Jan. 5, 1932. B. G. BJORNSON 1,840,015

TRANSMISSION CONTROL CIRCUIT

Filed Sept. 23, 1930

FIG. 1

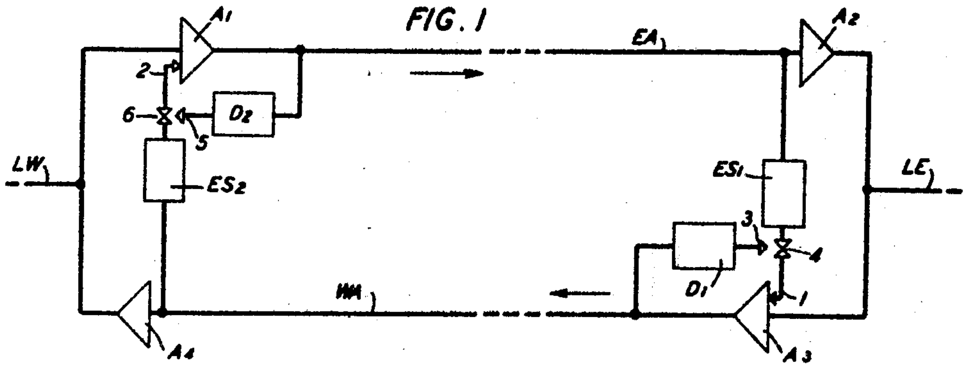


FIG. 2

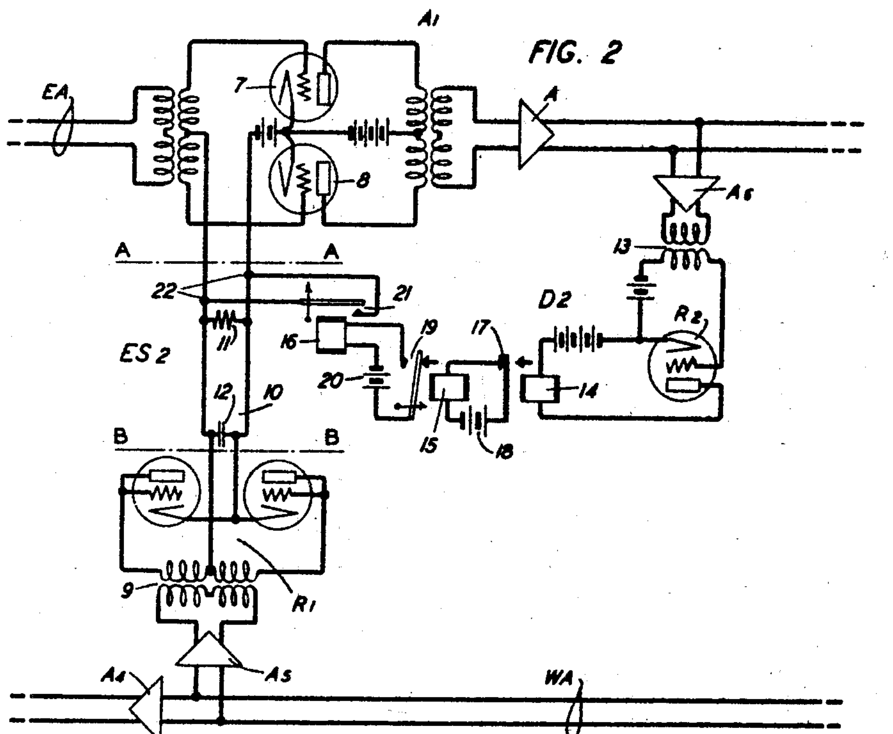
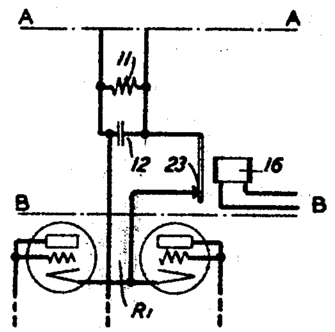


FIG. 3



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UNITED STATES PATENT OFFICE

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TRANSMISSION CONTROL CIRCUIT

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This invention relates to signal transmission circuits of the four-wire type and particularly to the signal-controlled means employed therewith for suppressing echoes and preventing singing.

