

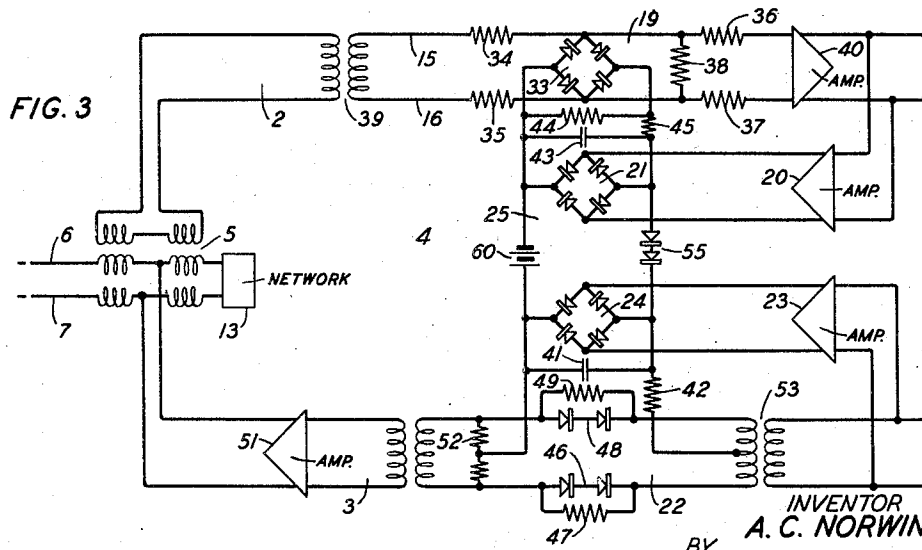
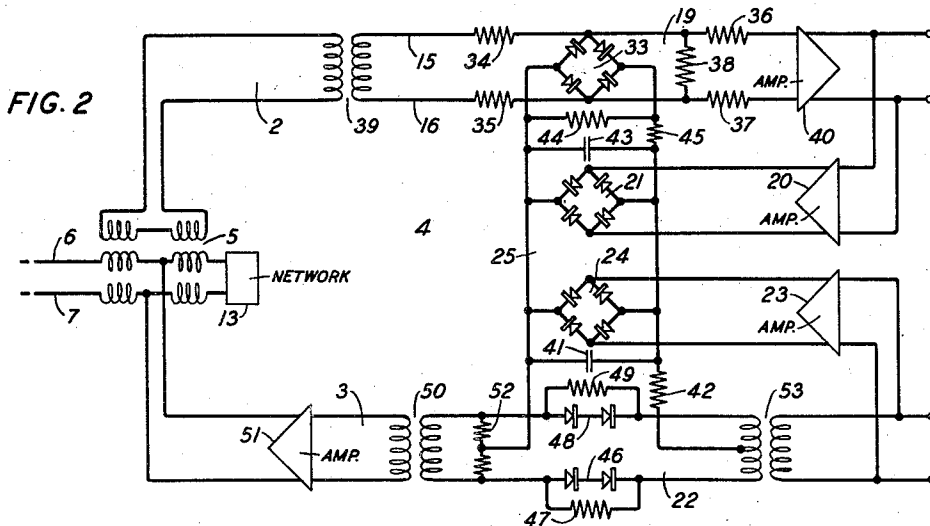
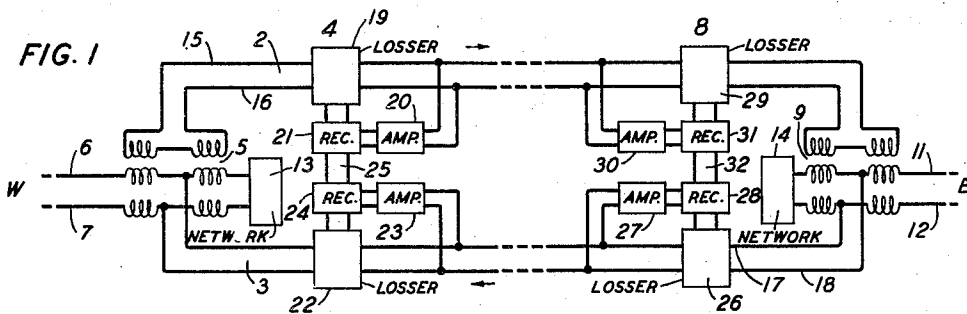
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SIGNAL TRANSMISSION SYSTEM

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SIGNAL TRANSMISSION SYSTEM

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10 Claims. (Cl. 178—44)

This invention relates to signal transmission systems and particularly to compression and expansion circuits for four-wire signal transmission systems.

