Dec. 10, 1929. D. MITCHELL ET AL 1,738,536

ECHO SUPPRESSOR

Filed Aug. 23, 1928 2 Sheets-Sheet 1

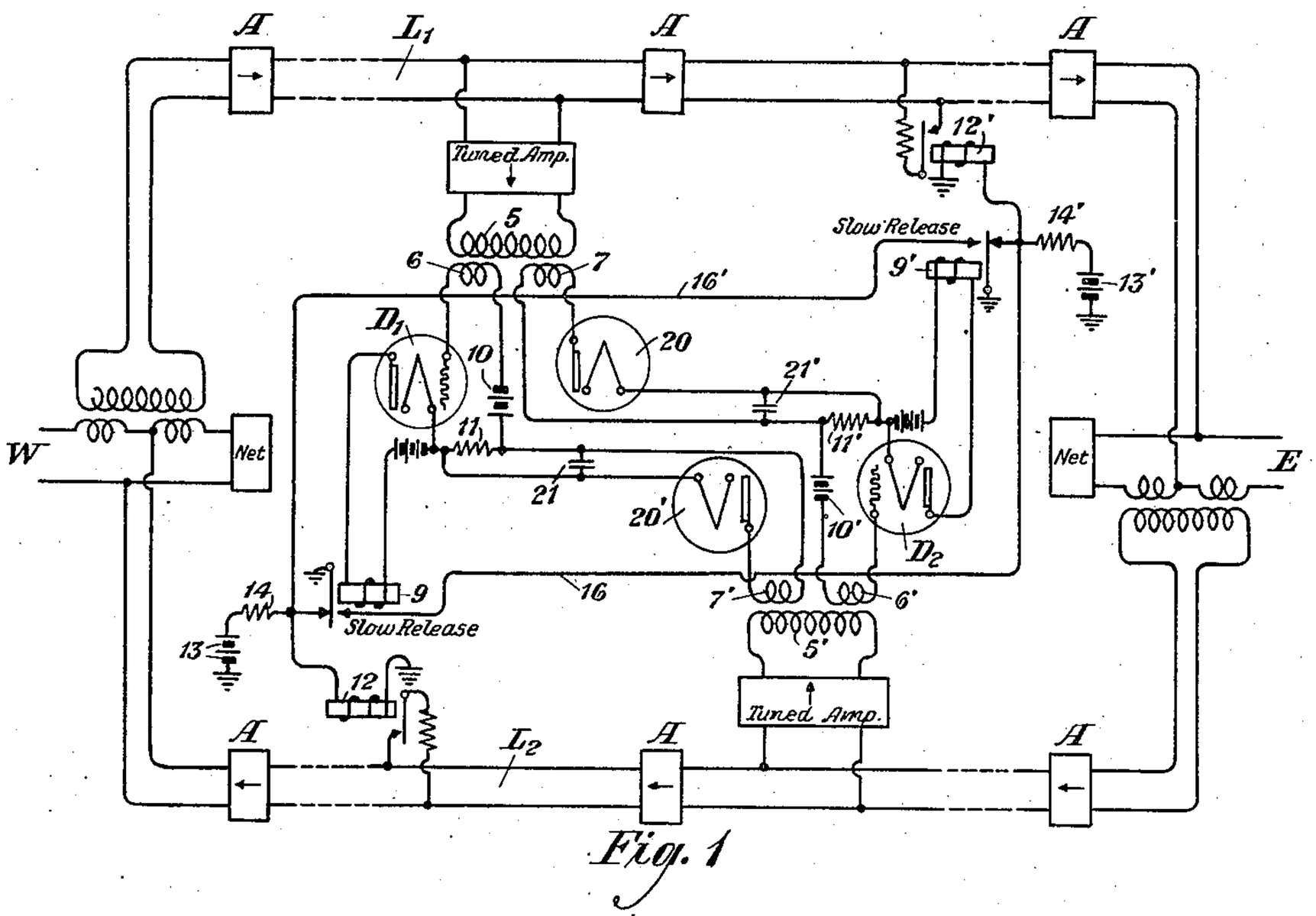

Fig. 1

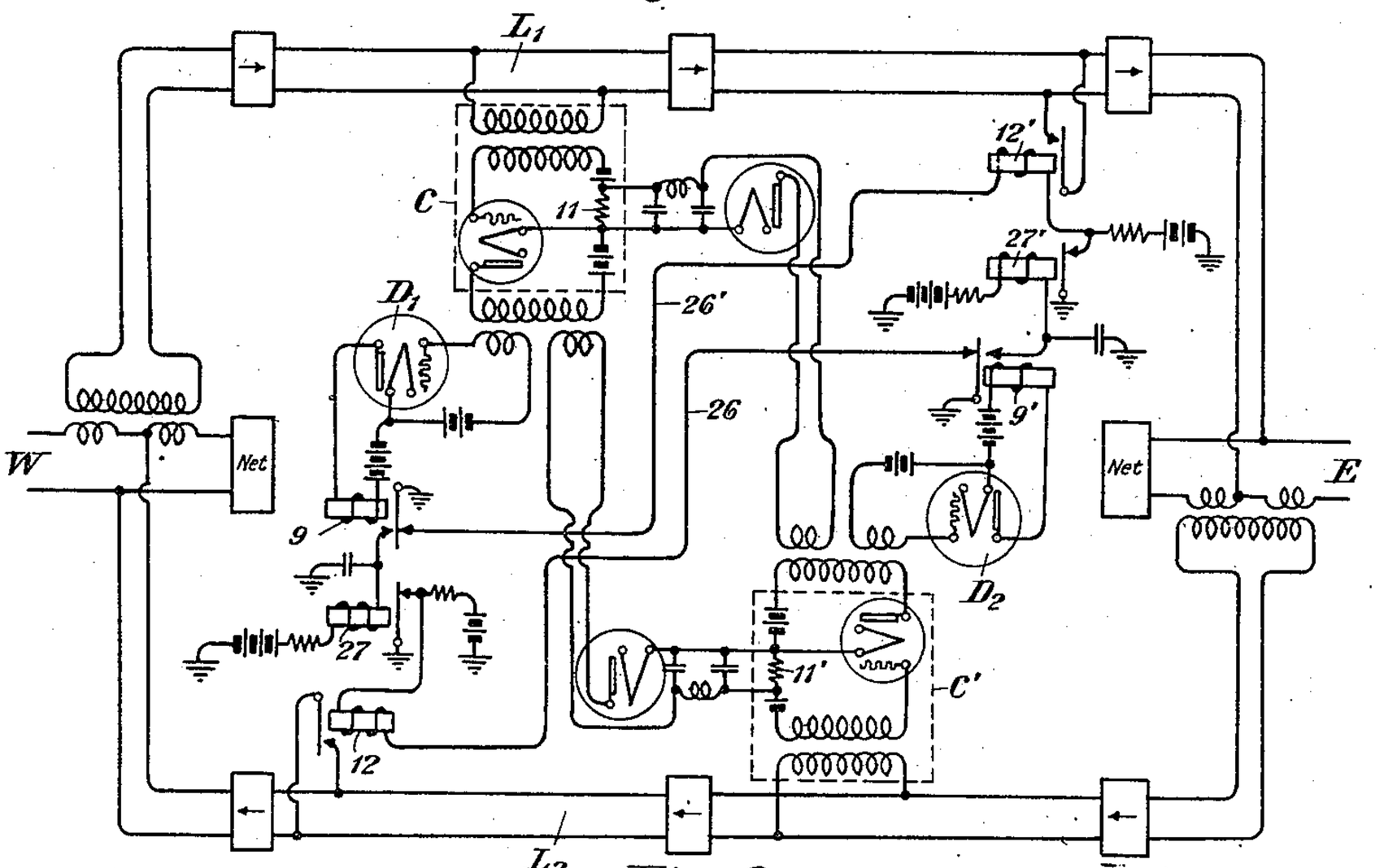

Fig. 2

