

June 5, 1934.

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1,961,279

ECHO SUPPRESSOR

Filed Jan. 30, 1931

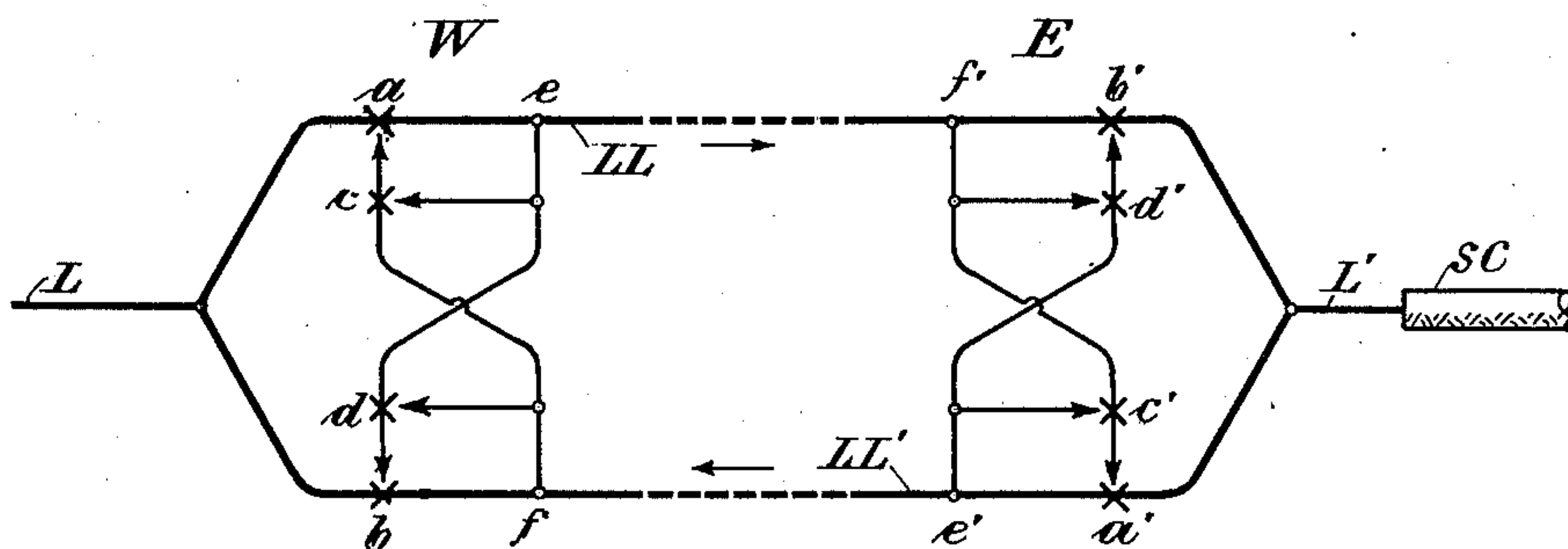


Fig. 1

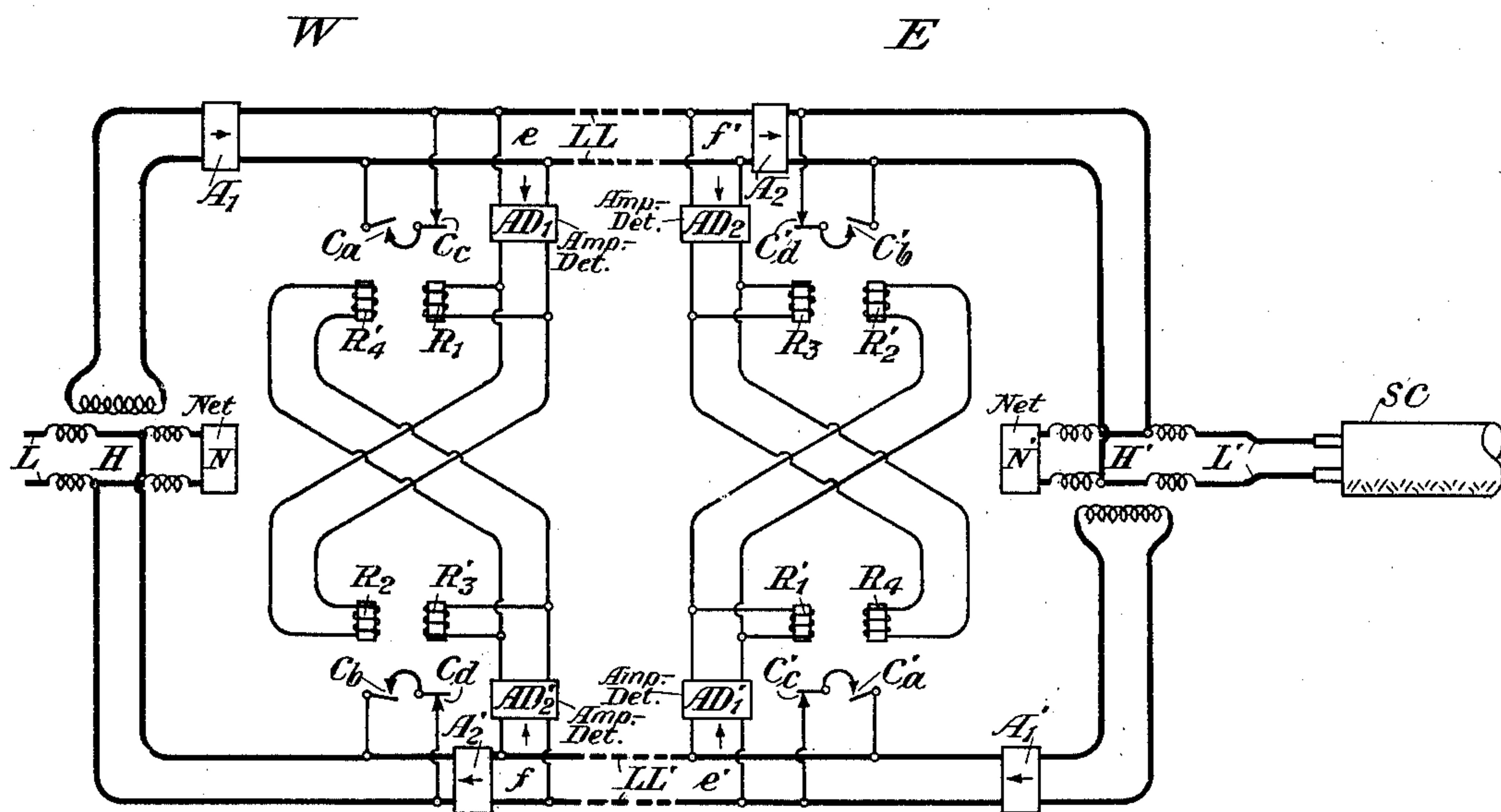


Fig. 2

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1,961,279

ECHO SUPPRESSOR

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Application January 30, 1931, Serial No. 512,442

18 Claims. (Cl. 179—170)

This invention relates to two-way telephone systems, and more particularly to methods of and means for suppressing echoes in such systems.

5 The apparatus for the suppression of echoes which is used at present on many types of two-way telephone circuits is disclosed in its essentials in United States Patent No. 1,434,790, granted November 7, 1922 to John Mills, and in
10 an article by A. B. Clark and R. C. Mathes entitled "Echo suppressors for long telephone circuits", appearing in the Journal of the American Institute of Electrical Engineers, June, 1925, pages 618 et seq.

15 The present invention is one of those made to solve the various problems of transmission control and echo suppression which arise as the principle disclosed in the above identified patent and article is applied—or as it is attempted to
20 apply it—to the various types of communication systems or in connection with other devices for the improvement of long distance telephony.

Reference may be had to United States Patent No. 1,826,196, granted October 6, 1931 to L. G. Abraham, in which there is disclosed the so-called "terminal echo suppressor". That arrangement was aimed at the substantial reduction of the "breaking time" and the lessening of the chance of mutual lockout, and has as one
30 of its principal novel features the placing of the echo suppressor devices at the terminals of the circuit to which they are applied.

The present invention is designed to retain some of the advantages of the terminal echo
35 suppressor—in particular, the reduction of the time required for one party to take control of the circuit after the other has stopped talking and the lessening of the chance of mutual lockout—and at the same time to provide proper
40 suppression of echoes arising at intermediate points on the circuit, as will be more fully discussed hereinbelow.