An object of the invention is to improve the operation characteristics of long four-wire signaling systems, employing signal-controlled apparatus for suppressing echoes and preventing singing.

To obtain proper operation of long four-wire telephone systems, it has been found necessary in the past to utilize in connection therewith signal-controlled apparatus for effectively disabling one of the associated two-wire paths while signal transmission is taking place over the other, so as to prevent echo currents or reflected currents from being transmitted back to the transmitting end of the system and causing either a disturbance or singing. The disabling apparatus usually comprises means, such as an amplifier-rectifier control circuit, for diverting a portion of the signaling currents from one path and utilizing it to control the open-circuiting or short-circuiting of the oppositely directed path, or to control the operation characteristics of an amplifier in the oppositely directed path.

It is the usual practice to arrange these signal-controlled devices, or echo suppressors as they are commonly called, one of which is associated with each two-wire line, at some intermediate station, for example, at a mid-way point. Such an arrangement has a disadvantage in that it may prevent the subscriber who desires to talk in one direction from getting immediate control of the circuit after it has been used by a subscriber talking in the other direction. This is due to the fact that, owing to the time interval which it takes for a wave to be transmitted from the echo suppressor at one side of the line through the terminal to the point at which the opposite line is disabled the echo suppressor must be provided with hang-over means to maintain the line disabled for a certain length of time after the first talker has finished talking. In another arrangement of the prior art this difficulty has been eliminated by locating the two units of the echo suppressor respectively at or near the ends of the four-wire circuit. This latter arrangement, however, has a disadvantage in that transmission lockouts may occur when the two subscribers at opposite ends of the system both start talking at about the same time, due to the simultaneous locking up of the two suppressor units.

The disadvantages mentioned above of the circuits of the prior art are eliminated in the circuit of the present invention by utilizing in combination with each suppressor unit for disabling one two-wire signaling path when signals are being transmitted over the other oppositely directed two-wire path, a circuit responsive to the transmission of signals over the first path for disabling the echo suppressor unit, but with a time delay of substantially the same order of magnitude as the overall transmission time of the four-wire circuit between terminals. In the system of the invention, when the subscribers at opposite ends of the system both start talking within a time interval equal to the overall transmission time of the four-wire circuit between terminals, complete control is obtained by the first talker, because, when an echo suppressor unit becomes operative before the associated echo suppressor disabling circuit, the disabling process is arrested. The necessity for utilizing appreciable hang-over in the echo suppressors is eliminated by locating the two echo suppressor units near opposite ends of the four-wire circuit, thus speeding up the operation of the system.

In a preferred modification of the invention, each echo suppressor unit comprises means for continuously applying negative grid potential to a vacuum tube amplifier in one two-wire path which is directly proportional to the amplitude level of the waves transmitted over the other path, so as to prevent the locking up of the circuit by noise while allowing operation of the echo suppressor on quiet lines at higher sensitivity, and each echo suppressor disabling circuit comprises an amplifier-detector circuit controlling a chain of mechanical relays in which the desired relay is produced by proper design of the operating and release times of the relays.

The objects and advantages of the invention will be better understood from the following detailed description thereof when read in connection with the accompanying drawings in which

Fig. 1 shows schematically a four-wire toll telephone circuit equipped with transmission control circuits in accordance with the invention;

Fig. 2 shows in greater detail a preferred construction of the transmission control circuits utilized in the system of Fig. 1; and

Fig. 3 shows a modification of a portion of the circuit of Fig. 2 which may be used as an alternative.

The diagram of Fig. 1 is not an actual circuit diagram but rather a single-line layout, each line indicating a transmission path. A normal break in a path is indicated by separated arrow heads; a normal make by contacting arrow heads. To show that a transmission element is to be varied by a device an arrow head points from the device toward the element. An arrow directed at a make point indicates that the path will be disabled at that point.

