Dec. 14, 1943. D. MITCHELL 2,336,880

STEREOPHONIC CONFERENCE SYSTEM

Filed May 28, 1942 2 Sheets-Sheet 1

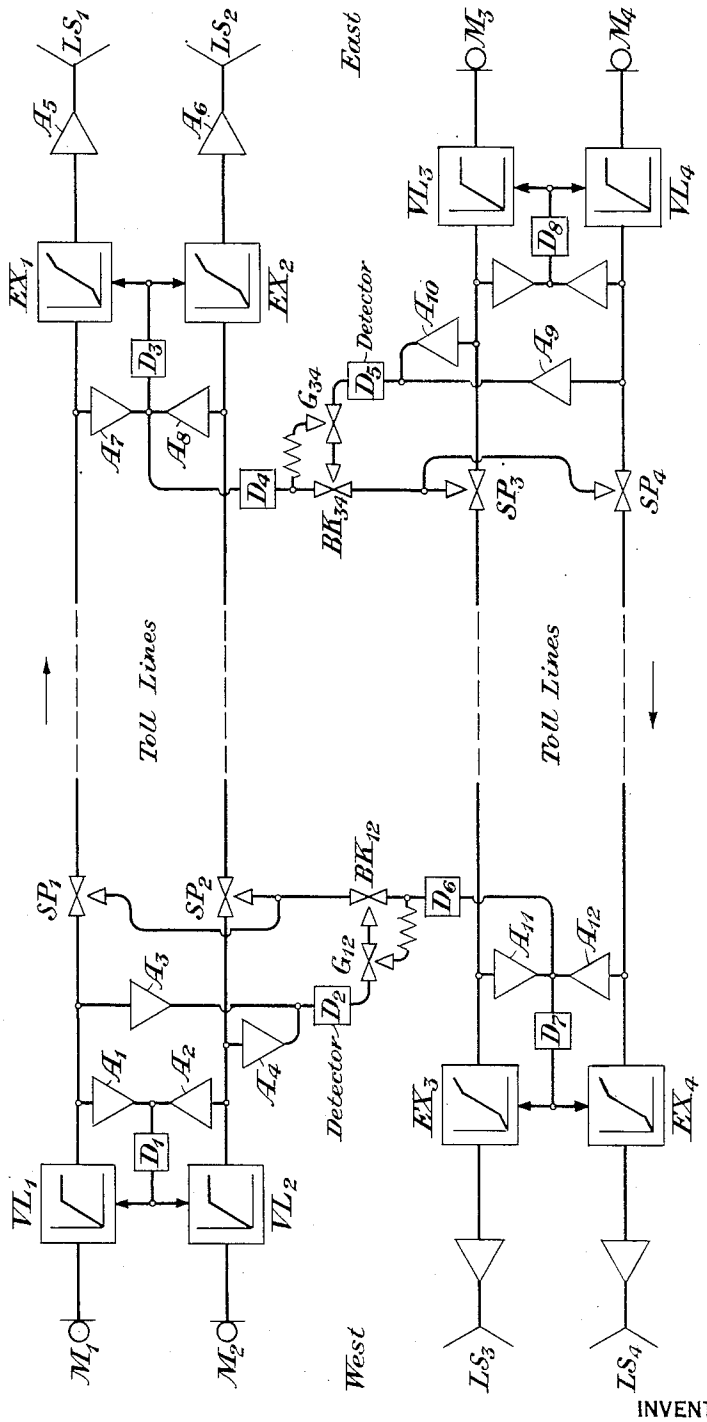

Fig. 1

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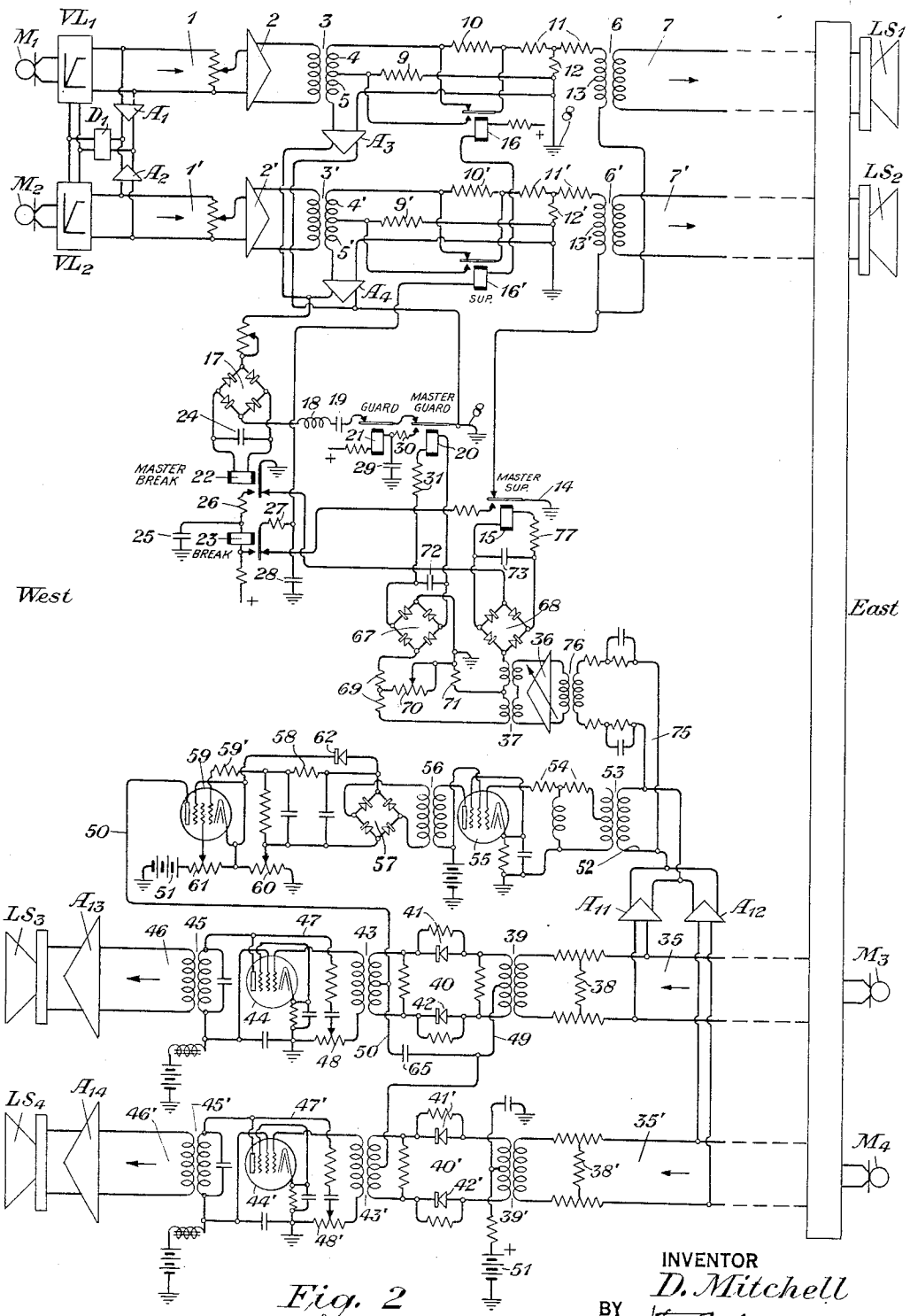

Fig. 2

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STEREOPHONIC CONFERENCE SYSTEM

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8 Claims. (Cl. 179—1)

This invention relates to a two-way speech transmission system characterized by the use at each terminal of two microphonic pick-up devices, each connected to its own transmission circuit, for the transmission of speech therefrom, and also having at each terminal two speech-producing devices, each connected to its own receiving circuit, whereby a stereophonic characteristic may be produced in the transmitted and received speech.

