

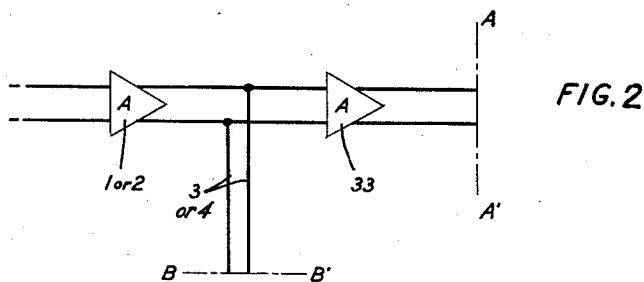
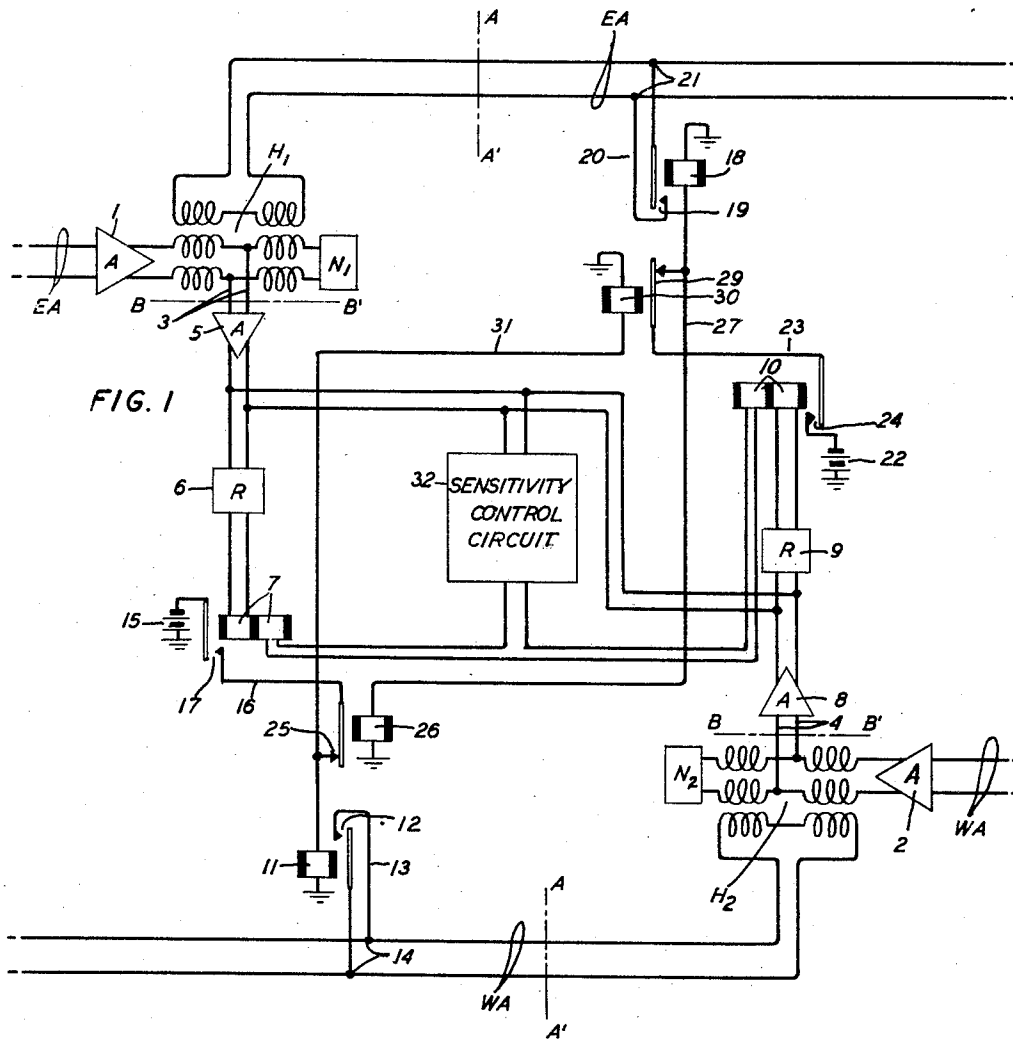
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B. G. BJÖRNSON

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TRANSMISSION CONTROL CIRCUITS

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INVENTOR  
B. G. BJÖRNSON  
BY *H. A. Burgess*  
ATTORNEY

## UNITED STATES PATENT OFFICE

BJÖRN G. BJÖRNSON, OF NEW YORK, N. Y., ASSIGNOR TO BELL TELEPHONE LABORATORIES, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK

## TRANSMISSION CONTROL CIRCUITS

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This invention relates to two-way signaling systems and particularly to four-wire repeating circuits and the devices associated therewith for suppressing echoes and preventing singing.