The four-wire telephone circuit of Fig. 1 comprises a one-way transmission path EA including the one-way amplifying devices A_1 and A_2 for repeating telephonic currents in the direction from west to east between the west two-way line section L_W and the east two-way line section L_E, and the one-way transmission path WA including the one-way amplifying devices A_3 and A_4 for repeating telephonic currents in the direction from east to west between the east two-way line section L_E and the west two-way line section L_W. In well known manner the oppositely directed one-way transmission paths EA and WA may be connected in substantially conjugate relation with each other and in energy transmitting relation with the west line section L_W and the east line section L_E, respectively for example, by hybrid coil transformers and associated balancing networks or other suitable means (not shown).

Bridged across the input of amplifier A_2 near the output of the path EA is the input of an echo suppressor unit ES_1 operating in response to the waves transmitted over the path EA to adjust the gain of the amplifier A_3 near the input of the path WA, as indicated by the arrow 1, so as to introduce in the path WA a loss which is directly proportional to the amplitude level of the waves from the part EA impressed upon the input of the echo suppressor ES_1. Similarly, bridged across the input of the amplifier A_4 near the output of the path WA is the input of an echo suppressor unit ES_2 operating in response to the waves transmitted over the path WA to adjust the gain of the amplifier A_1 near the input of the path EA, as indicated by the arrow 2, to introduce a loss in the path EA which is directly proportional to the amplitude level of the waves from the path WA impressed upon the input of the echo suppressor ES_2.

Connected across the output of the amplifier A_3 near the input of the path WA is the input of a device D_1, which will be referred to hereafter as the disabler D_1, which operates in response to the waves impressed thereon from the path WA, but with a given time delay, to effectively disable, as indicated by the arrow 3, the output of the echo suppressor ES_1, for example, by opening the normally closed contacts 4 therein. Similarly, connected across the output of the amplifier A_1 near the input of the path EA is the input of a device D_2, which will be referred to hereafter as the disabler D_2, which operates in response to the waves impressed thereon from the path EA, but with a given time delay, to disable the output of the echo suppressor ES_2, as indicated by the arrow 5, for example, by opening the normally closed contacts 6 therein. The time delay in the operation of the device D_1 in response to the waves from the path WA, and the time delay in the operation of the device D_2 in response to the waves from the path EA, is preferably substantially equal to the overall transmission time between the line sections L_W and L_E over one side of the four-wire circuit EA and WA, respectively.

The preferred construction of the echo suppressors ES_1 and ES_2 and the disablers D_1 and D_2 is shown in detail in Fig. 2. As indicated in Fig. 2, the amplifier A_1 in the path EA preferably consists of two or more stages, the first stage comprising the three-electrode vacuum tube amplifying devices 7 and 8 connected in push-pull relation. The echo suppressor ES_2 comprises the one-way amplifying device A_5 having its input connected across the path WA in the input of the amplifying device A_4, a full wave vacuum tube rectifier R_1 having its input connected to the output of the amplifying device A_5 through the transformer 9, and a network 10 comprising the resistance 11 and parallel condenser 12, connected in the common grid circuit for the push-pull tubes 7 and 8 in the first stage of the amplifier A_1 in the transmission path EA. Waves impressed on the input of the echo suppressor ES_2 will be amplified by the amplifying device A_5 and then rectified by the full wave vacuum tube rectifier R_1. The rectified output of the rectifier R_1 will be impressed on the input circuits of the tubes 7 and 8 in the push-pull stage of the amplifier A_1 across the parallel resistance 11 and condenser 12 causing a negative biasing potential to be applied in common to the grid of the tubes 7 and 8 which is directly proportional to the level of the waves in the input of the echo suppressor ES_2. This negative biasing potential applied to the grid of the tubes 7 and 8 in the amplifier A_1 will effectively vary the gain of the amplifier A_1 to insert a loss in the path EA which is directly proportional to the amplitude level of the waves transmitted over the path WA. The amplifiers A_1 and A_2 are so designed that when the associated suppressor is short circuited in its output the amplifier will repeat with maximum efficiency.

The purpose of the condenser 12 in network 10 is to smooth out the output of the rectifier R_1 so as to prevent sharp changes in the negative biasing potential applied to the grids of tubes 7 and 8.

