Oct. 6, 1931. L. G. ABRAHAM 1,826,196

ECHO SUPPRESSOR

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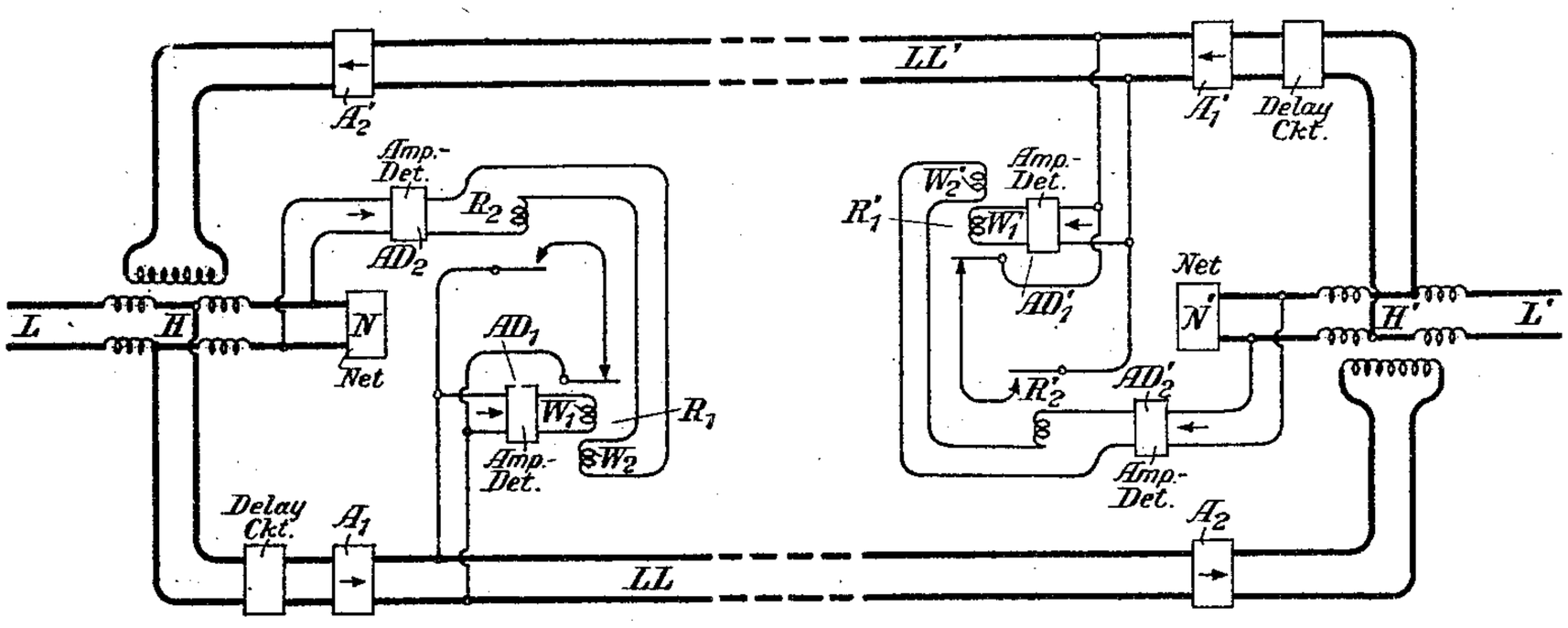