5 One object of the invention is to provide a four-wire transmission system with control circuits that shall operate not only for effecting compression and expansion of the signals on the system but also for governing the over-all attenuation of the system to prevent singing.

10 Another object of the invention is to provide a four-wire transmission system that shall control variolossers in the transmitting and receiving channels to compress the transmitted signals and to expand the received signals while governing the over-all attenuation of the system to prevent singing.

15 A further object of the invention is to provide a four-wire transmission system that shall control variolossers in the transmitting and receiving channels oppositely to expand received signals and compress transmitted signals while governing the overall attenuation of the system to prevent singing and that shall prevent simultaneous control of the variolossers from the transmitting and receiving channels.

20 In many signal circuits, and especially in circuits connected to radio transmitting and receiving terminals, it is very often desirable to compress the signals received from a telephone line before transmission to the radio apparatus in order to more completely load the space discharge devices in the transmitter and to expand the signals received from the radio apparatus in order to reduce the effective noise and to produce undistorted signals. A compressor and expander arrangement of the type disclosed in the patent to S. Doba, Jr., 2,018,489, October 22, 1935, or in the patent to L. Schott, 2,084,457, June 22, 1937, may be employed in case part of the four-wire system comprises a radio circuit.

25 The transmission equivalent of four-wire systems on which compressor and expander circuits are employed will vary by some amount due to changes in temperature and humidity and, in the case of a radio link, by fading. Changes in the transmission equivalent will give rise to difficulties because the expanders will magnify the variations caused in the signals. Trouble is caused because the expander sets the gain according to the received energy which must be the same as the energy leaving the compressor in order to obtain complementary gain settings. If the channel between a compressor and an expander changes so that it has two decibels gain, then the

expander obtains too great an input which causes the expander to have two decibels too much gain if a two to one ratio expander is employed. If the channel variations produce a loss, the expander will have too little gain and again accentuate the effect of the variation.

5 Accentuation of the channel variations will cause that part of the speech energy which returns to the station of a talker as an echo to be louder or weaker than without a compressor expander arrangement. In the absence of speech on a system equipped with compressor expander equipment, noise within the system may cause one or both of the expanders to increase gain. Echo currents around the whole system will be increased and, if the gain increase is sufficient, so-called singing will be produced.

10 In the above-mentioned patent to L. Schott, 2,084,457, singing on a four-wire system provided with a compressor expander equipment is prevented by means of an echo suppressor arrangement of relays. According to the present invention, singing is prevented by an interlock circuit connection between the compressor and the expander at each terminal station of the four-wire system.

15 The compressor at a terminal station is provided with a variollosser in the form of an impedance pad having a copper-oxide bridge with two opposite vertices connected across the transmitting channel at the station. The loss produced by the variollosser is controlled by varying the current flow between the other two vertices of the bridge.

20 The expander at a terminal station is provided with a variollosser in the form of an impedance pad having copper-oxide rectifier elements inserted in series with each side of the two-wire receiving channel. The loss caused by the variollosser is controlled by varying the current flow through the rectifier elements of the pad in the receiving channel.

25 An interlock circuit is connected between the variolossers of the compressor and the expander of each terminal station. Each interlock circuit has two bridge circuits connected across it which are composed of copper-oxide elements or other suitable non-linear elements. The bridge circuit adjacent to the variollosser in a compressor is governed by a backward-acting control circuit including an amplifier and connected to the transmitting channel beyond the variollosser of the compressor. The bridge circuit adjacent to the variollosser in an expander is governed by a forward-acting control circuit including an ampli-

fier which is connected to the receiving channel before the variolossor of the expander. In the interlock circuit between the variolossor associated with the compressor and the variolossor of the compressor is inserted a condenser resistance arrangement to produce a time constant. Another condenser resistance arrangement is inserted in the interlock circuit between the bridge associated with the expander and the variolossor of the expander to produce a time constant. The time constants of the condenser resistance arrangements are preferably of the order of forty milliseconds.