A loss in the path EA which is proportional to the amplitude level of the waves transmitted over the path WA could be produced in other ways than that shown. For example, the rectifier R_1 could be made to control the variable plate-filament impedances of vacuum tubes placed in series with or in shunt across the path WA, in accordance with the amplitude level of the waves in the path EA.

As indicated in Fig. 2, the disabler D_2 may comprise the one-way amplifying device A_6 having its input connected across the path EA in the output of the amplifying device A_1, a vacuum tube rectifier R_2 having its input connected to the output of the amplifying device A_6 through the transformer 13, and a slow-operating, slow-releasing relay circuit comprising the chain of relays 14, 15 and 16 controlled by operation of the rectifier R_2. The relay 14 is connected directly in the output circuit of the rectifier R_2 and is responsive to operation of that relay to open its normally closed contacts 17 to break the energizing circuit for slow operating relay 15 which is normally energized by current from the battery 18. This causes the relay 15 to release to close its normally open contacts 19 thereby closing an energizing circuit for the winding of relay 16 through the battery 20, causing the slow-releasing relay 16 to operate to close its normally open contacts 21 to short-circuit the output circuit of the echo suppressor ES_2 at the points 22.

The relay chain comprising the relays 14, 15 and 16, in the disabler D_2 is designed so as to accomplish the short-circuiting of the echo suppressor ES_2 at the points 22 in response to the west to east speech waves transmitted over the path EA, a given time after these waves are impressed on the input of the amplifying device A_6, and so as to maintain the echo suppressor ES_2 short-circuited for a given hangover time after the supply of the west to east speech waves to the input of the amplifying device A_6 ceases. The time delay in operation of the disabler D_2, and the hangover time for which it will remain operated, are preferably each made substantially equal to T, where T is the overall transmission time of one one-way path of the four-wire circuit between terminals, although, as will be brought out later, under certain conditions this delay and hangover time may be somewhat different. One way of producing this delay and hangover is as indicated in the drawings by making the relay 14 slow operating to a required degree and by making the relay 16 slow releasing to the required degree.

The echo suppressor ES_2 may be effectively disabled in response to the operation of the disabler D_2 by other means than those shown in Fig. 2. For example, the portion of the circuit contained between the dot-dash lines A—A and B—B in Fig. 2 may be modified as shown in Fig. 3 so that the relay 16 operates to open-circuit, instead of to short-circuit the output of the rectifier R_1 by opening normally closed contacts 23. This will serve to prevent a very sharp change in the transmission equivalent if the noise level is high on the transmission path WA.

The echo suppressor ES_1 and the associated disabler D_1 at the east end of the four-wire circuit may have constructions similar to that of the echo suppressor ES_2 and the disabler D_2 described above so as to operate in similar manner. For convenience, therefore, in the following description of the operation of the whole system, the elements of ES_1 and D_1 will be designated with the same characters as the corresponding elements of ES_2 and D_2 but followed by a prime (′) mark.

The operation of the system will now be described by reference to Figs. 1 and 2. It will be assumed that speech waves for transmission from west to east are received over the two-wire line L_W by the transmission path EA at the west terminal of the four-wire circuit, and at that time no speech waves have as yet been received at the east terminal from the two-wire line L_E for transmission from east to west over the transmission path WA.

The received speech waves will be amplified by the amplifier A_1 in the path EA, and will be transmitted freely thereby, the gain of the amplifier A_1 being normally adjusted so that there is minimum loss inserted in the path EA.

The main portion of the amplified west to east speech waves in the output of the amplifier A_1 in the path EA will be transmitted out over the path EA, which it will be assumed has an overall transmission time between the line sections L_W and L_E of substantially T seconds, to the east end of the four-wire circuit where it will be divided between the input of the amplifier A_2 in the path EA and the input of the echo suppressor ES_1. The portion impressed on the input circuit of the amplifier A_2 will be amplified thereby and then transmitted to the line section L_E over which it will be transmitted to the distant listening subscriber.