Fig. 1

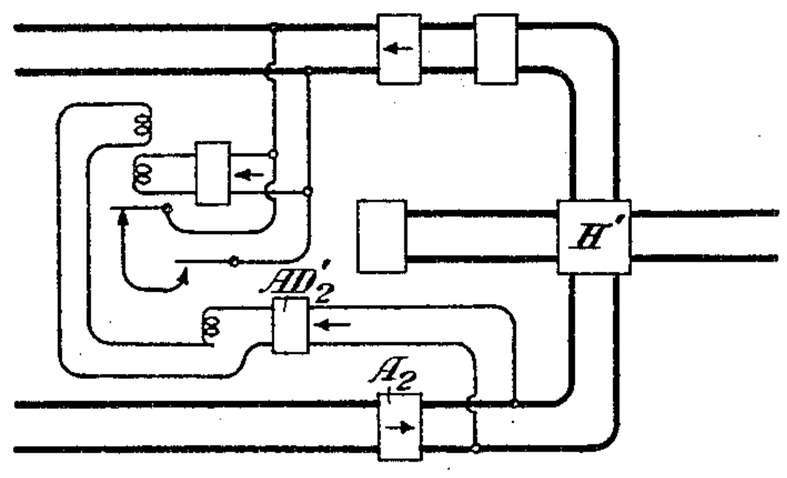

Fig. 2

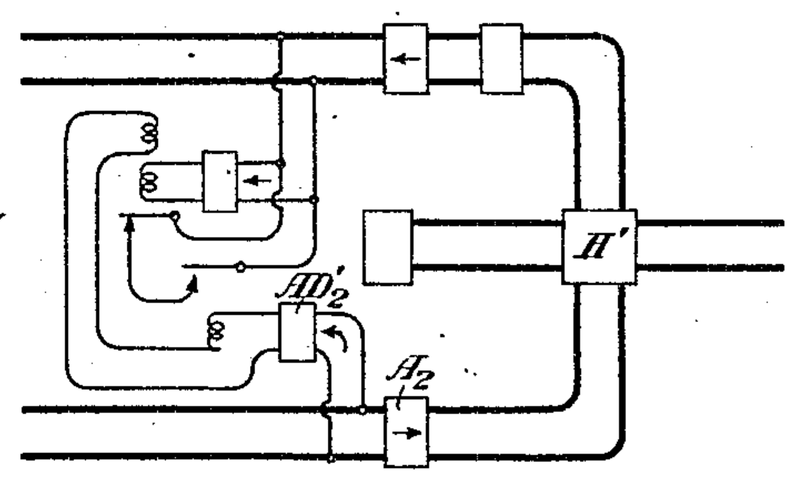

Fig. 3

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UNITED STATES PATENT OFFICE

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ECHO SUPPRESSOR

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

The apparatus which is used at present on many types of two-way telephone circuits is disclosed in 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. With the arrangements for suppressing echoes which have been devised heretofore, two major difficulties have been present and have not heretofore been substantially overcome. In the first place, when one party has taken control of the transmission circuit, causing the disabling of the one-way path in the opposite direction, an excessive time may be required, once this first party has stopped speaking, for the other party to take control of the circuit so that the currents representing his voice may reach the first party. In the second place, in order that adequate suppression of echoes may be had, it has been necessary to employ arrangements which leave a considerable chance of a mutual lock-out, i. e., a situation in which each party causes the disabling of the path which should carry the voice currents of the other party; the result of this situation is, of course, that both parties may speak while neither party hears the voice of the other.

The principal object of this invention is to provide satisfactory suppression of echoes in two-way circuits along with substantial reduction of the breaking time, and lessening of the chance of mutual lock-out.

A further object of the invention is to provide echo suppressor apparatus such that, if two four-wire circuits are in tandem and it is desired to cut the system through on a four-wire basis, removing the echo suppressors at the junction point, with advantage to be discussed hereinafter, this may be readily and simply done.

These objects and the various advantages of the invention are accomplished, in general, by placing apparatus at or near each end of the circuit, causing the incoming voice currents at either end of the circuit to disable the outgoing path, provided this path is not carrying voice currents which reach the apparatus before the arrival of the incoming currents, and causing the outgoing voice currents at either end of the circuit to prevent the disabling of the outgoing path by currents in the incoming path of simultaneous or later arrival.

The invention will be clearly understood when the following description of a desirable embodiment thereof and the operation involved is read with reference to the accompanying drawings, in which—

Figure 1 shows diagrammatically a four-wire circuit equipped with the novel echo suppressor apparatus of the invention;

Fig. 2. shows a part of the four-wire circuit and indicates a modification of the echo suppressor connections; and

Fig. 3, like Fig. 2, shows a part of the four-wire circuit and indicates an alternative modification of the echo suppressor connections.