The two bridges connected across the interlock circuit are poled so that they produce the same polarity of control voltage across the leads of the variolossors. Thus, control current from either control circuit may flow through each of the variolossors, changing their losses in opposite directions because their configurations are such that the losses are complementary. In a compressor expander arrangement, as above outlined, noise or speech entering the expander input will cause its gain to increase and will also cause the compressor gain to decrease. An input to the compressor will cause it to reduce the gain on the transmitting channel and will also cause the expander to increase the gain on the receiving channel. When currents are received by the expander, it may be noise currents or signal currents, the gain effected by the expander is compensated by an equal loss effected by the compressor so that there can be no increased tendency for the system to sing. When the transmitting channel is in service, the speech currents of the talker will compress transmitted signals but will also increase the gain of the expander upon the receiving channel which thereby raises the noise which the talker may hear. However, it has been shown by experience that this noise increasing feature, when the transmitting channel is in service, is not objectionable even with fairly high noise circuits if there is no appreciable delay in transmission because the noise level is high only when the speech is high in amplitude. When the talker is located at a distance from the compressor expander location, the noise variations are more readily perceptible.

In order to avoid raising the effective received noise when the subscriber is talking, a modified unilateral interlock circuit may be provided between the compressor and the expander at each terminal station. In the modified interlock circuit between the variolossors of the compressor and the expander, copper-oxide discs or similar one-way transmitting means are provided in the interlock circuit between the two bridges so that the two variolossors may be controlled from the receiving channel but not from the transmitting channel. In such a connection, outgoing speech cannot vary the incoming noise but incoming speech or noise will reduce the gain in the transmitting channel of the station.

An additional variation in the proposed modification may be provided by inserting a biasing potential in series with the rectifier units in the interlock circuit between the two bridges. The biasing potential is so poled that the expander rectifier voltage must always exceed this bias in order to control the compressor variolossor. This additional biasing potential may be advantageous if the system equipped with compressor expander circuits were so noisy that the expander control frequently reduced the compressor gain during outgoing weak speech currents.

The two bridges in the interlock circuit are so poled with respect to each other as to prevent control of the two variolossors from both the transmitting and receiving channels at the same time. If one bridge produces a greater voltage across the interlock circuit than does the other bridge, the second bridge is effectively biased and can supply little or no regulating current to the variolossors.

Fig. 1 in the accompanying drawing is a diagrammatic view of a four-wire system provided with compressor expander equipments constructed in accordance with the invention.

Fig. 2 is a diagrammatic view of one terminal station in the system shown in Fig. 1 with the interlock circuit between the compressor and the expander shown in detail.

Fig. 3 is a diagrammatic view of a terminal station with a modified interlock circuit between the compressor and the expander.

Referring to Fig. 1 of the drawing, a four-wire system is shown comprising a west-to-east channel 2 and an east-to-west channel 3. The two channels 2 and 3 of the four-wire system are connected at a west terminal station 4 by a hybrid coil 5 to a two-wire line comprising conductors 6 and 7. At an east terminal station 8 of the four-wire system the channels 2 and 3 are connected by a hybrid coil 9 to a two-wire circuit comprising conductors 11 and 12. Networks 13 and 14 are associated with the hybrid coils 5 and 9. The west-to-east channel 2 comprises conductors 15 and 16 into which are connected a compressor at the west station 4 and an expander at the east station 8. Similarly, the east-to-west channel 3, comprising conductors 17 and 18, has connected therein a compressor at the east terminal station 8 and an expander at the west terminal station 4.

The compressor at the west terminal station 4 on the channel 2 comprises a variolossor 19 which is controlled by a backward-acting control circuit comprising an amplifier 20 and a rectifier 21. The expander at the west terminal station 4 comprises a variolossor 22 which is controlled by a forward-acting control circuit comprising an amplifier 23 and a rectifier 24. Between the variolossor 19 in the channel 2 and the variolossor 22 in the channel 3 is connected an interlock circuit 25 which includes the rectifiers 21 and 24. The interlock circuit 25, which will be described more in detail when reference is made to Figs. 2 and 3 of the drawing, serves to interlock the two variolossors 19 and 22 so that they may be controlled from either of the channels 2 and 3.

At the east terminal station 8 on the four-wire circuit the compressor connected to the east-to-west channel 3 is provided with a variolossor 26. The variolossor 26 is controlled by a backward-acting circuit comprising an amplifier 27 and a rectifier 28. The expander in the channel 2 at the east terminal station 8 of the four-wire circuit comprises a variolossor 29 which is controlled by a forward-acting circuit comprising an amplifier 30 and a rectifier 31. The two variolossors 29 and 26 are connected by an interlock circuit 32 which includes the rectifiers 31 and 28. The interlock circuit 32 at the east terminal station 8, the same as the interlock circuit 25 at the west station 4, serves to insure that operation of each variolossor may be effected by either channel of the four-wire system.