The portion of the west to east speech waves diverted into the input of the echo suppressor ES_1 will be amplified by the one-way amplifying device A_5' therein and the amplified waves impressed upon the input of the full wave, vacuum tube rectifier R_1' through the transformer 9′. The rectified waves in the output of the full wave rectifier R_1' will be impressed across the condenser 12′ and the parallel resistance 11′ on the common grid circuit for the push-pull stage of the amplifier A_3 in the path WA causing a negative biasing potential to be continuously and smoothly applied to the grids of the tubes 7′ and 8′, which is directly proportional to the amplitude of the speech waves at the input of the echo suppressor ES_1.

The gain of the amplifier A^3 will therefore be automatically adjusted so as to insert a loss in the input of the path WA which is directly proportional to the amplitude of the speech waves in the input of the echo suppressor ES_1, which loss will be sufficient to insure that any east to west speech waves or any noise waves which may be thereafter transmitted out over the path WA to the west end of the four-wire circuit will not be of sufficient amplitude to operate the echo suppressor ES_2.

Meanwhile, a small portion of the amplified west to east speech waves in the output of the amplifier A_1 in path EA will be diverted into the input of the disabler D_2. These diverted speech waves will be amplified by the amplifier A_6 and the amplified waves impressed by the transformer 13 on the input of the rectifier R_2 causing the operation of that rectifier to energize the windings of the relay 14 connected in its output circuit. The relay 14 will then operate to open its contacts 17, causing the energizing circuit for slow-operating relay 15 to be broken. Relay 15 will then release to close the normally open contacts 19 in the energizing circuit for the slow-releasing relay 16, causing the windings of the relay 16 to be supplied with energizing current from the battery 20. Relay 16 will then operate to close the contacts 21, thereby connecting a short-circuiting connection across the output of the echo suppressor ES_2 at the points 22 therein.

Because of the delay of T seconds introduced by the disabler D_2, the short-circuiting of the output of the echo suppressor ES_2 at the points 22 will not occur until about the time the west to east speech waves which have been meanwhile transmitted out over the path EA have entered the input of the echo suppressor ES_1 at the east end thereof and operated that echo suppressor to effectively insert a loss proportional to the amplitude of the west to east speech current in the input of the transmission path WA.

From the above description of the system of Fig. 1 and 2, it is apparent that any east to west speech waves which may be sent out from the east terminal of the four-wire circuit over the path WA more than T seconds after the west to east speech waves have been transmitted out over the path EA from the west terminal of the four-wire circuit, will not be of such amplitude as to cause operation of the disabler D at the east terminal or the echo suppressor ES_2 at the west terminal station because of the loss which has been previously effectively inserted in the input of the path WA in response to the west to east speech waves previously transmitted from the west terminal. For this condition, complete control of the switching circuits at both terminals has been obtained by the first talker associated with the west terminal station by the two-wire line L_W.

Now, let it be supposed that the two subscribers at the opposite ends of the system both start talking about the same time, but that the talker at the east end of the system, that is, the talker associated with the two-wire line L_E starts talking just slightly before the talker at the west end of the system associated with the line L_W. The east talker's speech current will be amplified by the amplifier A_3 in the transmission path WA, which is at normal maximum amplifying efficiency.

The main portion of the east talker's amplified speech currents will be transmitted out over the path WA towards the east terminal, and a smaller portion will be diverted into the input of the disabler D_1 connected to the output of amplifier A_3 in the path WA near the east terminal. Substantially T seconds later, where, according to the assumption made T is the overall wave transmission time of the system between the two-wire line L_E and the two-wire line L_W over the path WA, the amplified waves transmitted over the path WA will cause the operation of the echo suppressor ES_2 at the west terminal of the four-wire circuit to insert a loss in the transmission path EA proportional to the amplitude of the east to west speech currents, and the waves diverted into the input of the disabler D_1 will cause the operation of the disabler D_1 at the east terminal of the four-wire circuit to disable the echo suppressor ES_1 in its output.