Signal-controlled, circuit-control apparatus, commonly known as echo suppressors are usually employed in connection with the repeating circuits of long two-way signaling systems to insure that the system transmits in only one direction at a time, so as to suppress echoes and to prevent singing. This is usually accomplished by making the circuit-control apparatus connected to one one-way repeating path responsive to signal transmission therein to disable effectively the oppositely directed one-way repeating path and the input of the corresponding circuit-control apparatus connected thereto. In order to prevent false operation of such a circuit by line noise, the suppressors must be so constructed that they will not be operated by noise.

Heretofore echo suppressors in which the sensitivity decreases as the line noise increases have been found useful in systems subjected to varying amounts of line noise to provide maximum efficiency for the varying noise conditions. Such are usually designed so that the suppressor connected to one repeating path and responsive to signals therein simultaneously short-circuits the return repeating path and the input of the echo suppressor associated therewith. It may be readily seen that this may result in false operation of the return path echo suppressor by line noise, inasmuch as the short-circuiting of the input of the return path echo suppressor may prevent proper operation of the means provided for varying the sensitivity of the echo suppressors in accordance with the line noise.

In accordance with the present invention, the above mentioned disadvantages are avoided by preventing transfer of energy between the disabling point in each repeating path and the input to the associated echo suppressor and sensitivity control circuit, and by causing the return path and its associated echo suppressor to be disabled independently. This is accomplished by (1) associating the

portion of each transmission path which is disabled and the input to the associated echo suppressor and to its sensitivity control circuit in substantially conjugate relation with each other, for example, by the use of a hybrid coil connection, or by inserting a unilateral transmission device, such as an additional repeater, in each repeating path between the disabling means therein and the input to the associated echo suppressor and its sensitivity varying means; and (2) by designing the circuits so that under control of the signals in one repeating path, the return line is disabled, and independently the output of the return-line echo suppressor is disabled.

The invention will be better understood from the following detailed description thereof when read in connection with the accompanying drawing, Fig. 1 of which shows a portion of a four-wire telephone repeating system embodying the invention and Fig. 2 of which shows an alternative circuit which may be used in place of a portion of the circuit of Fig. 1 embodying the invention.

The four-wire telephone repeating system shown in part in Fig. 1 comprises the one-way transmission path EA including the one-way amplifying device 1 for transmitting telephonic signals in the direction from west to east and the one-way transmission path WA including the one-way amplifying device 2 for transmitting telephonic signals in a direction from east to west. The two one-way amplifying paths EA and WA may be associated at the east and west terminals of the system by means of the usual hybrid coil transformers and associated balancing networks (not shown), in energy transmitting relation with two lines leading to a west and an east subscriber respectively, and in conjugate relation with each other in the manner well known in the art.

The outgoing portion of the transmission path EA and the input of the control circuit 3 are connected by means of the hybrid coil transformer H<sub>1</sub> and the associated impedance network N<sub>1</sub> simulating the impedance of the output of amplifying device 1, in conjugate

relation with each other and in energy transmitting relation with the output of the amplifying device 1, in well-known manner. Similarly, the outgoing portion of the transmission path WA and the input of a control circuit 4 are connected by means of a hybrid coil transformer  $H_2$  and the associated impedance network  $N_2$  simulating the impedance of the output of amplifying device 2, in conjugate relation with each other and in energy transmitting relation with the output of the amplifying device 2.

The control circuit 3 comprises the amplifying device 5 having its input connected across the bridge points between the line windings of hybrid coil  $H_1$ , the rectifier 6 having its input connected to the output of the amplifying device 5, and the left hand (operating) winding of the master echo suppressor relay 7 connected to the output of the rectifier 6. The control circuit 4 comprises the amplifying device 8 having its input connected across the bridge points between the line windings of hybrid coil  $H_2$ , a rectifier 9 having its input connected to the output of the amplifying device 8, and the right hand (operating) winding of the master echo suppressor relay 10 connected to the output of the rectifier 9.