Two-way speech transmission systems having separate transmitting and receiving circuits at each terminal of such a system have been employed in the so-called conference systems by which a group of persons at one location may maintain a conference with a group at a remote location by telephone circuits extending between such locations. Such a system is shown in the patent to Mitchell, 2,267,622, dated December 23, 1941. The system therein disclosed employs a single transmitting circuit and a single receiving circuit, the transmitting circuit having a transmitter, and the receiving circuit a loud-speaker at each terminal of the system. It has been found that by employing two transmitting circuits and two receiving circuits, each transmitting circuit having a transmitter connected therewith, and each receiving circuit having a loud-speaker connected therewith, it is possible to produce in the listeners a sense of location of the speaker, with respect to the transmitters, which adds greatly to the naturalness of the speech that is received at the distant end of the transmitting circuits. Such a system has an additional advantage in that it increases the chances of understanding speech under noisy conditions that may at times exist in a conference where this invention may be employed. The invention likewise may be employed in connection with television systems, being adapted to give a stereophonic effect that would be desirable in connection with television.

These and other objects of this invention and their manner of attainment will be apparent from the following description when read in connection with the attached drawings of which Fig. 1 shows schematically a form of the embodiment of the invention, and Fig. 2 shows in detail the apparatus and the circuit arrangements required for carrying out the invention shown broadly in Fig. 1.

In Fig. 1, M_1 and M_2 represent microphones at the west station of the system, and LS_3 and LS_4 represent loud-speakers at the same station. Each of the microphones is connected to a transmitting circuit that extends from the west station to the east station, such circuits comprising a pair of wires represented by a single line in Fig. 1. The transmitting circuit from the west station terminates in loud-speakers LS_1 and LS_2 at the east station, and at that same station the microphones M_3 and M_4 are connected to a transmitting circuit which becomes the receiving circuit at the west station. The voice waves from a speaker at the west station, falling upon the microphones M_1 and M_2, will produce in them an effect which, in the point of time, will depend upon the relative locations of the speaker and each microphone. The speech currents resulting therefrom will pass through the volume limiters VL_1 and VL_2, and if the suppressors SP_1 and SP_2 are closed, as indicated by the touching arrowheads of the figure, the speech currents will pass over the circuits to the east station. The volume of speech transmitted will depend upon the setting of the volume limiters, and that in turn will be controlled by the output of the detector D_1, the input of which is connected with both transmitting circuits through the amplifiers A_1 and A_2. In that way the volume in both paths may be held below the overload point in the usual manner but in such a way as to keep the loss in both paths always the same, thus maintaining the proper relationship for stereophonic transmission.

To allow break-in when the talker raises his voice, a portion of the speech energy is diverted into the circuit containing the amplifiers A_3 and A_4, the output of which is connected to the detector D_2. The detected current serves to operate the break relay BK_{12}, which disables the suppressors SP_1 and SP_2, and thus allows the west talker to break in. The currents transmitted from the west station will pass through the expanders EX_1 and EX_2 to the loud-speakers LS_1 and LS_2, the connection including amplifiers A_5 and A_6. A portion of the received energy is diverted into the control circuits of the expanders passing through the amplifiers A_7 and A_8, which are connected to the detector D_3, which in turn controls the expanders. Some of this diverted current also is rectified by the detector D_4, and operates the suppressors SP_3 and SP_4 in the circuit that transmits from the east station to the west station. The operation of those suppressors opens the east to west transmitting circuit and prevents singing that may result from sound waves from the loud-speakers at the east station falling upon the microphones thereat.

If the speaker at the east station desires to get control of the system, he may do so by raising

the volume level of his voice and thereby operate the break relay BK_{34}. That result is effected by the current that is diverted into the circuit of the amplifiers A_9 and A_{10}, the output of which, when rectified by the detector D_5, serves to operate break relay BK_{34}. The operation of that break relay restores the contacts of the suppressors SP_3 and SP_4 so that speech currents from the microphones M_3 and M_4 will pass over the westbound circuits to the west station. If the volume level of speech received at the west station is sufficiently high, it will serve to operate the guard relay G_{12}. That is accomplished by the current that passes through the amplifiers A_{11} and A_{12}, which is rectified by the detector D_6 and impressed upon the guard relay G_{12}. The operation of that relay deenergizes the break relay BK_{12}, thus preventing its operation on strong echo. If BK_{12} were allowed to operate on such strong echo, it would disable SP_1 and SP_2, thus allowing echo to get back to the east station and perhaps even allowing singing.