Meanwhile, the later initiated west talker's speech currents will have been amplified by the amplifier A_1 in the transmission path EA, which amplifier at that time is in its normal operating condition, that is, in the condition to amplify with maximum efficiency. The main portion of the amplified west to east speech waves in the output of the amplifier A_1 will be transmitted out over the path EA to the east terminal and will arrive there T seconds later. At the east terminal station the main portion of the received west to east speech waves will be amplified by the amplifier A_2 and the amplified waves in the output thereof impressed upon the east line section L_E and transmitted thereover to the listening subscriber associated therewith. Another portion of the west to east speech waves at the east terminal will be impressed on the input of the echo suppressor ES_1 and will cause the operation of the rectifier R_1' therein. The rectified speech currents in the output of rectifier R_1' will be impressed on the network 10′. However, this will not be effective to change the gain of the amplifier A_3 in the path WA because the output of the network 10′ has been previously short-circuited at the points 22′ by operation of the disabler D_1 in response to the west to east speech currents from the path EA.

Meanwhile the portion of the west to east speech currents diverted into the input of the disabler D_2 at the west terminal will cause operation of that disabler to short-circuit the echo suppressor ES_2 in its output but with a delay of T seconds. However, this will not effectively change conditions in the circuits because previous to this time the input currents to the echo suppressor ES_2 due to the previous operation of suppressor ES_1 at the east terminal are so reduced in amplitude as to be unable to operate the suppressor ES_2, and the amplifier A_1 in the path EA will therefore remain at maximum transmitting efficiency.

The circuits will remain in the operated condition as just described until the first talker's speech currents cease or there is an appreciable pause therein such as would occur at the end of the sentence. Due to the slow release times of T seconds of the disablers D_1 and D_2, the short-circuiting of the echo suppressors will be maintained after the supply of speech currents to the disablers cease for a sufficient interval of time to prevent false operation of the suppressors by echoes.

The effect therefore when two parties both start talking within T seconds of each other, that is, within a time interval substantially equal to the overall transmission time over one side of the four-wire circuit between terminals, is that the first talker's currents will be transmitted with maximum efficiency while only a portion of the speech of the second talker will get through to the first party. The latter may be of some advantage on long circuits from the standpoint of breaking in as will be brought out later.

The delay in operation of the disablers D_1 and D_2 at the two ends of the four-wire circuit should be preferably not less than T seconds in order that the first talker may have time to operate the echo suppressor at the opposite terminal before the second talker operates the suppressor at the first talker's terminal. As stated above, it is preferable that this delay in operation of the two disabler circuits be substantially equal to T seconds, that is, to the overall transmission time of the four-wire circuit between terminals. The delay time however may be less than T seconds, in which case when the two talkers at opposite ends of the system both start talking within the overall transmission time of the cable, each will cause the operation of the disabler at his own terminal to disable the echo suppressor controlled by the other talker's speech currents. Both echo suppressors will then remain ineffective while both parties continue talking, so that there will be no suppression of echoes. This will result in a certain amount of double talking on each transmission path which will be more or less annoying, but not necessarily a serious hindrance to the carrying on of the conversation.

If the delay time of the two disablers D_1 and D_2 is greater than T seconds, that is, greater than the overall transmission time of the four-wire circuit between terminals, transmission lockouts may occur when the two parties both start talking within an interval equal the overall transmission time of the cable. Ordinarily, double talking is considered less harmful than transmission lockouts, and, therefore, the design of the disablers D_1 and D_2 so that they have a delay time less than T is preferred to a design which would give them a delay time greater than T.

In the above description nothing has been said about the effect of transmission noise in the transmission paths on the operation of the circuit. The effect of noise on the system of the invention will depend upon whether the noise originates in the transmission path EA or WA or in the two-way line section L_W or L_E. Noise originating in the transmission paths EA and WA of the four-wire circuits will merely cause the echo suppressors ES_1 or ES_2 to introduce a certain amount of loss in the opposite transmission path. As soon as the disabler connected to that path is operated by speech, this loss is removed. The circuits should preferably be designed so that this loss is removed gradually in order to prevent very sharp changes in the transmission equivalents of the transmission path.

