volume expandor in the other line. The rectifying circuit which is of the type shown in the Doba application for controlling either the compressor or the expandor, is connected to the transmitting line and the receiving line of the four-wire section of the transmission system by means of a suitable hybrid coil. The hybrid coil is connected to the transmitting line beyond the compressor and is connected to the receiving line before the expandor. The rectified potential supplied by the rectifying circuit controls the grid bias on the space discharge devices connected across the pad in the transmitting line and the grid bias on the two space discharge devices effectively connected in series with the receiving line. The characteristic of the rectifying circuit has a definite relation with respect to the characteristic of the compressor so that the volume range of the signals on the transmit-

ting line beyond the compressor are compressed with respect to the volume range of the signals before the compressor according to a fixed ratio. The characteristic of the rectifying circuit also bears a definite relation with respect to the characteristic of the space discharge devices in the expandor to expand the volume range of the signals beyond the expandor with respect to the volume range of the signals before the expandor according to a fixed ratio.

A relay is provided for blocking the output of the compressor in the transmitting line when the receiving line is in service. A similar relay is provided for blocking the output of the expandor in the receiving line when the transmitting line is in service. Preferably, the two blocking relays which selectively block the output circuits of the compressor and the expandor are under the control of the echo suppressor circuits.

The single figure in the accompanying drawing is a diagrammatic view of a signal transmission system constructed in accordance with the invention.

Referring to the drawing, a two-wire line comprising conductors 1 and 2 is shown connected to a four-wire line by means of a hybrid coil 3. The four-wire line comprises a transmitting channel 4 and a receiving channel 5. In the transmitting channel 4 a potentiometer 6 forming a part of a volume control apparatus is directly connected to the hybrid coil 3. The potentiometer 6 is connected by a transformer 7 to an amplifier 8 which is preferably of the space discharge type. The amplifier 8 is connected through delay circuits 9 to an amplifier 10 which is preferably of the space discharge type. The delay circuits 9 and amplifier 10 cooperate with an echo suppressor circuit 11 to be described later. The amplifier 10 is connected by transformers 12 and 13 to a variable repeater 14 in the form of an H-type pad. The pad 14 comprises four resistance elements 15, 16, 17, and 18 in series with the line and two space discharge devices 19 and 20 connected across the line between the resistance elements 15 to 18, inclusive. The devices 19 and 20 are preferably of the three-element type but it is to be understood that other types of space discharge devices may be employed if so desired. The variable repeater 14 is connected by transformers 21 and 21*a* to the transmitting conductors 22 and 23.

The incoming conductors 24 and 25 on the receiving channel 5 are connected by transformer 26 to an amplifier 27 which is preferably of the space discharge type. The amplifier 27 is connected by a pad 28 and an echo suppressor coil arrangement 30 to a volume limiter 31.

The volume limiter 31 comprises an input transformer 32, an output transformer 33 and two three-element space discharge devices 34 and 35 which are effectively connected in series with the line between the secondary windings of the two transformers 32 and 33. A normal bias is impressed upon the grids of the devices 34 and 35 by means of a battery 36. A variable negative bias is impressed upon the grids of the devices 34 and 35 according to the charge on a condenser 37. The condenser 37 is charged at times by a feed-back circuit 38 which is connected to the receiving channel 5 at a point beyond the transformer 33. The feed-back circuit 38 comprises a transformer 39, a three-element space discharge device 40, the output circuit of which is connected across the condenser 37. The device 40, which serves as a detector, is biased by means of a battery 41 so that the feed-back circuit does not operate until the peaks of the signal waves on the receiving signal beyond the transformer 33 are above a predetermined level. The device 40 is provided with a plate battery 42.

A relay 43, which is controlled by a master echo suppressor relay 44, connects a resistance 45 in shunt to the condenser 37 when speech operates in the receiving line. The tendency of this shunt thus applied is to reduce the charge on condenser 37 which in turn increases the gain in the volume limiter 31. The combined actions of this shunt 45 and the feed-back circuit 38 insure control of the speech volume to maintain a suitable volume at the output of transformer 33. The operation of the master relay 44 will be described hereinafter.

The volume limiter 31 is connected to an expandor 46. The expandor 46 comprises an input transformer 47, an output transformer 48 and two three-element space discharge devices 49 and 50 which are effectively connected in series with the line. Resistance elements 51 and 52 are connected across the sections of the secondary winding for the output transformer 48. The grids of the devices 49 and 50 are controlled by a rectifier circuit 53 which also controls the grids of the devices 19 and 20 in the compressor circuit 14. The operation of the rectifier circuit 53 in controlling the negative bias on the devices 19 and 20 in the transmitting channel 4 to compress the signal volume and in controlling the negative bias on the devices 49 and 50 in the receiving channel 5 will be described hereinafter.