This invention is applicable to many different types of two-way circuits. For instance, it is
45 applicable to a four-wire circuit which is extended at one end by a land two-wire line and at the other end by a submarine cable circuit. Again, the four-wire circuit to the terminals of which the echo suppressor apparatus is directly
50 applied may include sections intermediate to which are hybrid coils, no intermediate echo suppressor apparatus being applied.

In general, the applicant associates echo suppressor apparatus with each end of the four-
55 wire circuit and arranges this apparatus so that

voice waves which pass the apparatus at the talker's end of the circuit will reach the listener's end under any conditions and will disable the opposite path provided no voice wave is traveling in that path, and echoes from intermediate points
60 on the four-wire circuit of voice waves traveling from either end thereof will be suppressed while the party at the end of origin continues to talk without interruption.

The invention will be clearly understood when
65 the following description is read with reference to the accompanying drawing.

Figure 1 of the drawing is a schematic disclosure illustrating the applicant's methods in one form and indicating the essentials of the
70 arrangement of echo suppressor apparatus.

Fig. 2 of the drawing shows diagrammatically and in part schematically one desirable embodiment of the invention.

Like characters of reference in the two figures
75 of the drawing designate corresponding elements or points.

With reference to the details of Fig. 1, there is shown schematically a four-wire circuit extending between a point W at the left and a point
80 E at the right. This circuit is extended at its left end by a two-wire line L, which may be taken to be a land line. At the right end, the four-wire circuit is extended by the two-wire
85 line L', which may be the circuit of a submarine cable SC. It will be understood that the connections between the four-wire circuit and the lines L and L' may be made in any suitable manner known to the art.

The four-wire circuit extending between points
90 W and E comprises the two-wire path LL adapted for transmission from W to E and the two-wire path LL' adapted for transmission from E to W. It will be noted that the lines representing these two wire paths are broken over the intermediate
95 portion lying between the two sets of echo suppressor apparatus (schematically indicated). It will be understood that the four-wire circuit may be very long and may have, in its intermediate section hybrid coils or other arrangements which
100 may produce unbalances. A circuit is contemplated which has no echo suppressor apparatus applied to it between the points W and E. It is understood that the apparatus indicated at W or E is placed at or near the terminal of the four-
105 wire circuit.

In the case of a long four-wire circuit such as that indicated above and suggested by the disclosure of the drawing, unbalances, temporary or otherwise, may produce what may be termed
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intermediate echoes; in other words, due to the unbalances, voice waves passing over one of the paths LL and LL' may be reflected toward the talker. These unbalances or the equivalents may
5 be produced by crosstalk between the two paths, by monitoring on the four-wire circuit and by the application of hybrid coils, for instances.

As indicated above, one of the principal objects of the present invention is the suppression of the
10 intermediate echoes caused by unbalances produced between the points W and E without rendering it difficult for one subscriber to break in when the other stops talking and without avoidable chance of mutual lockout.

15 It will be understood, in connection with the consideration of Fig. 1, that the heavy lines discussed above represent paths over which the voice waves are transmitted, while the lighter lines represent control paths over which parts of the
20 energy of the voice waves act to operate certain control devices such as relays. The arrowheads represent relays or equivalent devices and the crosses indicate relay controlled contacts or the equivalents.

25 Thus, it is indicated at the W end of the four-wire circuit that arrangements of relays and contacts or the equivalents control the transmission path LL at *a* and the transmission path LL' at *b* and the control paths at points *c* and *d*. At
30 points *e* and *f*, operating connections are made from the voice transmission paths LL and LL', respectively, to the echo suppressing apparatus. Likewise, at the E end of the circuit, corresponding elements and points are designated by the
35 corresponding letters primed.

The essential features of the applicant's echo suppressor arrangement will be best understood in connection with Fig. 1 from the following discussion of the operation of the circuits.