Referring to Fig. 2 of the drawing, the west terminal station 4 is shown more in detail. The variolossor 19 in the transmitting channel 2 is

shown comprising a bridge 33 composed of copper-oxide rectifier elements. If so desired, the bridge may be composed of any other suitable elements having a non-linear coefficient of resistance. Two opposite vertices of the bridge 33 are connected across the channel 2 adjacent resistance elements 34, 35, 36 and 37 to form a resistance pad. A resistance element 38 is also connected in shunt across the channel 2. The resistance element 38 determines the minimum loss of the variolossor 19. The variolossor 19 is connected to the hybrid coil 5 by means of transformer 39. An amplifier 40 is preferably associated with the variolossor. The backward-acting control circuit comprising the amplifier 20 and the rectifier 21 is provided for controlling the variolossor 19 to compress the transmitted signals. The rectifier 21 is preferably in the form of a bridge composed of copper-oxide rectifier elements. Two vertices of the bridge 21 are connected to the amplifier 20 and the other two vertices of the bridge are connected across the interlock circuit 25. A condenser 43 and resistance elements 44 and 45 are connected to the interlock circuit 25 between the bridge 21 and the variolossor 19 in order to provide a time constant in the control of the variolossor. This time constant may be varied, if desired, but is preferably of the order of forty milliseconds.

The variolossor 22 in the expander at the west terminal station 4 comprises copper-oxide elements 46 shunted by a resistance 47 in one side of the channel 3 and copper-oxide elements 48 shunted by a resistance element 49 in the other side of the channel 3. The copper-oxide elements 46 and 48 are directly connected in the channel 3 and vary the gain on the channel 3 directly in accordance with their resistance. The variolossor 22 is connected to the hybrid coil 5 by means of a transformer 50 and an amplifier 51 of any suitable type. On one side of the copper-oxide elements 46 and 48 of the variolossor 22 a resistance element 52 is connected across the channel 3 and on the other side of the copper-oxide elements 46 and 48 is connected a transformer 53. Control for the copper-oxide elements 46 and 48 is effected from a mid-point of the resistance 52 and a mid-point of the secondary winding of the transformer 53. The variolossor 22 is controlled by the forward-acting control circuit comprising the amplifier 23 and the rectifier 24. The rectifier 24 is in the form of a copper-oxide bridge similar to the bridge 21 in the control circuit for the variolossor 19. Two vertices of the bridge 24 are connected across the interlock circuit 25 and the other two vertices of the bridge are connected to the amplifier 23. A condenser 41 and a resistance element 42 are connected to the interlock circuit 25 between the bridge 24 and the variolossor 22 in order to provide a time constant in the operation of the variolossor. This time constant may be changed, if desired, and preferably is of the order of about forty milliseconds. It should be noted in the circuit arrangement, shown in Fig. 2 of the drawing, that the time constant for the variolossor 19 and for the variolossor 22 are controlled by the condensers 41 and 43 and the resistance elements associated with the condensers. This condition is apparent because the two condensers 41 and 43 are connected in parallel across the interlock circuit 25.

In the system, as shown in Fig. 2 of the drawing, incoming speech currents on the two-wire line comprising conductors 6 and 7 will be trans-

mitted over the channel 2 to the distant terminal station 8 of the four-wire system. The variolossor 19 under control of the amplifier 20 and the rectifier 21 will compress the transmitted signals and at the same time the potential from the rectifier 21 will operate the variolossor 22 to increase the gain on the channel 3. The increase in the gain on the channel 3 will only take place when the speech currents are high on the channel 2 and will not cause any bad effect unless the talker should be at a distance from the terminal station of the four-wire system. When speech or noise currents are received over the channel 3, the variolossor 22 is operated by the amplifier 23 and the rectifier 24 to expand the volume of the received signals. At the same time, the variolossor 19 in the channel 2 is operated by the potential from the bridge 24 to lower the gain on the channel 2. The lowering of the gain on the channel 2 will insure against any increased interference by singing or echoes. The two bridge circuits 21 and 24 are so poled with respect to each other that simultaneous control of the two bridges from the two channels 2 and 3 cannot take place at the same time. The bridge which has the highest potential impressed thereon will assume control and bias the other bridge against operation.