The output transformer 48 of the expandor 46 is connected through a pad 55 and delay circuits 56 to a space discharge amplifier 57. The amplifier 57 is connected through a volume control potentiometer 58 to a space discharge amplifier 59. The amplifier 59 is connected through a pad 60 to the hybrid coil 3.

The echo suppressor circuit 11 comprises a space discharge detector tube 61 having the input circuit thereof connected across the transmitting channel 4 beyond the amplifier 8. The output circuit of the detector 61 is connected to the coil of a master relay 62. The energizing circuit for the master relay 62 is also controlled by a relay 63 which, in turn, is controlled by the master relay 44. The master relay 62 when operated completes a circuit from a battery 64 for operating relays 65, 66, 67, and 68. The relays 65 and 66 when in released position block the transmitting channel before and after the compressor 14. The relay 68 when in operated position blocks the receiving channel 5 beyond the expandor 46. The relay 67 when in operated position effects blocking of the receiving channel before the volume limiter 31. Thus, when signal waves are to be transmitted over the transmitting channel 4, the master relay 62 is operated to effect operation of the relays 65 and 66 to clear the transmitting signal and to effect operation of the relays 67 and 68 to block the receiving channel 5. The relays 65, 66, and 68 are slow to release and have a hang-over time of the order of 0.12 second. The relay 67 is slow to release and has a hang-over time of the order of 0.17 second.

The operating coil for the master relay 44 is connected to the output circuit of a space discharge detector 70. The input circuit of the detector 70 is connected across the receiving channel 5 before the limiter 31. When the receiving

channel 5 is in use, the master relay 44 is operated to complete a circuit from the battery 71 to operate the relays 43 and 63. The relay 63 when operated insures against any operation of the master relay 62. This insures that the relays 65 to 68, inclusive, will be held in released position so that the transmitting channel is blocked and the receiving channel is held open.

The rectifier circuit 53 is connected to the transmitting channel beyond the compressor 14 and to the receiving channel before the expandor 46 by means of a hybrid coil 72. The rectifier circuit 53 comprises a two-element rectifier 73 which is connected to the hybrid coil 72 by means of a transformer 74. In circuit with the rectifier 73 is a resistance element 75 shunted by condenser 76 and a biasing battery 77. Preferably, the biasing battery is of the order of 6 volts. A grid biasing battery 78 is connected to the resistance element 75 and the resistance element 75 is connected to the grids of the devices 19 and 20 in the compressor 14 and the grids of the devices 49 and 50 in the expandor 46. The condenser 76 by-passes high frequency currents and provides a time constant so that voltage across the resistance 75 varies according to the syllabic frequency. The potential drops across the resistance element 75 act in series with the grid biasing battery 78 to cause reductions in the normal grid voltage applied to the devices 19 and 20 of the compressor 14. It is apparent that the filament-to-plate impedance of the devices 19 and 20 serves as the shunt member of the H-type pad in the transmitting channel 4 and thus any reduction in the normal grid bias from the battery 78 will change the impedance of the pad and introduce loss in the transmitting channel. The constants of the rectifier circuit 53 and the devices 19 and 20 operate to give waves at the output of the compressor 14 which are equal to the square root of the waves appearing at the input of the compressor. Thus, in the case of speech waves, an amplitude range of about 40 decibels at the input will be compressed to a range of about 20 decibels at the output with corresponding compression for intermediate values. A more complete description of the operation of the compressor is given in the above-mentioned patent to Stephen Doba, Jr., No. 2,018,489, dated October 22, 1935.

A portion of the signal waves which pass into the expandor 46 is also impressed on the rectifier circuit 53 by means of the hybrid coil 72. The rectifier circuit 53 operates in the manner above set forth to effect reduction in the normal grid bias supplied by the battery 78 to the grids of the devices 49 and 50 in the expandor 46. The reduction in the normal grid bias on the devices 49 and 50 causes reduction in the transmission loss in the receiving channel. The combination of the actions of the rectifier circuit 53 and the devices 49 and 50 in the expandor 46 results in producing waves at the output of the expandor which are the square of the waves at the expandor input. A speech wave of 20 decibels amplitude range at the expandor input is expanded to a speech wave of 40 decibels, with intermediate values correspondingly expanded.