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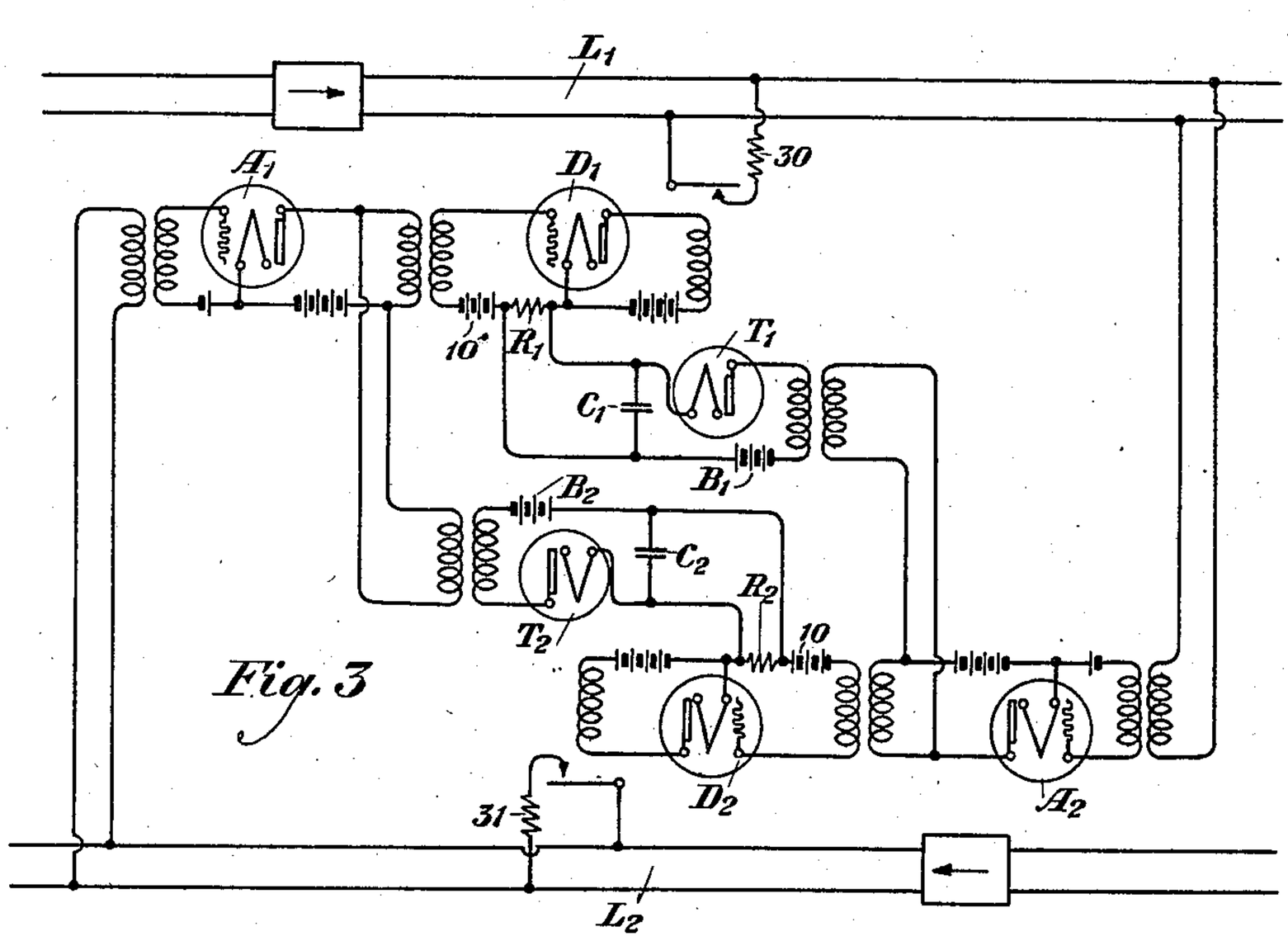