Adjacent the path WA is a relay 11 which when energized is adapted to operate so as to close the normally open contacts 12 in the connection 13 so as to short circuit the outgoing portion of the path WA at the points 14. The relay 11 is arranged to be supplied with energizing current from the battery 15 over the conductor 16 when the normally open contacts 17 therein are closed by operation of relay 7 in response to the energization of the operating winding thereof under control of the rectified currents from the output of the rectifier 6. Adjacent the path EA is a relay 18 which when energized is adapted to operate so as to close the normally open contacts 19 in the connection 20, thereby short-circuiting the outgoing portion of the path EA at the points 21. The relay 18 is arranged to be supplied with energizing current from the battery 22 over the conductor 23 when the normally open contacts 24 therein are closed by operation of the relay 10 in response to the energization of the operating winding thereof under control of the rectified currents from the output of the rectifier 9.

In the conductor 16 are the normally closed contacts 25 adapted to be opened by operation of the relay 26. The relay 26 is arranged to be supplied with energizing current from the battery 22 over the conductor 27 and the conductor 28 when the normally closed contacts 24 in the latter are closed by operation of the relay 10. In the conductor 23 are the normally closed contacts 29 adapted to be opened by operation of a relay 30.

Relay 30 is arranged to be supplied with energizing current from the battery 15 over the conductor 31 and the conductor 16 when the normally open contacts in the latter are closed by operation of the relay 7.

Relay 7 has a right hand winding, which we will refer to hereafter as the biasing winding, so wound that when supplied with energizing current it will effectively oppose the action of the operating winding of the relay, that is, it will bias the relay 7 against operation. Similarly, the relay 10 has a left-hand winding, which will be referred to hereafter as the biasing winding, so wound that when supplied with energizing current it will oppose the action of the right hand (operating) winding of the relay, that is, it will bias the relay 10 against operation. To control the current through the biasing windings of relays 7 and 10, and consequently the sensitivity of these relays to operation, a sensitivity control circuit, represented by the box 32, is employed. The input of the device 32 is connected in parallel across the control circuit 3 between the amplifier 5 and the rectifier 6 therein and across the control circuit 4 between the amplifier 8 and the rectifier 9 therein, and, therefore, will be supplied with the amplified speech and noise currents diverted into control circuits 3 and 4 from transmission paths EA and WA, respectively. The output of the device 32 is connected to the biasing windings of relays 7 and 10 in such manner that its output currents will be divided equally between the biasing windings of the two relays.

The sensitivity control circuit 32 may be any circuit which will be unresponsive to fluctuating voice currents impressed on its input, but will be responsive to the comparatively steady noise currents impressed on its input so as to produce in its output, currents varying in direct proportion to the amplitude of the steady noise currents. The box 32 may comprise, for example, the circuit disclosed for a similar purpose in the co-pending application of D. Mitchell and H. C. Silent, Serial No. 341,542, filed February 20, 1929, now Patent No. 1,772,551. In the drawing of the latter application the right-hand windings of relays  $R_1$  and  $R_2$  would correspond to the operating windings of relays 7 and 10 in the drawing of the present application, and the amplifiers  $A_1$  and  $A_2$  in the former application would correspond to the amplifiers 5 and 8 of the present application. The apparatus contained within the box 32 in the present application, therefore, may comprise all the apparatus shown connected between the outputs of amplifiers  $A_1$  and  $A_2$  and the biasing windings of relays  $R_1$  and  $R_2$  in the drawing of the Mitchell-Silent application including resistance  $r_1$ , hybrid coil HC and the tubes  $VT_1$ ,  $VT_2$ , and  $VT_3$ . The manner of operation of this

apparatus is explained in the above mentioned application.

The output current of the sensitivity control circuit 32 will be supplied, as stated above, to the biasing windings of relays 7 and 10 and act therein so as to bias these relays against operation. Of course, a portion of the amplified steady noise currents from the transmission path EA in the output of amplifier 5 in control circuit 3 will be impressed on the rectifier 6 along with the speech currents, and will be rectified thereby and supplied to the operating winding of relay 7. Similarly a portion of the noise currents from the path WA in the output of amplifier 8 in control circuit 4 will be rectified by rectifier 9 and supplied to the operating winding of relay 10. If the gain of the sensitivity control circuit 32 and that of the rectifier 6, and the rectifier 9 were the same, the noise currents supplied to the two windings of the relays would be equal and, the two windings of each relay being wound in opposition, the noise currents would effectively neutralize each other as regards affecting the operation of the relays. To prevent this, the gain of the rectifiers 6 and 9 are adjusted with respect to the gain of the sensitivity control circuit 32 by suitable means so that the noise currents supplied thereby to the biasing windings of relays 7 and 10 respectively, will be greater in magnitude than the rectified noise currents supplied to the rectifying windings of these relays from the outputs of rectifiers 6 and 9 respectively. The net effect of the control circuit 32, therefore, is to reduce the sensitivity of the relays 7 and 10 as the amplitudes of the noise waves in either of the transmission paths EA and WA increase, in direct proportion to these amplitudes.