Referring to Fig. 3 of the drawing, a modification of the interlock circuit, shown in Fig. 2, is illustrated. The circuits shown in Fig. 3 are similar to the circuits shown in Fig. 2 with the exception of the interlock circuit and like parts have been indicated by similar reference characters. In the interlock circuit 25 shown in Fig. 3 of the drawing, unilateral devices 55 are provided for insuring that the variolossor 22 in the channel 3 will not be operated from the channel 2. The variolossor 19 in the channel 2 may be operated from the channel 3 simultaneously with the variolossor 22. The unilateral elements 55 are preferably copper-oxide discs which serve to effect flow of current in the interlock circuit in one direction only. Signal currents or noise currents on the channel 3 operate the amplifier 23 and the bridge 24 to effect operation not only of the variolossor 22 to effect expansion but also to effect operation of the variolossor 19 in the channel 2 to effect compression in the channel 2. The simultaneous operation of the two variolossors 19 and 22 insure against any increased trouble from singing or echoes. A biasing battery 60 may be added to the interlock circuit 25 which is so poled that the expander rectifier voltage must exceed the bias to effect any operation of the variolossor 19 in the channel 2. The addition of the biasing battery 60 may be advantageous if noise in the channel 3 becomes so high that the expander control frequently reduces the compressor gain during transmission of weak speech currents. In the circuit shown in Fig. 3 of the drawing, the variolossors 19 and 22 may be operated with different time constants. It is possible to hold the loss caused by the variolossor 19 on the transmitting channel 2 for a period of time after the expander variolossor 22 has returned to normal condition. The holding of the loss in the transmitting channel for an extended period of time is desirable in the case of delayed echoes.

Although no radio apparatus is shown on the drawing, it is to be understood that, if so desired, a portion of the four-wire circuit may include a radio link. The circuit arrangement shown in Fig. 2 of the drawing will prevent trouble from

echoes and singing due to the variable gain compressors and expanders under most operating conditions. Under some noise conditions, it may be desirable to employ the circuit arrangement shown in Fig. 3 of the drawing if the circuit has sufficient singing margin.

Modifications in the circuits and in the arrangement and location of parts may be made within the spirit and scope of the invention. Such modifications are intended to be covered by the appended claims.

What is claimed is:

1. In a signal transmission system having a four-wire section with transmitting and receiving channels connected to a two-wire section, two variolossers respectively located in the transmitting and receiving channels to effect compression and expansion of signals, an interlock circuit between said variolossers, control means connecting said interlock circuit to said channels for compressing transmitted signals and expanding received signals, and means for connecting said control means to said interlocked circuit in a manner to prevent simultaneous control of the two variolossers from the two channels.

2. In a signal transmission system having a four-wire section with transmitting and receiving channels connected to a two-wire section, two variolossers respectively located in the transmitting and receiving channels to effect compression and expansion of signals, an interlock circuit between said variolossers, two bridge circuits formed of elements having non-linear coefficients of resistance and each having two opposite vertices connected across said interlock circuit, means controlled by the signals on the transmitting channel and connected to two vertices of one bridge for controlling the variolossers in the transmitting channel to effect a compression operation and means controlled from the receiving channel and connected to two opposite vertices of the other bridge for controlling the two variolossers to effect expansion on the receiving channel and attenuation on the transmitting channel, said bridge circuits being poled so that only one bridge circuit can effect a control operation at one time.

3. In a signal transmission system having a four-wire section with transmitting and receiving channels connected to a two-wire section, two variolossers respectively located in the transmitting and receiving channels to effect compression and expansion of signals, an interlock circuit connected between said variolossers, two bridge circuits composed of copper-oxide elements connected across said interlock circuit, said bridge circuits being similarly poled with respect to the interlock circuit, and means comprising a backward-acting control circuit for controlling one of said bridges from the transmitting channel to govern the variolossers in the transmitting channel and effect compression on the transmitting channel, a forward-acting control circuit for controlling the other bridge from the receiving channel to govern both of said variolossers and effect a loss in the transmitting channel and expansion in the receiving channel, the attenuation on said channels being governed by the variolossers under control of the control circuits to prevent singing action.

4. In a signal transmission system having a four-wire section with transmitting and receiving channels connected to a two-wire section by a hybrid coil, a variolossers in the transmitting channel to effect signal compression, a variolossers

in the receiving channel to effect signal expansion, an interlock circuit between said variolossers, means connected to the interlock circuit for controlling said variolossers oppositely from the transmitting channel, means connected to the interlock circuit for controlling said variolossers oppositely from the receiving channel, and means for connecting said last two means to the interlock circuit to insure operation of the variolossers only from one channel at the same time.