Fig. 3

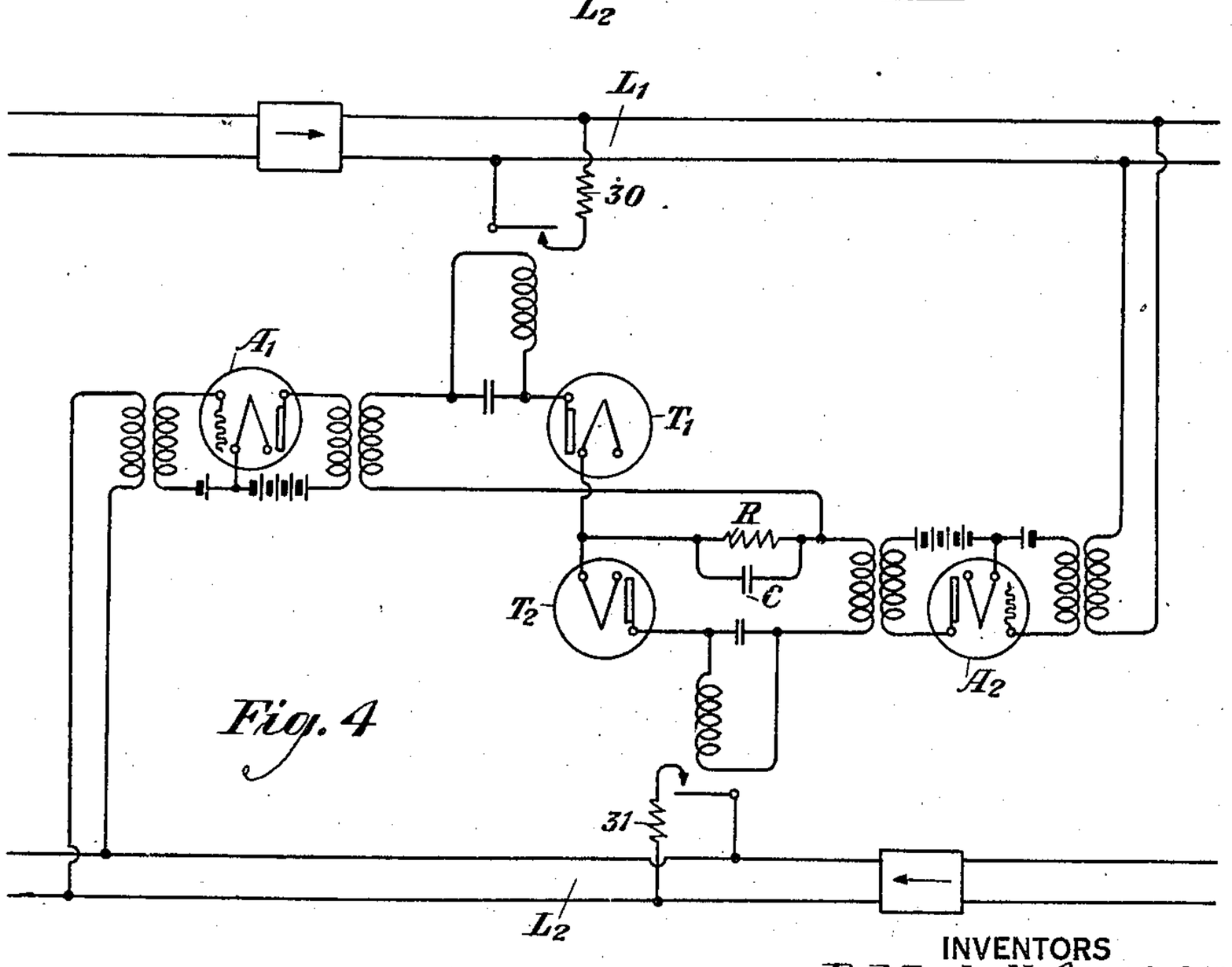

Fig. 4

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UNITED STATES PATENT OFFICE

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ECHO SUPPRESSOR

Application filed August 23, 1928. Serial No. 301,660.