The speech currents being transmitted from the east to west for the actuation of the loud-speakers LS_3 and LS_4 will pass through the expanders EX_3 and EX_4, which are controlled by the rectified output of the detector D_7. All of the expanders of this system are preferably of a type having a fixed loss normally present in them, which loss is adapted to be taken out by the operation of the control devices. The removal of the losses from each pair of expanders is effected simultaneously and equally by the rectified current of the associated detector, which is connected to both circuits through the associated amplifiers.

It will thus be seen that the speech currents from the west station will pass over the transmitting circuits to the east station, and the speech will be reproduced thereat by the loud-speakers LS_1 and LS_2 provided, of course, that the suppressors SP_1 and SP_2 are closed. Those speech currents from west to east will likewise normally operate the suppressors SP_3 and SP_4 at the east station thus preventing echoes and singing. If, however, the east speaker desires to get control of the circuit he may, by raising the volume of his speech, operate the break relay BK_{34} which disables suppressors SP_3 and SP_4 thus permitting transmission from east to west. He cannot break through if west were also talking loud since in this case the guard relay G_{34} would have also been operated. In practice, however, it has been found that talkers seldom speak loud enough continuously to hold the guard relays operated for long periods at a time. Those transmitted currents will then operate the suppressors SP_1 and SP_2, thereby breaking transmission from west to east.

Fig. 2 shows in detail the circuit arrangements for accomplishing the result set forth broadly above. The microphones M_1 and M_2 are connected through the volume limiters VL_1 and VL_2 to the circuits 1 and 1' to which circuits are connected the amplifiers A_1 and A_2, which apply their output currents to the detector D_1, which controls the volume limiters. The currents in circuits 1 and 1', when amplified by the amplifiers 2 and 2', are applied to the transformers 3 and 3', the secondary winding of each of which is divided as indicated by 4 and 5. The voltage across the winding 4 is applied to a circuit that may be traced from ground at 14 through back contact of relay 15, through winding 13, resistances 11, upper contact of relay 16, winding 6, resistance 9, to ground at 8, which circuit is shunted in part by resistance 12. The resistance 10 is normally shunted by the path from the upper contact of relay 16, and the circuit as thus arranged permits the maximum transmission therethrough to the line 7 by which speech is transmitted to the loud-speaker LS_1 at the east end of the circuit. In like manner the speech currents in circuit 1' are transmitted to the line 7' for transmission thereover to the loud-speaker LS_2, the apparatus between the transformers 3' and 6' being similar to that between transformers 3 and 6 of the upper transmission circuit.

Winding 5 is connected to the input of the amplifier A_3, the output of which is connected to the rectifier 17. In similar fashion winding 5' is connected to the amplifier A_4, the output of which is similarly connected to the said rectifier. The current rectified by 17 controls the master break relay 22, which in turn controls the break relay 23. The break relay in turn controls the suppressor relays 16 and 16'. The master guard relay 20 is controlled through the rectifier 67, which is connected through a network to the transformer 37 to which is applied a voltage that represents the combined effect of the currents in the receiving paths 35 and 35'. The circuits just traced, including the suppressor circuits between the transformers 3 and 6 and 3' and 6', respectively, are in general similar to those shown in the patent to Mitchell, 2,267,622, to which reference is made for an understanding of the characteristics of certain details which are fully described therein.