40 If the subscriber connected to line L, for instance, begins to talk, the voice waves travel over the transmission path LL. At *e*, a portion of the energy of the voice wave is diverted to operate the contacts or other devices at points
45 *b* and *c*. The voice waves travel on to the E end of the circuit and, at point *f*', a further portion of the energy of the voice wave is diverted and causes the operation of the contacts or other devices at *a*' and *d*', provided the subscriber con-
50 nected to line L' has not begun to talk. The contact at *b* at the W end of the circuit prevents the return to this end of any echoes arising at points on the four-wire circuit between W and E and the contact at *a*' disables the transmission
55 path LL' at the E end; thus, the subscriber connected to line L has complete control of the circuit. The contact at *c* disables the suppressing contact at *a*—that is, it prevents the functioning of the contact indicated at *a* to disable the
60 transmission path LL. Thus, there is prevented any interruption of the transmission of the voice wave from line L in case waves from the E end of the circuit reach W over the path LL' before
65 the subscriber connected to line L has gained complete control of the circuit. If the subscriber connected to line L' starts to talk before the other subscriber has gained complete control of the
70 circuit, the voice wave from L' will travel on to W and, at the point *f*, a portion of the energy of the wave will be diverted to operate the contact or other device at *d*. This operation immediately clears the path LL' at *b*, preventing
75 the closing of a contact, for instance, or, if it be already closed, reopening it. Thus, the voice of the subscriber connected to the line L' is

enabled, under any conditions, to pass the point *b* and will be heard by the subscriber connected to line L.

If, now, the subscriber connected to line L
80 pauses for a moment and the subscriber connected to line L' starts talking as soon as he perceives the pause, the voice wave from L' will pass the point *a*', since the disability at that point is now removed, but will not prevent breaking in
85 by the subscriber connected to line L, if he starts to talk again right away, since, as soon as a new voice wave travels from W to E in LL, the apparatus at *d*' operates to remove any disability placed on the path LL at *b*'. When the voice
90 wave from L' reaches W, the contact at *d* operates to remove any disability on the path LL' at *b*, or to prevent such disability, and the voice wave reaches the subscriber connected to line L, indicating that the subscriber at the other end
95 wishes to break in.

It will be noted that the contacts or other devices at points *b* and *b*' insure the suppression of all echoes unless the listener is successfully trying to break in on the talker. It will be noted further that neither subscriber can lock out the
100 other if the voice wave from the subscriber starting to talk after the other succeeds in passing the near suppressor contacts at *a* or *a*'.

While the problems of adjusting the sensitivities, operating times and hangover times of the
105 apparatus schematically indicated in Fig. 1 will present no extraordinary difficulties, it may help to clarify the disclosure of the applicant's invention to make the following statements:

The contact at *a* (the apparatus at W being
110 specifically considered) must operate promptly in order to suppress quick echoes returning from the near connecting circuit L. This contact must have a hangover long enough to take care of the slowest echoes returning over the line L.
115 The contact *b* must operate quickly enough to suppress echoes arising at points intermediate to W and E and should have a hangover time at least twice as long as the time required for transmission between W and E. The hangover
120 of *b* should be effective when the subscriber connected to line L stops talking but it must not be effective when this contact is disabled by the contact at *d* (see the discussion of Fig. 2 of the drawing contained hereinafter). The contact at
125 *c* must operate promptly to prevent clipping of the voice of the subscriber connected to line L by the operation of the suppressor contact at *a*, due to the voice waves in the path LL'. The hangover of contact *c* need be only long enough
130 to prevent terminal clipping in the case of the presence of voice waves in the path LL'. The contact *d* must operate quite promptly and cause the immediate removal of the disability which may have been placed on the path LL' at *b*.
135 This immediate clearing of the path LL' prevents avoidable clipping of the voice of the subscriber connected to line L' when attempts to break in on the other subscriber are made. The hangover time of contact *d* should be long enough to cause
140 the reduction of terminal clipping if there are voice waves present in the path LL.

The sensitivity of the voice responsive apparatus connected to the path LL at *e* is limited only
145 by the requirement that this apparatus must not be falsely operated by echoes of waves in the path LL' which are not strong enough to operate the suppressor contacts at *a* and that the apparatus must not be falsely operated by noise in the line
150 L. The sensitivity of the apparatus connected to

the path LL' at *f* is limited by the requirement that it must not be operated by any echoes arising at points intermediate to W and E but must operate in response to voice waves in the path LL'.

5 In Fig. 2 of the drawing, there is disclosed somewhat specifically an arrangement of apparatus which meets the essential requirements discussed above in connection with Fig. 1. The transmission paths LL and LL' lying between 10 points W and E as parts of the four-wire circuit are as indicated in Fig. 1, and likewise the four-wire circuit is extended at its left end by the two wire line L and at its right end by the two-wire line L', forming the circuit of a submarine cable 15 SC. The line L is connected to the four-wire circuit through the hybrid coil H and is balanced by the artificial network N. Likewise, the line L' is connected to the four-wire circuit through the hybrid coil H' and is balanced by the network N'. 20 It will be understood that these connections of the four-wire circuit and the extending circuits may be replaced by any other suitable form of connection.