This invention relates to echo suppressors on telephone lines, and more particularly to a method and means by which the sensitivity of the suppressor may be increased without deleterious effects from noise. Another object is to devise a system which makes it possible for the talking party who does not have control of the line to obtain such control if need be; that is, to permit "breaking." We obtain these results by a special differential action between the two parts of a suppressor as connected to the opposite lines.

The invention will be better understood from the following specification and the accompanying drawing in which Figure 1 is a circuit diagram of a four-wire telephone circuit with a suppressor showing our invention. Figs. 2, 3 and 4 each represent modifications of the invention of Fig. 1.

Referring more particularly to Fig. 1, there is shown the four-wire circuit consisting of the lines L_1 and L_2, the upper one of the figure being adapted to transmit conversation from west to east and the other from east to west. These two lines are associated at their terminals E and W with the usual hybrid coils from which lines continue to the subscribers. In general, the lines L_1 and L_2 will be provided with a number of amplifiers or repeaters A. Bridged across the line L_1, preferably adjacent to one of the repeater stations, is a tuned amplifier circuit with adjustable amplification the output of which contains a transformer or other suitable connection to one side of the suppressor. As shown in the figure, the transformer has a primary winding 5 and two secondary windings 6 and 7. The secondary winding 6 leads to the input of a detector circuit comprising the detector tube D_1 the output circuit of which contains the winding 9 of a relay. This detector circuit is supplied with the usual batteries for filament heating and for plate voltage. In addition, it may include a grid biasing battery 10 and in the grid circuit there is also included a resistance 11 the function of which will be later explained. The relay 9 is taken to represent a single relay or a chain of relays devised to give a slow release in any manner well known in the art.

Adjacent the line L_2 is a relay 12 which, by suitable contacts, will upon operation put a short-circuit or other loss across the line L_2. The relay 12 is supplied with power from the battery 13 through a resistance 14. When the relay 9 is not operated, a ground connection is established through the back contact of the relay which short-circuits the relay 12, thus leaving this in the off position. Upon operation of the relay 9, however, this short-circuit is removed and the relay 12 may then be operated by the battery 13 to place the loss across the line L_2.

A strictly symmetrical arrangement is provided for the lines, looked upon in the reverse direction, there being bridged across the line L_2 the tuned amplifier with the output transformer having coils 5′, 6′ and 7′. The coil 6′ is connected to the input of a detector D_2 the grid circuit of which contains the biasing battery 10′ and the resistance 11′ and the output of which includes the slow release relay or chain of relays 9′, all as described previously. There is also provided the relay 12′ for placing a short-circuit or loss across the line L_1, and a battery 13′ and resistance 14′ to perform the same functions as already described.

An interlocking connection is provided between the two parts consisting of the conductor 16 leading from the back contact of the relay 9′ to the front contact of the relay 9. Similarly, a conductor 16′ leads from the back contact of the relay 9 to the front contact of the relay 9′. Another cross-connection between the two parts of the suppressor is provided in that the secondary winding 7 is connected through a rectifier 20 across the resistance 11′ in the grid circuit of the detector D_2. Similarly, the secondary winding 7′ is connected through a rectifier 20′ across the resistance 11 in the grid circuit of the detector D_1. Condensers 21 and 21′ are shunted across the resistances 11 and 11′.

The operation of the circuit is as follows. Telephone current arriving from W will pass over the line L_1. Part of this will be diverted into the tuned amplifier and will be detected in the detector circuit D_1, operating the relay 9 to remove the short-

circuit from the relay 12 and thus placing a short across the line L_2. This short or introduction of loss on the line L_2 eliminates the echo effects which it is the purpose of this invention to suppress. Simultaneously with the operation of D_1, part of the output of the tuned amplifier passes into rectifier 20, causing the charging up of condenser 21′ and the placing of an additional negative potential on the grid of detector D_2. This additional negative potential prevents the false operation of detector D_2 and relay 9′ by the echo returned from E on line L_2. Resistance 11′ causes the slow discharge of condenser 21′, providing for a restoration of the circuit to normal after the speech currents have ceased for sufficient time, so that there is no longer any echo in L_2.