Each receiving circuit has therein apparatus (expander) for gradually cutting out a loss so as to increase the output of such circuit. That is represented by the apparatus between the circuits 35 and 46 and 35' and 46', and also by the apparatus that is connected to the transformer 53. The received speech waves pass from the circuit 35 through the pad 38 to the loss circuit 40, and thence through the amplifier 44 to the outgoing circuit 46, which is connected through the amplifier A_{13} to the loud-speaker LS_3. In order to remove the loss normally present in circuit 40, a portion of the speech waves is diverted to the circuit 52, which is connected to both incoming circuits 35 and 35' and is impressed by transformer 53 upon the amplifier tube 55. The network included in that connection is designed to make the circuit sensitive to the high energy portion of the speech band in the vicinity of 1,000 cycles. The speech waves amplified by 55 pass through the transformer 56 to the rectifier 57. The rectified current, with the pulsations suppressed by the filter 58, are impressed upon the tube 59. The space current of that tube flows from the battery 51 through the winding of the transformer 39', the varistors 41' and 42' in parallel to the mid-point of the primary winding of transformer 43', thence to the mid-point of the secondary winding of transformer 39, thence through the varistors 41 and 42 in parallel to the mid-point of the primary winding of transformer 43, thence by conductor 50 to the plate of the tube 59. An increase of current flow through this circuit decreases the loss in the circuit 40, and also 40', by lowering the impedance of the varistors 41 and 42, and also 41' and 42'. The effect of the incoming speech in the branch 52 is to operate the controlled devices that correspond to the expanders EX_3 and EX_4 of Fig. 1, and thereby to remove loss from

the expander circuits and thus give an increased volume of speech in the circuits 46 and 46'.

The manner in which the aforedescribed apparatus operates in order to attain the objects of this invention is as follows: With the relays 15, 16 and 16' in their normal unoperated condition the speech currents originating in the microphones M_1 and M_2 will be transmitted through the suppressor circuits to the lines 7 and 7', and will in turn be transmitted to the loudspeakers at the distant ends of those lines. A portion of such currents will be amplified by A_3 and A_4, and the current resulting from the combination will be rectified by 17 and will operate relay 22 if the talker were speaking loudly. The opening of the right-hand contact of that relay will cause the master suppressor relay 15 to fall back even though it was already operated by the received currents in the circuit 75. Upon the closing of the left-hand contact of relay 22, relay 23 will be energized, and the positive battery associated with relay 23 will immediately charge up condenser 28 if it were partially discharged. Thus relays 16 and 16' will immediately release without having to wait for the normal hangover time. With the latter relays unoperated the shunts around the resistances 10 and 10' are maintained, thereby maintaining through transmission conditions into the lines 7 and 7'. When the west talker speaks in a normal manner, he will only occasionally operate relays 22 and 23, however.

When the person or persons at the east terminus of the system speak, the resultant speech currents are diverted in part from the lines 35 and 35', and when amplified by A_{11} and A_{12} are impressed by the circuits 52 and 75 across the transformer 76. The resultant voltage, when amplified by 36, is impressed across the transformer 37, the secondary winding of which is split.

Let us assume for the moment that no speech of sufficient magnitude is coming from west to operate relays 22 or 23. In this case the voltage in the upper half of transformer 37 will be rectified in rectifier 68 and operate the master suppressor relay 15. Operation of this relay immediately disables the transmitting paths by removing ground from transformers 13 and 13' and also initiates operation of relays 16 and 16'. The latter is accomplished by discharging condenser 28 through resistance 27, back contact of relay 23 and the front of relay 15. Relays 16 and 16' will then remain operated for a time after the release of relay 15 while condenser 28 is being charged up through their windings and the resistance shown. This prevents the return of any delayed echoes due to room reverberations.

Speech energy from the lower half of transformer 37 is applied through the loss network 69, 70 and 71 to rectifier 67, and if of sufficient magnitude, operates the master guard relay 20. This in turn operates the guard relay 21 which is given hangover time by the usual arrangement of resistances and condenser 29 indicated. As long as either one of these relays is operated, it will be impossible for speech waves to operate the break relay 22. Thus, when receiving speech is sufficiently strong to cause very strong echoes, operation of the guard relays prevents operation of the break relays by echoes. As noted previously, this is necessary to prevent strong echoes from breaking in and possibly causing singing.

At the same time these speech waves are passed through circuit 52 to operate the two expanders, thus removing loss and allowing speech to pass through to the loud-speakers LS_3 and LS_4.