The operation of the system of Fig. 1 in the present application will now be described. As the operation of the system when speech waves are being transmitted from west to east is identical with the operation as when speech waves are being transmitted from east to west, only the operation in the former case need be described.

It will be assumed that speech waves are being transmitted over the transmission path EA in the direction from west to east, and at that time no speech currents are being transmitted over the transmission path WA in the direction from east to west. The speech currents transmitted over the path EA will be amplified by the amplifier 1 therein and transmitted into the hybrid coil  $H_1$ . The main portion of the amplified speech currents will be impressed by the hybrid coil  $H_1$  upon the outgoing portion of the transmission path EA, and the contacts 19 of the connection 20 being in their normal open condition, these waves will be transmitted over the path EA

to the line connected to the listening subscriber.

A portion of the speech waves in the output of the amplifier 1 will be transmitted from the hybrid coil  $H_1$  into the control circuit 3 bridged across the path EA and will be amplified by the amplifier 5 therein. The amplified speech waves in the output of the amplifier 5 will be divided between the input of the sensitivity control circuit 32 and the input of the rectifier device 6. The portion diverted into the input of control circuit 32 will be dissipated therein as that circuit, as stated above, is designed to be unresponsive to fluctuating speech waves. The portion of the amplified speech waves in the output of amplifier 5 impressed on the input of rectifier 6 will be rectified and supplied to the operating winding of relay 7 causing that relay to be operated.

Meanwhile, a portion of the noise waves which may happen to be present in the input of the transmission path EA at the time the speech waves are being transmitted over the paths EA will also be diverted into control path 3 and amplified by the amplifier 5 therein. Similarly, a portion of any noise waves which may be present in the input of the path WA at this time will be diverted into the control circuit 4 and amplified by the amplifier 8 therein. The amplified noise waves in the output of amplifier 5 will be divided between the input circuit of the sensitivity control circuit 32 and the input circuit of the rectifier 6. Similarly, the amplified noise waves in the output of amplifier 8 in control circuit 4 will be divided between the input circuit of the sensitivity control circuit 32 and the input circuit of the rectifier 9. The portion of the noise waves impressed on the input circuit of rectifier 6 will cause rectified current varying in accordance with the impressed noise waves to be supplied to the operating winding of relay 7, and the portion of the amplified noise waves impressed on the input circuit of rectifier 9 will similarly cause rectified current varying in accordance with the impressed noise to be supplied to the operating winding of relay 10.

The portions of the amplified noise waves diverted into the input of the control circuit 32 from the output of amplifier 5 in control circuit 3 and from the output of amplifier 8 in control circuit 4 will be superposed in the input of circuit 32, causing this circuit to operate and supply equal currents varying in accordance with the impressed noise to the biasing windings of relays 7 and 10 connected to the output of the circuit 32. The portion of the currents in the biasing windings of relays 7 and 10 not effectively neutralized as regards operation of the relays by the rectified noise currents supplied to the operating windings of these relays from the output of rectifiers 6 and 9 respectively, will effectively op-

pose any pull tending to close the relay contacts, exerted by the operating windings of the relays in response to impressed speech currents. The net effect of this opposing action will be to reduce the sensitivity of the relays 7 and 10 as regards operation in direct proportion to an increase in the amplitude of the noise waves in the transmission paths EA and WA.

The current supplied to the operating windings of relay 7 from the output of rectifier 6, comprising as it does the superposed rectified speech waves and the rectified noise currents, will be greater in magnitude than the current supplied to the biasing winding of relay 7 which comprises noise currents only, and, therefore relay 7 will be operated.

The operation of relay 7 will close the normally open contacts 17 in conductor 16, causing relay 11 to be energized over conductor 16 and relay 30 to be energized over conductors 16 and 31, both from battery 15.