In the path LL are shown schematically one- 25 way amplifiers A₁ and A₂ at the ends W and E, respectively, and in the path LL' are the one-way amplifiers A'₁ and A'₂ at the ends E and W, respectively. Connected across the path LL at the point *e*, which, it is understood, is at or near the 30 left terminal of the four-wire circuit, is an amplifier-detector AD₁ which controls relays R₁ and R₂. At the right end of the path LL, at a point *f*', there is connected the amplifier-detector AD₂ which controls relays R₃ and R₄. Similarly, the 35 path LL' has connected across it at the point *e*' near its right end an amplifier-detector AD'₁ controlling relays R'₁ and R'₂; likewise, at the left end of the path LL' there is connected at the point *f* an amplifier-detector AD'₂ controlling relays 40 R'₃ and R'₄.

It will be noted that contacts C_a, normally open, and C_c, normally closed, controlled by the electromagnets R'₄ and R₁, respectively, are connected 45 in series across the path LL at the W end; also the contacts C_b, normally open, and C_a, normally closed, are controlled by the electromagnets of relays R₂ and R'₃, respectively, and are connected in series across the path LL' at the W end. Also, 50 at the E end of the circuit, contacts C'_a and C'_c controlled by relays R₄ and R'₁, respectively, are connected across the path LL', and contacts C'_b and C'_a, controlled by relays R'₂ and R'₃, respectively, are connected in series across the path LL.

It will be readily understood that the operation 55 of the echo suppressor apparatus in the case of Fig. 2 follows the description given above in connection with Fig. 1. It should be noted, however, that when the contact C_a is closed in response to a voice wave in the path LL' through the operation of amplifier-detector AD'₂ and relay R'₄ 60 echoes are suppressed in the path LL, provided contact C_c has not been opened by waves in LL of earlier arrival. Contact C_c, if it is already opened, can render ineffective the closing of contact C_a, but once contact C_a has closed, later arriving waves in LL cannot operate amplifier-detector AD₁ and relay R₁ to remove the disability placed on LL. Likewise it will be noted that when 65 the energy of a voice wave in LL' is diverted at *f* to operate amplifier-detector AD'₂ and relay R'₃ and the contact C_a opens, the voice wave in the path LL' travels without fail to the extending circuit L, regardless of the condition of the contact C_b. 70

It will be noted that the one-way amplifier A'₂ 75

is shown between the point *f* and the contacts C_b and C_a. This arrangement prevents the operation of amplifier-detector AD'₂ and the contacts C_a and C_a by voice waves originating in the line L, and also insures that voice waves arriving over LL' will reach the input of AD'₂ even if 80 both of the contacts C_b and C_a are closed. It will be understood, however, that this result may be reached in other suitable ways. For instance, the amplifier-detector may be operated from the 85 output side of the line amplifier and a directionally selective bridge such as that disclosed in the applicant's United States Patent No. 1,755,243 may be employed to enable the amplifier-detector to discriminate between the voice waves from 90 the distant end of the circuit and voice waves originating in the line L.

While the invention has been disclosed somewhat specifically for the purpose of illustration, it will be understood that its scope is not limited 95 thereby but is determined by the appended claims.

Furthermore it is to be noted that, while the echo suppressing apparatus shown at one end of the four-wire circuit is described in combination 100 with like apparatus at the other end of the circuit, and will be so employed on some systems, it is capable of use at one end of a two-way circuit to the other end of which there is applied a different arrangement of voice-operated apparatus. For instance, in the system shown, com- 105 prising a four-wire circuit extended at W by a land line and at E by a submarine cable, the echo suppressor apparatus at W may be substantially as disclosed while the voice-operated arrangements at E are of a different type. It is to be 110 understood that the duplicate showing of the echo suppressor apparatus applied to the four-wire circuit does not limit the invention, which resides as well in the use of such apparatus at one terminal—or in combination with different appa- 115 ratus at the distant terminal.

What is claimed is:

1. In a two-way telephone circuit including paths adapted for transmission in opposite directions, the method of transmission control and 120 echo suppression which consists in causing the incoming voice waves near either end of the circuit to disable the outgoing path, provided said path is not carrying voice waves of earlier arrival, causing the outgoing voice waves near either end 125 of the circuit to disable the incoming path temporarily, provided said path is not carrying voice waves of earlier arrival, and causing the incoming voice waves near either end of the circuit to prevent the disabling of the incoming path or, 130 if it be already disabled, immediately to restore it to operative condition.