5. In a signal transmission system having a four-wire section with transmitting and receiving channels connected to a two-wire section, a variolossers in the transmitting channel to effect signal compression, a variolossers in the receiving channel to effect signal expansion, an interlock circuit between said variolossers, a condenser resistance arrangement inserted in said interlock circuit for providing a time constant in operating the variolossers, means connected to said interlock circuit for operating said variolossers from the transmitting channel, means connected to the interlocked circuit for operating said variolossers from the receiving channel and means for connecting said last two means to the interlocked circuit to insure operation of the variolossers under control of the signals in one channel at a time.

6. In a signal transmission system having a four-wire section with transmitting and receiving channels connected to a two-wire section by a hybrid coil, a variolossers in the transmitting channel, a variolossers in the receiving channel, an interlock circuit between said variolossers, two bridge circuits formed of elements having non-linear coefficients of resistance and each having two opposite vertices connected across said interlock circuit, means controlled by the signals on the transmitting channel and connected to two vertices of one of said bridges for controlling the variolossers in the transmitting channel to effect compression of the signals and for controlling the variolossers in the receiving channel in an opposite manner, means controlled from the receiving channel and connected to the other bridge for controlling the two variolossers to expand the signals on the receiving channel and to add loss on the transmitting channel, said bridge circuits being poled so that only one bridge can control the variolossers at one time.

7. In a signal transmission system having a four-wire section with transmitting and receiving channels connected to a two-wire section, a variolossers in the transmitting channel to effect signal compression, a variolossers in the receiving channel to effect signal expansion, an interlock circuit between said variolossers, unilateral transmitting means inserted in said interlock circuit, means connected to the interlock circuit on one side of said unilateral transmitting means for controlling the variolossers in the transmitting channel from the transmitting channel, and means connected to the interlock circuit on the other side of the unilateral transmitting means for controlling the variolossers in each of said channels from the receiving channel.

8. In a signal transmission system having a four-wire section with transmitting and receiving channels connected to a two-wire section, two variolossers respectively located in the transmitting and receiving channels to effect compression and expansion of signals, an interlock circuit between said variolossers, transmitting control means connected between the transmitting channel and the interlock circuit for governing

the variolosses in the transmitting channel to effect a compression operation, receiving control means connected between the receiving channel and the interlock circuit for governing the variolosses in the receiving channel to effect an expanding operation and for governing the variolosses in the transmitting channel to effect attenuation, and means in the interlock circuit for preventing operation of the variolosses in the receiving channel by the transmitting control means.

9. In a signal transmission system having a four-wire section with transmitting and receiving channels connected to a two-wire section, two variolosses respectively located in the transmitting and receiving channels to effect compression and expansion of signals, an interlock circuit between said variolosses, two bridge circuits formed of elements having non-linear coefficients of resistance and each having two opposite vertices connected across said interlock circuit, unilateral transmitting means comprising copper-oxide rectifier elements inserted in said interlock circuit between the connections of said bridges to the interlock circuit, means controlled by the signals on the transmitting channel and connected to the bridge adjacent to the variolosses in the transmitting channel for controlling the variolosses in the transmitting channel to effect a compression operation, said unilateral means preventing operation of the variolosses in

the receiving channel by the signals on the transmitting channel, and means controlled from the receiving channel and connected to the other bridge for controlling the two variolosses to effect expansion in the receiving channel and a loss in the transmitting channel.

10. In a signal transmission system having a four-wire section with transmitting and receiving channels connected to a two-wire section, a variolosses in the transmitting channel to effect signal compression, a variolosses in the receiving channel to effect signal expansion, an interlock circuit between said variolosses, unilateral transmitting means inserted in said interlock circuit, rectifying means connected between the transmitting channel and the interlock circuit on one side of said unilateral transmitting means for controlling the variolosses in the transmitting channel, receiving rectifying means connected between the receiving channel and the interlock circuit on the other side of said unilateral transmitting means for controlling both variolosses to expand the signals on the receiving channel, and to add loss to the transmitting channel, and a biasing potential inserted in said interlock circuit for preventing operation of the variolosses in the transmitting channel from the receiving channel until the receiving rectifying means supplies potential to the interlock circuit above the potential of the bias.

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