Operation of relay 11 will cause the outgoing portion of transmission path WA to be disabled by the resulting short circuit across the points 14 therein. The disabling of the outgoing portion of the path WA will not effect the input to the control circuit 4 inasmuch as the outgoing portion of path WA and the input of control circuit 4 are connected in conjugate relation with each other by means of the hybrid coil  $H_2$  and the associated balancing network  $N_2$ .

Relay 30 will operate simultaneously with relay 11 to open the normally closed contacts 29 in the energizing circuits for relays 18 and 26. This will prevent relays 18 and 26 from being thereafter operated due to the false operation of relay 10 to close the short-circuiting connection 20 across the outgoing portion of the transmission path EA and to break the energizing circuit for relay 11, respectively, as long as relay 7 is maintained operated by the west to east speech currents.

A particular feature of the circuit of the invention as above described is that of having the echo suppressor master relays 7 or 10 associated with the transmission paths EA and WA respectively, when operated by a speech impulse transmitted over the associated path, disable the circuits controlled by the other master relay instead of disabling the input to that relay. This will prevent the false operation of the master relay associated with the transmission path transmitting speech currents by noise waves or by any wave energy which may leak through the hybrid coil associated with the outgoing portion of the path transmitting the speech waves into the input of the other transmission path, before the sensitivity control circuit 32 becomes effective to reduce the sensitivity of the master relay, from causing the disabling of the first transmission path and

effectively disabling the echo suppressor fed from that path.

It may be desirable to utilize a delay circuit in either control circuit 3 or 4, for example, comprising an extra relay controlled by the master transmitting relay and operating a definite time thereafter, so as to compensate for any time differences between the arrival of the operating impulses at the controlling relays caused by differences in the characteristics of the lines over which the operating impulses are transmitted.

The various control relays used in the system should be designed, of course, to have the required amount of hang-over in their action to prevent clipping of speech caused by their premature release when one party ceases talking.

Fig. 2 shows an alternative circuit arrangement in accordance with the invention which may be substituted for each of the portions of the circuit of Fig. 1 contained within the dot-dashlines A—A' and B—B'. In the substituted circuit an additional amplifier 33 is substituted for and utilized to perform the same functions as the hybrid coils  $H_1$  or  $H_2$ , that is, to prevent the short circuiting of one transmission path in response to the operation of the control circuit associated with the other transmission path, from affecting the input to the sensitivity control circuit 32. Amplifier 33 being a one-way device will prevent any change in its output caused by the short circuiting of the outgoing transmission path from affecting its input, and thus from affecting the input to the sensitivity control circuit 32 over the control circuits 3 or 4.

The invention has been described in connection with a four-wire echo suppressor in which the sensitivity of the suppressor as regards operation by voice currents is varied in accordance with the amount of noise on either side of the circuit by applying a current varying in accordance with the noise to biasing windings on the relays controlling the disabling of the return path. It is apparent that the invention is applicable as well to echo suppressors employing sensitivity varying means of other types, for example, the type in which the noise currents in either or both of the oppositely directed transmission paths are utilized for varying the sensitivity of the amplifier-rectifier tubes controlling the echo suppressor relays instead of the sensitivity of the relays themselves. Other sensitivity controlling circuits which may be used are disclosed in the co-pending applications of A. B. Clark, Serial No. 301,867, filed August 24, 1928, of D. Mitchell, Serial No. 341,543, filed February 20, 1929, and of Wright-Mitchell, Serial Nos. 283,406 and 283,407, filed June 6, 1928.

In the particular modifications of the invention which have been illustrated and described, current controlled mechanical relays

are employed for disabling the transmission paths by connecting short circuits across these paths. It is apparent that it is within the scope of the invention to utilize other well-known means for disabling these paths, for example, current-controlled means for connecting loss networks across the paths or for open-circuiting these paths. Instead of utilizing mechanical relays and movable contacts for performing the switching operations, stationary means may be used for that purpose, such as vacuum tube relays disclosed, for example, in an article by C. A. Berris and G. T. Evans in the *Journal of the Institute of P. O. Electrical Engineers* (London), vol. 20, pages 65 to 72, inclusive, published in April, 1927, or in the United States patent to Crisson No. 1,647,212, issued November 1, 1927.

What is claimed is:

1. In combination in a signal transmission system, two signal transmission paths subject to interfering noise, means responsive to signal transmission in one of said paths for disabling the other of said paths, means connected to said paths and automatically responsive to the noise therein to control the operation characteristics of the disabling means in accordance with the amount of noise in said paths, and means for preventing the operation of said disabling means from affecting the automatic control of the operation characteristics thereof in accordance with the amount of noise in said transmission paths.