It is now apparent that if the east talker, for example, is speaking in a normal tone of voice, he will operate the suppressor relays 16 and 16' a large portion of the time and will also remove practically all of the loss from the expanders. Due to their substantially lower sensitivity, he will only occasionally operate the guard relays 20 and 21. Thus if the west talker desires to break in, he may do so by raising his voice sufficiently to operate the break relays 22 and 23, provided that he speaks for a sufficient time to operate these relays in intervals in which the guard relays are not operated. As noted previously, the difference in sensitivity of the guard relays and suppressor relays causes the guard relays to be operated a much smaller part of the time than the suppressor relays and the result is that break-in is, as a rule, quite easy on this system.

From the foregoing description it will be seen that the loss in each path may be changed in the same manner as shown in the aforesaid patent to Mitchell, 2,267,622, but in such a way as to keep the loss in both paths always the same. In that way the proper relationship for stereophonic transmission is always maintained, and in addition singing or echo difficulties, which might result if the losses in the two paths were different, are avoided.

While this invention has been disclosed as embodied in a particular form of an arrangement of parts, it is capable of embodiment in other and different forms without departing from the spirit and scope of the appended claims.

What is claimed is:

1. A stereophonic speech transmission system comprising two one-way transmitting circuits, each of the said circuits having a transmitter at one and the same end thereof, and having a loud-speaker at the other end thereof, volume-limiting devices in each of said circuits, and means controlling said volume-limiting devices by the resultant of the currents in both circuits, to reduce equally the volume in each circuit, thereby maintaining the proper relationship for stereophonic speech transmission.

2. A stereophonic speech transmission system comprising two one-way transmitting circuits, two one-way receiving circuits, means connected to each transmitting circuit to regulate the transmission characteristics of that circuit, and means connected to both receiving circuits and responsive to the resultant of the currents in both receiving circuits to vary simultaneously and equally the loss in the receiving circuits, thereby maintaining the proper relationship for stereophonic speech transmission.

3. In a two-way stereophonic speech transmission system, the combination with two outgoing speech paths at each station of two incoming speech paths at the same station, adjustable means in each outgoing speech path to introduce a loss therein, controlling means operated by the resultant of the speech currents in both incoming paths to control the loss-introducing means in both outgoing paths, and breaking means controlled by the resultant of the speech currents in both outgoing paths to prevent the actuation of the loss-introducing means by the said controlling means.

4. The system defined by claim 3 further characterized by means controlled by the resultant

of the speech currents in both incoming paths to render inoperative the said breaking means whenever the intensity of the current in the incoming paths reaches a predetermined level.

5. A two-way stereophonic speech transmission system comprising at each station two outgoing speech paths, and also at each station two incoming speech paths, each of the said outgoing paths at each station having a transmitter connected thereto and each of the said incoming paths at each station having a loudspeaker connected thereto whereby speech may be stereophonically transmitted and reproduced, means in the outgoing paths at each station to introduce a loss therein to prevent singing when the sound produced by the loud-speakers at a given station reaches a predetermined level, and means controlling the said loss-introducing means by the resultant of the currents in both incoming paths at that station.

6. The system defined by claim 5 further characterized by a breaking means controlled by the resultant of the currents in both outgoing paths from a given station to remove the loss put in the outgoing paths by the loss introducing means in the said outgoing paths.

7. The system defined by claim 5 further characterized by a breaking means controlled by the resultant of the currents in both outgoing paths from a given station to remove the loss put in the outgoing paths by the loss introducing means in the said outgoing paths, and means controlled by the resultant of the currents in the incoming paths, whenever that resultant reaches a predetermined level to render ineffective the said breaking means, thereby leaving the loss-introducing means in the outgoing paths under the control of the speech currents in the incoming paths.

8. In a two-way stereophonic speech transmission system, the combination with two circuits both arranged to transmit from east to west, of two other circuits both arranged to transmit from west to east, each of said circuits having a transmitter at one end and a loud-speaker at the other end thereof, a volume limiter in each circuit, means for controlling the pair of volume limiters in the westbound circuits by the joint effect of the currents in both of the latter circuits, similar means in the eastbound circuits similarly controlled, means in the westbound circuits to introduce a loss therein, means connected to both eastbound circuits and responsive to the joint effect of the currents therein to control the loss-introducing means in the westbound circuits, and similar loss-introducing means in the eastbound circuits controlled by the joint effect of the currents in the westbound circuits.

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