2. In a two-way telephone circuit including paths adapted for transmission in opposite directions, the method of transmission control and 135 echo suppression which consists in causing the incoming voice waves near either end of the circuit to disable the outgoing path, provided said path is not carrying voice waves of earlier arrival, causing the outgoing voice waves near either 140 end of the circuit to disable the incoming path temporarily, provided said path is not carrying voice waves of earlier arrival, causing the incoming voice waves near either end of the circuit to prevent the disabling of the incoming path or, if 145 it be already disabled, immediately to restore it to operative condition, and causing the outgoing voice waves to prevent the disabling of the outgoing path by incoming voice waves of later arrival. 150

3. In a two-way telephone circuit including paths adapted for transmission in opposite directions, apparatus relatively near each end of the circuit comprising means responsive to voice waves in the incoming path for disabling the outgoing path, means responsive to voice waves in the outgoing path for disabling the incoming path, means responsive to voice waves in the outgoing path for preventing the disabling of said path by later arriving voice waves in the incoming path, and means responsive to voice waves in the incoming path for preventing the disabling of said path and for restoring the same to operative condition if it be already disabled.
4. In a two-way telephone circuit including paths adapted for transmission in opposite directions, apparatus relatively near each end of the circuit comprising means whereby the outgoing path when it is not carrying voice waves will be disabled in response to voice waves in the incoming path, means whereby the incoming path when it is not carrying voice waves will be disabled in response to voice waves in the outgoing path, and means responsive to voice waves in the incoming path for preventing the subsequent disabling of said path and for restoring the same to operative condition if it be already disabled.
5. In a two-way telephone circuit including paths adapted for transmission in opposite directions, echo suppressor apparatus associated with each end of the circuit and so arranged that voice waves which pass the apparatus at the talker's end will reach the listener's end under any conditions and will disable the opposite path provided no voice wave is traveling in said path, and echoes from intermediate points on the circuit of voice waves traveling from the talker's end thereof will be suppressed before they reach said talker's end while the party at the end of origin continues to talk without interruption.
6. In a two-way telephone circuit including paths adapted for transmission in opposite directions, the method of transmission control and echo suppression which consists in causing the incoming voice waves near one end of the circuit to disable the outgoing path, provided said path is not carrying voice waves of earlier arrival, causing the outgoing voice waves near said end of the circuit to disable the incoming path temporarily, provided said path is not carrying voice waves of earlier arrival, and causing the incoming voice waves near said end of the circuit to prevent the disabling of the incoming path, or if it be already disabled, immediately to restore it to operative condition.
7. In a two-way telephone circuit including paths adapted for transmission in opposite directions, the method of transmission control and echo suppression which consists in causing the incoming voice waves near one end of the circuit to disable the outgoing path, provided said path is not carrying voice waves of earlier arrival, causing the outgoing voice waves near said end of the circuit to disable the incoming path temporarily, provided said path is not carrying voice waves of earlier arrival, causing the incoming voice waves near said end of the circuit to prevent the disabling of the incoming path, or if it be already disabled, immediately to restore it to operative condition, and causing the outgoing voice waves to prevent the disabling of the outgoing path by incoming voice waves of later arrival.
8. In a two-way telephone circuit including paths adapted for transmission in opposite directions, apparatus near one end of the circuit comprising means responsive to voice waves in the incoming path for disabling the outgoing path, means responsive to voice waves in the outgoing path for disabling the incoming path, means responsive to voice waves in the outgoing path for preventing the disabling of said path by later arriving voice waves in the incoming path, and means responsive to voice waves in the incoming path for preventing the disabling of said path and for restoring the same to operative condition if it be already disabled.
9. In a two-way telephone circuit including paths adapted for transmission in opposite directions, apparatus near one end of the circuit comprising means whereby the outgoing path when it is not carrying voice waves will be disabled in response to voice waves in the incoming path, means whereby the incoming path when it is not carrying voice waves will be disabled in response to voice waves in the outgoing path, and means responsive to voice waves in the incoming path for preventing the subsequent disabling of said path and for restoring the same to operative condition if it be already disabled.
10. In a two-way telephone circuit including paths adapted for transmission in opposite directions, voice operated control apparatus associated with each end of the circuit, said apparatus at a certain near end of the circuit being so arranged that voice waves which pass the apparatus at the distant end will reach said near end under any conditions and will disable the opposite path at said near end provided no voice wave is traveling in said path, and echoes from intermediate points on the circuit of voice waves originating at the talker's end thereof will be prevented from reaching said talker's end while the party at the end of origin continues to talk without interruption.
11. In a two-way telephone circuit including paths adapted for transmission in opposite directions, echo suppressor and associated apparatus near one end of the circuit, said apparatus comprising means responsive to voice waves in the outgoing path for closing a circuit designed to short-circuit the incoming path, means responsive to voice waves in the incoming path for closing a circuit designed to short-circuit the outgoing path, means responsive to voice waves in the incoming path for opening the circuit designed to short-circuit said path, and means responsive to the voice waves in the outgoing path of earlier arrival than voice waves in the incoming path for opening the circuit designed to short-circuit said outgoing path.
12. In a two-way telephone system, a four-wire circuit having paths adapted for transmission in opposite directions; apparatus near one end of said four-wire circuit comprising means responsive to voice waves in the incoming path for disabling the outgoing path, means responsive to voice waves in the outgoing path for disabling the incoming path, means responsive to voice waves in the outgoing path for preventing the disabling of said path by later arriving voice waves in the incoming path, and means responsive to voice waves in the incoming path for preventing the disabling of said path and for restoring the same to operative condition if it be already disabled; a two-way line connected in extension of said four-wire circuit at one end thereof, and a submarine cable circuit connected