Like characters of reference in the three figures of the drawings designate corresponding elements of the circuits.

With reference to Fig. 1 of the drawings, there is disclosed between two two-wire lines L and L′ a four-wire circuit having a two-wire path LL adapted for transmission from line L to line L′ and a two-wire path LL′ adapted for transmission from line L′ to line L. The usual one-way amplifiers are conventionally represented by A_1, A_2, A'_1 and A'_2. At the left end of the four-wire circuit, there is shown the usual hybrid coil H, and an artificial network N balances the two-wire line L; likewise, at the right end of the four-wire circuit, there is disclosed the hybrid coil H′ and the balancing network N′. It will be understood, of course, that the four-wire circuit may be quite long—1,000 miles or considerably longer—or, in fact, of any desired length; the broken line portions of the lines LL and LL′ may therefore represent a very long intermediate section of the four-wire circuit, and it is to be understood that the echo suppressor apparatus shown at the left end of the four-wire circuit is located comparatively near that end of the circuit and

the apparatus indicated at the right comparatively near the right end of the circuit and there is no echo suppressor apparatus associated with the intermediate portions of the four-wire circuit.

Associated with the left end of the four-wire circuit are amplifier-detectors AD_1 and AD_2 controlling relays R_1 and R_2, respectively; likewise, at the right end of the four-wire circuit are amplifier-detectors AD'_1 and AD'_2 controlling relays R'_1 and R'_2, respectively. An understanding of the arrangement of the echo suppressor and associated apparatus will be best arrived at by a reading of the following description of the operation of the apparatus:

Let it be assumed that the subscriber connected with the two-wire line at L at the left end of the four-wire circuit starts to talk before the subscriber connected to line L' at the right end of the circuit. The speech currents coming over line L divide at the hybrid coil H, a part of the energy being dissipated in the output of the one-way amplifier A'_2 and the other part being amplified in A_1 and sent on over the path LL. The currents in LL will operate the amplifier-detector AD_1 and the relay R_1 controlled thereby. As clearly indicated in the drawings, the operation of relay R_1 opens a circuit which is adapted to short the transmission path LL, under certain conditions, upon the operation of relay R_2. The speech currents in line LL upon reaching the right end of the four-wire circuit divide at the hybrid coil H' between the network N' and the two-wire line L'. The speech currents transmitted toward the network N' enter AD'_2, are amplified and rectified and operate relay R'_2. The operation of this relay completes a circuit through the armature and contact and places a short upon the transmission line LL', which is adapted, as explained above, to transmit from two-wire line L' at the right to two-wire line L at the left. This short circuit placed upon the line LL' causes the suppression of any echoes returned from the line L' and the hybrid coil H'. The amplifier-detector AD'_1 and the relay R'_1 at the right end of the four-wire circuit function as do the corresponding elements AD_1 and R_1 at the left end of the circuit. It will be noted in the case of relay R'_1 that in addition to winding W'_1 connected in the output of amplifier-detector AD'_1 there is a second winding W'_2 differentially wound with respect to winding W'_1. This winding W'_2, it will be noted, is in series with the winding of relay R'_2. Accordingly, when relay R'_2 is energized, as a result of the operation of amplifier-detector AD'_2, the winding W'_2 of relay R'_1 is also energized. The action of winding W'_2 serves to prevent the operation of relay R'_1 by any echoes returning from the right end of the four-wire circuit before relay R'_2 has had time to complete its operation. In other words, the contact of relay R'_1 is held closed until the contact of relay R'_2 is closed, at which time, in addition to the shorting of transmission path LL', there is a shorting of the input of amplifier-detector AD'_1, and subsequent currents in LL' returning from the hybrid coil H' as echoes can have no effect on the relay R'_1. In summary, at the right end of the four-wire circuit, upon the talking of the subscriber connected to line L, a short circuit is placed upon the transmission path LL' by the operation of relay R'_2, and any currents passing over line LL' which are of later arrival at the end of the four-wire circuit than the currents in line LL cannot prevent the shorting of line LL' at first because of the action of winding W'_2 of relay R'_1 and subsequently because the full operation of relay R'_2 places a short on both the transmission path LL' and the input of the amplifier-detector AD'_1.