Noise originating in the two-wire line section L_W or L_E will tend to operate the disablers D_2 and D_1 respectively. If there is noise on both two-way line sections L_W and L_E, both disablers D_2 and D_1 will be operated to disable the corresponding echo suppressors, and there will be no echo suppression. The disablers will be subject to noise from the two-wire lines only, and there would be, therefore, effectually less noise to deal with than if the echo suppressors were located at the mid-point of the four-wire circuit. To avoid operation from noise, it is preferable that the disablers be set so that they are less sensitive than ordinary echo suppressors. This can be accomplished by the proper choice of the rectifiers R_2, R_2' and the proper design of the relay circuits in the disablers. Reduction in the sensitivity of the disablers, of course, introduces the possibility of interruption of the talker by the listener. The chance of this occurring is not great as weak speech syllables on the whole are also of short duration. The release time, or hangover, of the disablers could be set a little longer by proper design of the relay circuits therein so as to often hold over during the passing of short syllables, and thus to minimize the change of interruption of the talker by the listener.

A particular advantage of the circuits of the invention as just described is that, because the transmission efficiency of the transmission paths is merely lowered by the insertion of a loss therein in response to operation of the suppressor rather than reduced to zero by the open-circuiting or short-circuiting of these paths, one party by talking loud enough can always over-ride the loss produced by the other party's speech. It is seen therefore that the circuits of the invention are such as to facilitate "break-ins".

In the preferred form of the invention which has been illustrated and described, chains of relays are utilized in the disablers D_1 and D_2 for producing the required delay in the operation thereof. It is within the scope of the invention to utilize a greater number or a lesser number of relays in the chains in the disablers for producing the required delay, or to utilize any other means for accomplishing the same result. For example, electrical delay circuits may be used in place of some of the relays.

In the circuits of the invention which have been illustrated and described, echo suppressors of the type which operate to insert losses in a transmission path proportional to the amplitude level of the waves in the opposite path are employed. It is of course within the scope of the invention to utilize other types of echo suppressors well known in the art in place of the echo suppressors illustrated.

Other modifications which may be made in the circuits illustrated and described within the scope and spirit of the invention will be apparent to persons skilled in the art. The invention is to be limited only within the scope of the appended claims.

What is claimed is:

1. A two-way signaling system comprising stations, two one-way transmission paths for transmitting signals in opposite directions between said stations, means connected to one of said one-way paths and responsive to wave transmission thereover for varying the transmission efficiency of the other of said one-way paths, and means responsive to transmission of signals in said other one-way path for effectively disabling said transmission efficiency varying means within a time interval after the initiation of said signals in said other one-way path at least as small as the overall wave transmission time of one of said one-way paths between said stations.

2. A two-way signaling system comprising two one-way transmission paths for transmitting signals in opposite directions between stations, means connected to one one-way path and responsive to wave transmission thereover for varying the transmission efficiency of the other one-way path, and means responsive to transmission of signals in said other one-way path for effectively disabling said transmission efficiency disabling means at a time after the initiation of said signals in said other one-way path substantially equal to the overall wave transmission time of one of said one-way paths between said stations.

3. In combination with a two-way signaling system comprising one-way paths for transmitting signals in opposite directions between two-way line sections, means connected to each of said paths and responsive to the waves transmitted thereover for varying the transmission efficiency of the other one-way path near the input thereof, and means for preventing transmission lockouts caused by the simultaneous operation of both transmission efficiency varying means by signals initiated in both paths about the same time comprising means connected to each path near the input thereof and responsive to the transmission of signals therein for effectively disabling the transmission efficiency varying means connected to the other path within a time interval after the initiation of said signals in the first path at least as small as the overall wave transmission time of said other one-way path between said two-way line sections.

4. In combination with a two-way signaling system comprising two one-way transmission paths for transmitting signals in opposite directions between two-way line sections, means responsive to the waves transmitted over one of said one-way paths for varying the transmission efficiency of the other one-way path in proportion to the amplitude level of said waves in said one one-way path, and means responsive to the

transmission of signals in said other one-way path for effectively disabling said transmission efficiency-varying means within a time interval after the initiation of said signals in said other path at least as small as the overall transmission time of one of said one-way paths between said two-way line sections.