2. In a two-way signal transmission system, a four-wire repeater circuit for repeating signal waves for both directions of transmission, means connected to each repeating path and responsive to transmission of signal waves therein for suppressing echoes in the oppositely directed repeating path, the characteristics of said echo suppressing means being automatically controlled in accordance with the amount of sustained line noise in said repeater circuit, and means for preventing false operation by line noise of the echo suppressor connected to one repeating path when signals are being transmitted over the other repeating path without interfering with the automatic control of the characteristics of the echo suppressors in accordance with the amount of line noise.

3. In a two-way signal transmission system, a four-wire repeater circuit for repeating signal waves in opposite directions over that system, control means connected to each repeating path and responsive to signal transmission therein for effectively disabling the other repeating path, means automatically responsive to line noise in the repeating paths of said system for varying the sensitivity of said control means in proportion to the amount of said noise, and means for substantially preventing said sensitivity-varying

means from being affected by the disabling of said other repeating path.

4. In a two-way signal transmission system, a four-wire repeater circuit for repeating signal waves in opposite directions over said system, control means connected to each repeating path in the output of the amplifying means therein and responsive to amplified signal waves therein for disabling the other repeating path, and for effectively disabling the control means connected to said other path, means for varying the sensitivity of said control means in accordance with the amount of line noise in the system and means for preventing the operation of said sensitivity-varying means from being affected by the disabling of said other repeating path.

5. In a two-way signal transmission system, a four-wire repeater for amplifying signal waves transmitted in opposite directions over said system, control means connected to each repeating path and responsive to waves therein, means controlled by operation of the control means connected to each repeating path for effectively disabling the other repeating path, means for varying the sensitivity of the control means in accordance with the amount of line noise in the system, and means responsive to the operation of one control means in response to signal transmission in the repeating path connected thereto for, without adversely affecting the operation of said means for varying the sensitivity of the control means, preventing the disabling of that repeating path and the control means connected thereto by false operation by line noise of the other control means.

6. The system of claim 3 and in which the last mentioned means includes means for substantially preventing the transmission of reflected wave energy back from the disabling point in said other repeating path to the input of said sensitivity-varying means.

7. The system of claim 3 and in which the last mentioned means includes a one-way transmission device connected in each repeating path between the point of connection thereto of the input to said sensitivity varying means and the disabling point in that path, and poled so as to prevent return currents in that path from reaching the input to said sensitivity-varying means.

8. The system of claim 5 and in which the last mentioned means includes means controlled by the control means connected to the path transmitting signals but independent of the means disabling the other repeating path, for blocking the operation of said other control means without blocking the input to the sensitivity-varying means.

9. The system of claim 5 and in which the last mentioned means includes means controlled by the control means connected to the path transmitting signals but independent of the means disabling the other repeating path,

for open-circuiting the output of said other control means.

10. The system of claim 4 and in which the last mentioned means comprises means for preventing the disabling of said other path  
5 from affecting the input to said sensitivity-varying means, and means controlled by the control means connected to the path transmitting signals but independent of the means  
10 disabling the other path, for blocking the action of said other control means without blocking the input to said sensitivity-varying means.

11. The system of claim 4 and in which the  
15 last mentioned means includes a transmission device connected between the disabling point in each repeating path and the input to the control means connected thereto, said transmission device being adapted to allow trans-  
20 mission of waves between the output of the amplifying means and said disabling point and to preventing transmission of waves between said disabling point and the input of said control means.

12. In combination, in a two-way signal  
25 transmission system, a four-wire repeater circuit for repeating signals for both directions of transmission, control means connected to each of the oppositely directed repeating  
30 paths and responsive to waves therein, means responsive to operation of the control means connected to each repeating path for disabling the other repeating path, means connected to both repeating paths and responsive  
35 to sustained line noise in either of said paths for decreasing the sensitivity of the control means as the amount of sustained noise increases, means responsive to the operation of the control circuit connected to one repeat-  
40 ing path in response to signal transmission therein without affecting the operation of said sensitivity decreasing means, for preventing said one repeating path and the control means connected thereto from being disabled by the  
45 false operation by line noise of the control means connected to the other repeating path.

In witness whereof, I hereunto subscribe my name this 24th day of July, 1930.

BJÖRN G. BJÖRNSON.

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