At this point, it should be noted that under certain conditions, in order to prevent the passing of a spurt of echo current over the line LL' before relay R'_2 has fully operated, it may be necessary to insert a delay circuit, as indicated, or the equivalent between the hybrid coil H' and the input to amplifier-detector AD'_1.

If the subscriber connected to line L' begins to talk after the subscriber at the distant end of the circuit, the former's speech current will be suppressed until the subscriber connected to line L has stopped talking long enough to permit the release of relay R'_2. As soon as this relay has released the voice currents originating with the subscriber on line L' will cause the operation of relay R'_1 and the opening of the circuit adapted to short the transmission path LL' and if the distant speaker should start to speak again, causing the operation of amplifier-detector AD'_2, and the relay R'_2, the closing of the contact of this relay will have no effect since the shorting circuit is opened at relay R'_1. The voice currents passing over line LL' will reach the left end of the four-wire circuit, operate relay R_2 and close the shorting circuit on transmission path LL; thus, the return of echoes from the left end of the four-wire circuit to the right end is prevented. As is the case at the right end of the circuit, the winding W_2 of relay R_1 is connected in series with the winding of relay R_2, is differentially wound with respect to the winding W_1 and, accordingly, serves to hold the contact of relay R_1 closed until relay R_2 has had time to complete its operation and disable the path LL and the amplifier-detector AD_1.

From the above discussion, it will be understood that if the near talker with respect to either end of the four-wire circuit begins to speak before the distant talker, the out-

going path of the four-wire circuit will be clear as long as the outgoing speech continues; at the far end the outgoing path (from that end) will be disabled. However, it is to be noted that if both talkers begin to speak at or near the same time, both paths at both ends will be clear. Thus, if the apparatus functions normally, there is no chance of mutual lock-out; there will merely be the situation, in the event of speech beginning nearly simultaneously at the two ends, of both subscribers talking and each subscriber hearing the other. Any echoes in the circuit will do no harm as both subscribers will be talking and not listening in such a case. This protection from mutual lock-out is one of the major advantages of the applicant's arrangement.

In case two or more circuits equipped with this type of apparatus are connected in tandem it is possible for lockouts to occur between the echo suppressors at the junction points on the various circuits. The chance that such lock-outs will occur, however, is much smaller than would be the case if the circuits were equipped with the type of apparatus now in use. This possibility of lock-out, moreover, may be eliminated by removing the echo suppressors from the circuits at the junction points.

Due to the position of the echo suppressor apparatus at or near the ends of the four-wire circuit and due to the novel arrangement of the echo suppressor apparatus, the breaking time, i. e., the time during which one talker must pause in order to permit the other to take control of the circuit, can be materially reduced. A comparison of applicant's arrangement with the arrangement disclosed in the above identified article by Clark and Mathes will make this clear.

It will be noted that in the arrangement of Fig. 1, the amplifier-detectors AD_2 and AD'_2 are connected between the hybrid coil H and the network N and between the hybrid coil H′ and network N′, respectively. This point of connection is not essential, though in many cases it will be desirable. In Fig. 2 of the drawings, the amplifier-detector AD'_2 at the right end of the four-wire circuit is shown connected between the one-way amplifier A_2 and the hybrid coil H′; in Fig. 3, the amplifier-detector AD'_2 is shown connected to the transmission path on the input side of the one-way amplifier A_2. It will be understood, of course, that corresponding connections may be made at the distant end of the four-wire circuit. In the case of Fig. 2 and Fig. 3, if the distance from the end of the circuit to the echo suppressor apparatus is great enough, no artificial delay will be necessary.