It may be that a certain amount of noise current exists on either of the lines, and there may in particular be sufficient noise on the line L_2 to operate the relay 9′ through the detector D_2. In order to overcome this action, while telephone current is coming in from W, the winding 7, with its rectifier 20, is again used for introducing bias on D_2. The larger the amount of noise on the line L_2 the greater must this biasing voltage be, and this is naturally provided for by the subscriber at W speaking more loudly. Thus, his control of the circuit, due to the differential action of the apparatus, depends on the volume of his speech currents being greater than the volume of the noise currents. By the selection of the proper apparatus this differential action may be obtained so long as the transmission lines are not too noisy to be practical for telephone transmission service.

The action in the reverse direction is identically the same and, therefore, does not need to be explained. It should be pointed out, however, that in case E commences talking while W has control of the line he will find his own line L_2 short-circuited, so that his speech will not be transmitted through to W. It will, however, be transmitted through the tuned amplifier circuit to the detector D_2, but in general the biasing effect on the resistance 11′ will be sufficient to leave W in control of the line so long as he continues speaking. The arrangement does, however, permit E to break in, for if he speaks with sufficient loudness he will overcome the bias introduced at 11′ and operate the relay 9′, thus removing the short across the line L_2 through the releasing of the relay 12 by making contact with the conductor 16′. Here again, then, the differential action between the two telephone currents is operative to permit breaking.

One aspect of the circuit arrangement of Fig. 1 is that the tuned amplifier bridge of the line L_1 shall be separated from the short circuit controlled by the relay 12′ by some suitable devise so that the short circuit will not be effective or completely effective against the bridged tuned amplifier. This may be accomplished by having these two bridges on the opposite sides of a repeater A or by replacing such a repeater by an artificial line of suitable impedance characteristics. We consider this feature of the separation of the two functions of a suppressor—namely, that of putting a loss across the line and that of preventing false operation—to be of importance.

The bridged amplifiers have been spoken of as tuned. This is for the purpose of discriminating against the noise currents which are most likely to be troublesome in such a line. Obviously, the tuning may consist of the usual resonant circuit tuned for any desired frequency, and generally quite flatly, or it may consist of a band filter permitting the passage of those voice frequencies which are most effective and which, at the same time, are not too close to those characteristic of the noise disturbances of the line. In addition, the amplification given by these amplifiers is made adjustable to permit of applying the required amount of power to the rectifiers or detectors associated with their outputs.

Fig. 2 shows a circuit which is in most part essentially the same as that of Fig. 1 but incorporating certain modifications to our invention. This figure shows the lines L_1 and L_2, and the separation of the two functions of the suppressors by the insertion of a repeater or an artificial line, or other equivalent arrangement, between the loss bridge and the tuned amplifier bridge. In this modification the biasing resistances 11 and 11′, which in Fig. 1 were in the grid circuit of the detector tubes, have been placed in the grid circuits of the tuned amplifier circuits, here indicated by C and C′. In connection with these biasing resistances there are shown condensers and inductances to filter out the alternating current component of the rectified currents in much the same way as shown for Fig. 1. A second modification in this figure relates to the connections for the relays 12 and 12′. Upon the operation of the relay 9, the ground connection for the relay 12′ through the conductor 26′ is interrupted, thereby keeping clear the line for conversation from west to east. At the same time, the circuit is closed for the relay 27 which, upon operation, removes the short-circuiting ground for the relay 12, permitting the operation of this relay through a circuit comprising battery, relay 12, conductor 26 to ground through the back contact of the relay 9′. It will be noted from this figure that if E speaks with sufficient volume to operate the relay 9′, the bridging circuit of the relay 12 is immediately opened, clearing the line for his conversation. This

particular type of interlocking circuit we find of special advantage.