in extension of said four-wire circuit at the other end thereof.

13. In a two-way system for the transmission of energy, comprising two separated stations connected by two paths adapted for transmission in opposite directions, the method of transmission control which consists in causing the energy received at one of said stations to control the transmission efficiency of the transmitting path, provided said path is not carrying energy of earlier arrival, causing the energy transmitted from said station to control the transmission efficiency of the receiving path, provided said path is not carrying energy of earlier arrival, and causing the received energy to render the receiving path at all times exempt from control by energy in the transmitting path.

14. In a two-way system for the transmission of energy, two separated stations, two paths connecting said stations and adapted for transmission in opposite directions, and apparatus at one of said stations comprising means whereby the transmission efficiency of the transmitting path will be controlled by energy in the receiving path, provided said transmitting path is not carrying energy of earlier arrival, means whereby the transmission efficiency of the receiving path will be controlled by energy in the transmitting path of earlier arrival than energy in the receiving path, and means whereby energy in the receiving path will at all times render said path exempt from control by energy in the transmitting path.

15. In a two-way system for the transmission of energy, comprising two separated stations connected by two paths adapted for transmission in opposite directions, the method of transmission control which consists in causing the energy in the same one of said paths to control the transmission efficiency of the opposite path at each of said stations, provided said opposite path is not carrying energy of earlier arrival, and causing the energy received at one of said stations over said opposite path to exempt said path at

all times from transmission efficiency control at said station by energy in the first mentioned path.

16. In a two-way system for the transmission of energy, comprising two separated stations connected by two paths adapted for transmission in opposite directions, the method of transmission control which consists in causing the energy in one of said paths to disable the opposite path at each of said stations, provided said opposite path is not carrying energy of earlier arrival, and causing the energy received at one of said stations over said opposite path to prevent said path from being disabled at said station by energy in the first mentioned path, or if it be already disabled, immediately to restore it to operative condition.

17. In a two-way system for the transmission of energy, two separated stations, two paths connecting said stations and adapted for transmission in opposite directions, means at each of said stations responsive to energy in the same one of said paths for affecting the transmission efficiency of the opposite path, provided said opposite path is not carrying energy of earlier arrival, and means at one of said stations responsive to energy received from the other station over said opposite path for rendering the local means for affecting the transmission efficiency exempt at all times from control by energy in the first mentioned path.

18. In a two-way system for the transmission of energy, two separated stations, two paths connecting said stations and adapted for transmission in opposite directions, means at each of said stations responsive to energy in the same one of said paths for disabling the opposite path, provided said opposite path is not carrying energy of earlier arrival, and means at one of said stations responsive to energy received from the other station over said opposite path for rendering the local disabling means exempt at all times from control by energy in the first mentioned path.

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