5. In combination with a two-way signaling system comprising two one-way paths for transmitting signals in opposite directions between two-way line sections, means responsive to the waves transmitted over one of said one-way paths for inserting a loss in the other of said one-way paths varying in value in proportion to the amplitude level of said waves in said one one-way path, and means responsive to the transmission of signals over said other one-way path for effectively disabling said loss-inserting means within a time interval after the initiation of said signals in said other one-way path at least as small as the overall transmission time of said one one-way path between said two-way line sections.

6. In combination with a two-way signaling system comprising two two-way line sections and two one-way transmission paths for transmitting signals in opposite directions between said two-way line sections, means for varying the transmitting efficiency of one of said paths in proportion to the amplitude of the waves transmitted over the other of said paths, and means responsive to the transmission of signals in said one path for effectively disabling said transmitting efficiency-varying means at a time after the initiation of said signals in said one path substantially equal to overall transmission time of said other one-way path between said two-way line sections.

7. In a system for suppressing echoes in a two-way signaling circuit comprising two one-way transmission paths for transmitting signals in opposite directions between two-way line sections, means for continuously reducing the transmission efficiency of one of said one-way paths in proportion to the rise in amplitude lever of the waves transmitted over the other one-way path, and means responsive to the transmission of signals in said one one-way path for effectively disabling said transmission efficiency reducing means at a time after the initiation of the signals in said one one-way path substantially equal to the over-all transmission time of one one-way path of the two-way circuit between said two-way line sections.

8. In a system for suppressing echoes in a two-way signal transmission circuit comprising one-way paths normally adapted for repeating signals in opposite directions between said two two-way line sections with maximum transmission efficiency, means responsive to the waves transmitted over one of said one-way paths for continuously varying the transmitting efficiency of the other of said one-way paths so that it is proportionately reduced when the amplitude level of said waves increase about a certain normal value, and means responsive to the transmission of signals in said other of said paths for effectively disabling said transmission efficiency-varying means within a time interval after the initiation of said signals in said other path at least as small as the overall transmission time of said one one-way path between said two-way line sections.

9. In a system for suppressing echoes in a two-way signaling circuit comprising two one-way transmission paths for transmitting signals in opposite directions between stations, each including an amplifier, means responsive to the wave transmitted over one of said one-way paths for continuously varying the gain of the amplifier in the other of said paths in proportion of the amplitude level of said waves, and means responsive to the transmission of signals over said other path for effectively disabling said amplifier gain-varying means within a time interval after the initiation of said signals in said other path at least as small as the overall wave transmission time of said one one-way path between said stations.

10. In a system for suppressing echoes in a two-way signal transmission circuit comprising two one-way paths for transmitting signals in opposite directions between stations, each including a vacuum tube amplifying device having input and output electrodes, means responsive to the waves transmitted over one of said paths for continuously applying to the input electrodes of the amplifying device in the other of said paths a biasing potential varying in proportion to the amplitude level of said waves, said biasing potential being such as to effectively disable the amplifier when the amplitude level of the waves in said one one-way path exceeds a certain predetermined value, and means responsive to the transmission of signals in said other path for effectively disabling said means for applying a biasing potential within a time interval after the initiation of said signals in said other path at least as small as the overall wave transmission time of said one one-way path between said stations.

11. In combination with a four-wire signaling system comprising two one-way transmission paths each including amplifying means, for repeating signals in opposite directions between two-way line sections, means responsive to waves transmitted over one of said one-way paths for continuously varying the amplifying efficiency of the amplifying means in the other of said one-way paths in proportion to the amplitude level of said waves, and for effectively disabling said am-

plifying means in said other path when the amplitude level of said waves exceeds a predetermined value, and means responsive to the transmission of signals over said other one-way path for effectively disabling said amplifying efficiency-varying means at a time after the initiation of said signals in said other path substantially equivalent to the overall wave transmission time of one one-way path of said four-wire system between said two-way line sections.

In witness whereof, I hereunto subscribe my name this 19th day of September, 1930.

BJORN G. BJORNSON.