Briefly reviewing the operation of the system, signals received over the conductors 1 and 2 will be transmitted over the channel 4. The master relay 62 will be operated to effect operation of the relays 65 and 66 to insure against any blocking of the transmitting channel 4. The relays 68 and 67 will be operated to insure blocking of the receiving channel 5. The relay 68 effectively blocks the output of the expandor 46 when the transmitting channel 4 is in use so that unbalanced currents arising from variations of the grid bias in the expandor 46 also cannot be transmitted beyond the expandor 46. The relay 66 performs a like operation with respect to the compressor 14 when the receiving channel 5 is in use.

The signal waves passing through the compressor 14 operate the feed-back rectifier circuit 53 for effecting a compression of the waves beyond the compressor with respect to the waves before the compressor according to a fixed ratio. Preferably the waves are compressed one-half.

Upon receipt of signal waves over conductors 24 and 25 of the receiving channel 5 the master relay 44 is operated to effect operation of the relay 63. The relay 63 upon operation insures against any operation of the master relay 62 which is controlled from the transmitting channel 4. Accordingly, the relays 65, 66, 67, and 68 are held in released position. This insures blocking of the transmitting channel before and after the compressor 14 so that unbalanced currents arising from variations of the grid bias in the compressor cannot disturb the operation of the system. The incoming waves on the receiving channel 5 pass through the volume limiter 31 to the output circuit thereof and if the waves are too strong, they cause operation of the gain decreaser feed-back circuit 38. This feed-back circuit begins charging of the condenser 37. The voltage built up across condenser 37 acts in series with the fixed grid bias from the battery 36 to increase the total bias and lower the gain. When the output from the volume limiter is normal, the gain decreaser circuit stops functioning. On the other hand, if the charge on the condenser 37 is too high so that the gain in the output is low, the circuit through the resistance 45 which is completed when relay 43 operates, causes the charge on the condenser to leak off. The circuits for charging and discharging the condenser 37 are designed so that a satisfactory input wave is supplied to the expandor 46. A portion of the waves which are supplied to the expandor 46 controls the rectifier circuit 53 to control the grid bias on the tubes 49 and 50 of the expandor 46. The expandor 46 serves to expand the waves beyond the expandor with respect to the wave before the expandor according to a fixed ratio. Preferably, the output waves are the square of the input waves.

In the above circuit arrangement, it will be noted the rectifier circuit 53 serves as a feed-back circuit for controlling the compressor 14 and serves as a forward-acting control circuit for controlling the expandor 46. The operation of the rectifier circuit 53 in controlling the compressor 14 or the expandor 46 is the same as that described in the above-mentioned patent to Stephen Doba, Jr., No. 2,018,489 dated Oct. 22, 1935. In the present invention, only one rectifier circuit is required for controlling the compressor and the expandor at both ends of a four-wire line.

Modifications in the system and in 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 transmission system, a four-wire section, an impedance in the transmitting line of the four-wire section comprising a space discharge device for variably controlling the signal volume, a space

discharge device in the receiving line for variably controlling the signal volume, and one control circuit connected to the transmitting and receiving lines and rectifying a portion of the signals on each of said lines for governing the grid bias impressed on said devices to control the volume beyond said devices in the transmitting and receiving lines.

2. In a transmission system having a four-wire section, an impedance in the transmitting line of the four-wire section comprising a space discharge device for controlling the signal volume, a space discharge device in the receiving line for controlling the signal volume, means comprising one rectifier circuit connected to the transmitting and receiving lines and rectifying a portion of the signals on each of said lines for controlling the grid bias impressed on said devices to control the volume beyond said devices in the transmitting and receiving lines, and means for blocking the output circuit of the device in one line when the other line is in use.

3. In a transmission system having a four-wire section, compressing means in the transmitting line for variably compressing the volume range of the signals, expanding means in the receiving line for variably expanding the volume range of the signals, a hybrid coil connected between the transmitting and receiving lines, said hybrid coil being connected to the transmitting line beyond the compressing means therein and to the receiving line before the expanding means therein, and means comprising a rectifying circuit connected to said hybrid coil for controlling said compressing means and said expanding means.

4. In a transmission system, a four-wire section, means in the transmitting line for variably compressing the volume range of the signals, means in the receiving line for variably expanding the volume range of the signals, means comprising one rectifying circuit connected to the transmitting and the receiving lines and rectifying a portion of the signals on each of said lines for controlling said compressing means and said expanding means respectively by the signals on the transmitting and receiving lines, and means for blocking the output from the compressing means when the receiving line is in use and for blocking the output from the expanding means when the transmitting line is in use.