While the invention has been disclosed in certain specific embodiments which are deemed desirable, it is to be understood that the true scope of the invention is not limited thereby but is determined by the appended claims.

What is claimed is:

1. In a two-way telephone circuit including paths adapted for transmission in opposite directions, apparatus associated with each of two distant points at or relatively near the respective ends of the circuit, said apparatus comprising means operable by voice currents in the receiving path for disabling the transmitting path, means operable by voice currents in the transmitting path for preventing the disabling of said path, and circuit arrangements connecting said first named means with said second named means in such a manner as to oppose the operation of the latter while the former is in process of operation.

2. 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 will normally be disabled in response to voice currents in the incoming path and means whereby currents in the outgoing path will prevent the disabling of said path by subsequently arriving currents in the incoming path.

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 whereby the outgoing path will normally be disabled in response to voice currents in the incoming path and means whereby currents in the outgoing path will prevent the disabling of said path by subsequently arriving currents in the incoming path without disabling the incoming path.

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 will normally be disabled in response to voice currents in the incoming path, means whereby currents in the outgoing path will prevent the disabling of said path by subsequently arriving currents in the incoming path, and means whereby later flowing currents in the outgoing path are prevented from interrupting the disabling of said path by earlier flowing currents in the incoming path.

5. In a two-way telephone circuit having paths adapted for transmission in opposite directions, echo suppressor apparatus associated with each end of the circuit and so arranged that if the near talker, with respect to either end, begins to speak before the distant talker, the outgoing path will be clear as long as the outgoing speech continues and the incoming path will be disabled, whereas if both talkers begin to speak at approxi-

mately the same time, both paths will be clear.

6. In a two-way telephone circuit including paths adapted for transmission in opposite directions, echo suppressor and associated apparatus relatively near each end of the circuit, said apparatus comprising means responsive to voice currents in the incoming path for closing a circuit designed to short circuit the outgoing path, means responsive to voice currents in the outgoing path for preventing the closure of said shorting circuit, thereby preventing the disabling of the outgoing path, and means responsive to current flow in the incoming path for preventing the operation by currents of later arrival of said means for preventing the closure of the shorting circuit.

7. In a two-way telephone circuit including paths adapted for transmission in opposite directions, echo suppressor and associated apparatus relatively near each end of the circuit, said apparatus comprising means responsive to voice currents in the incoming path for closing a circuit designed to short circuit the outgoing path, means responsive to voice currents in the outgoing path for opening said shorting circuit, thereby preventing the disabling of the outgoing path, and means responsive to current flow in the incoming path for preventing the operation by currents of later arrival of said means for opening the shorting circuit.

8. In a two-way telephone circuit including paths adapted for transmission in opposite directions, echo suppressor and associated apparatus relatively near each end of the circuit, said apparatus comprising means responsive to voice currents in the incoming path for closing a circuit designed to short the outgoing path, means responsive to voice currents in the outgoing path of earlier arrival than currents flowing in the incoming path for preventing the closure of said shorting circuit, thereby preventing the disabling of the outgoing path, and means responsive to current flow in the incoming path for preventing the operation by currents of later arrival of said means for preventing the closure of the shorting circuit.

9. In a two-way telephone circuit having paths adapted for transmission in opposite directions, the method of suppressing echoes which consists in causing the incoming voice currents near either end of the circuit to disable the outgoing path, provided said path is not carrying voice currents of earlier arrival, and causing the outgoing voice currents near either end of the circuit to prevent the disabling of the outgoing path by currents in the incoming path of simultaneous or later arrival.

10. In a two-way telephone circuit having paths adapted for transmission in opposite directions, the method of suppressing echoes which consists in causing the incoming voice currents near either end of the circuit to disable the outgoing path, provided said path is not carrying voice currents of earlier arrival, and causing the outgoing voice currents near either end of the circuit to prevent the disabling of the outgoing path by currents in the incoming path of simultaneous or later arrival without disabling the incoming path.

In testimony whereof, I have signed my name to this specification this 3rd day of September, 1929.

LEONARD G. ABRAHAM.