5. In a transmission system having a four-wire section, compressing means in the transmitting line for variably compressing the volume range of the signals, expanding means in the receiving line for variably expanding the volume range of the signals, a hybrid coil connected to the transmitting line beyond said compressing means and to the receiving line before said expanding means, means comprising a rectifying circuit connected to said hybrid coil for controlling said compressing means and said expanding means, and means for blocking the output from the compressing means when the receiving line is in use and for blocking the output from the expanding means when the transmitting line is in use.

6. In a transmitting system, a four-wire section, an impedance pad in the transmitting line of the four-wire section having a space discharge device connected across it, a space discharge device connected effectively in series with the receiving line of said four-wire section, and one rectifying circuit connected to the transmitting line and to the receiving line and rectifying a portion of the signals on each of said lines for controlling the device in the transmitting line and the device in the receiving line, said rectifying circuit having a characteristic with a definite relation with respect to the characteristics of the devices in the transmitting and receiving lines for effecting a compression of the volume range on the transmitting line beyond said pad with respect to the volume range before the pad according to a fixed ratio and for effecting an expansion of the volume range beyond the device in the receiving line with respect to the volume range before the last mentioned device according to a fixed ratio.

7. In a transmitting system, a four-wire section, an impedance pad in the transmitting line of the four-wire section having a space discharge device connected across it, a space discharge device connected effectively in series with the receiving line of said four-wire section, means comprising a single rectifying circuit connected to the transmitting line and to the receiving line and rectifying a portion of the signals on each of said lines for controlling the device in the transmitting line and the device in the receiving line respectively by the signals on the transmitting and receiving lines, said rectifying circuit having a characteristic with a definite relation with respect to the characteristics of the devices in the transmitting and receiving lines for effecting a compression of the volume range on the transmitting line beyond said pad with respect to the volume range before the pad according to a fixed ratio and for effecting an expansion of the volume range beyond the device in the receiving line with respect to the volume range before the last mentioned device according to a fixed ratio, and means for blocking the output circuit of the device in the receiving line when the transmitting line is in use and for blocking the output circuit of the device in the transmitting line when the receiving line is in use.

8. In a transmission system, a four-wire section, an impedance pad in the transmitting line of said four-wire section, two space discharge devices in push-pull relation connected across said pad, two space discharge devices in push-pull relation effectively connected in series with the receiving line of said four-wire section, a hybrid coil connected to the transmitting line beyond said pad and to the receiving line before said devices, and means comprising a rectifying circuit connected to said hybrid coil for impressing a biasing potential on the grids of the devices in the transmitting line to compress the volume range beyond the pad with respect to the volume range before the pad according to a fixed ratio and for impressing a biasing potential on the grids of the devices in the receiving line to expand the volume range beyond the devices in the receiving line with respect to the volume range before said device according to a fixed ratio.

9. In a transmission system, a four-wire section, an impedance pad in the transmitting line of said four-wire section, two space discharge devices in push-pull relation connected across said pad, two space discharge devices in push-pull relation effectively connected in series with the receiving line of said four-wire section, a hybrid coil connected to the transmitting line beyond said pad and to the receiving line before said devices, means comprising a rectifying circuit connected to said hybrid coil for impressing a biasing potential on the grids of the devices in the transmitting line to compress the volume

range beyond the pad with respect to the volume range before the pad according to a fixed ratio and for impressing a biasing potential on the grids of the devices in the receiving line to expand the volume range beyond the devices in the receiving line with respect to the volume range before said devices according to a fixed ratio, and means for blocking the output circuits of the devices in the transmitting line when the receiving line is in use and for blocking the output circuits of the devices in the receiving line when the transmitting line is in use.

10. In a transmission system, a four-wire section connected to a two-wire section, a space discharge device connected across a pad in the transmitting line of the four-wire section, a space discharge device connected effectively in series with the receiving line of the four-wire section, a control hybrid coil connected to the transmitting line of the four-wire section beyond said device in the transmitting line and to the receiving line of the four-wire section ahead of said device in the receiving line, means comprising a rectifying circuit connected between said control hybrid coil and the grids of the devices in the transmitting and receiving lines for obtaining a variation in volume range beyond the device in the transmitting line with respect to volume range input thereto according to a fixed ratio and for obtaining a variation in volume range beyond the device in the receiving line with respect to the volume range input thereto according to a fixed ratio, and means for blocking the output circuit of the device in the transmitting line when the receiving line is in service and for blocking the output circuit of the device in the receiving line when the transmitting line is in service.

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