In Fig. 3 still a further modification of our circuit is shown. In this case, E—W conversation is impressed on the amplifier A_1 and detector D_1 to operate the loss bridge 30. At the same time, part of the output of the amplifier A_1 is shunted to supply a rectifier T_2, causing current to flow through resistance R_2 which is in the grid circuit of the detector D_2. The rectified current in R_2 is in such a direction as to put a negative bias on the grid of D_2, thus partially disabling that detector. A battery B_2 is so poled that current tends to flow through the resistance R_2 in the opposite direction. In view of the rectifier T_2, however, no such current can flow, but it does prevent biasing current from flowing through R_2 in the desired direction unless and until the alternating current voltage impressed on the rectifier exceeds the voltage of the battery B_2. An exactly symmetrical arrangement is provided for telephone currents coming from the opposite direction onto line L_2. In order to obtain proper adjustment for the operations noted above the biasing batteries B_1 and B_2 should be given a definitely chosen value. Thus, there is always a certain negative bias on the tubes T_1 and T_2, and in order that false operation protection shall be established by these tubes it is necessary that the currents arriving at the tuned amplifier shall exceed a certain minimum. This minimum is set in accordance with the amount of loss placed on the line by resistances 30 and 31 so that there will be no protection established against false operation until the protection established by these resistances has become inadequate. In this circuit, also, we find it desirable to place in the grid circuit of D_1 and D_2 biasing batteries. In this modified circuit, as in the others, it will be noted that there is present the differential action between the currents on the two lines.

Fig. 4 shows still a further modification. Here E—W conversation will be impressed upon the amplifier A_1 with the output of which there is associated a rectifier T_1 and a relay controlling the bridged loss 30. It will be observed that in this much simplified circuit the functioning of the detectors and rectifiers have been combined. Also, it is to be understood, in this as well as in the three previous circuits, that full wave rectifiers may be desirable in place of the simple ones shown, and also, it is to be understood that detectors may be used instead of rectifiers, or the reverse. Also, in the cases of Figs. 3 and 4, it is to be understood that there may be interlocking actions in the relay chains associated with the loss bridges in the manner shown in Figs. 1 and 2.

What is claimed is:

1. In a telephone circuit comprising an echo suppressor, the method of eliminating false operation which consists in controlling the W—E suppressor from the E—W suppressor by the differential action of the currents in the W—E and E—W lines.

2. In a telephone circuit comprising an echo suppressor, the method of eliminating false operation which consists in controlling the W—E suppressor from the E—W suppressor by the excess of telephone current in the E—W line over that in the W—E line.

3. In a telephone circuit comprising an echo suppressor, the method of eliminating echo which consists in separating the suppressor functions of introducing loss and of preventing false operation and of controlling the one side of the suppressor from the other side by the differential action of the currents in the W—E and E—W lines.

4. In a four-wire telephone circuit, an echo suppressor comprising an E—W and a W—E suppressor, and means in the W—E suppressor to partially prevent its operation, said means responding in proportion to the current in the E—W line.

5. In a four-wire telephone circuit, an echo suppressor comprising an E—W and a W—E suppressor adapted to be operated, respectively, by currents in the E—W and the W—E lines, and means in each to partially disable it, said means responding in proportion to the current in the other line.

6. In a four-wire telephone circuit, an echo suppressor comprising an E—W and a W—E suppressor and a loss bridge for each line, means in the W—E suppressor to partially prevent its operation, said means responding in proportion to the currents in the E—W line, and an interlocking connection between the E—W and the W—E suppressors by which one loss bridge is opened when the other is closed.

7. In a four-wire telephone circuit, an echo suppressor comprising an E—W and a W—E suppressor adapted to be operated respectively by currents in the E—W and the W—E lines, each of these suppressors including a vacuum tube amplifier-detector, means connected with each of the latter for partially disabling it, said means responding in proportion to the current in the other line.

8. In a four-wire telephone circuit, an echo suppressor comprising an E—W and a W—E suppressor adapted to be operated respectively by currents in the E—W and the W—E lines, each of these including a vacuum tube amplifier-detector, a biasing resistance in a grid circuit of each of the latter, a cross-connection between the two circuits whereby blocking current through the resistance in the W—E and in the E—W suppressor will flow in proportion respectively to the current in the E—W line and in the W—E line.

9. In a four-wire telephone circuit, an echo suppressor comprising an E—W and a W—E

suppressor adapted to be operated respectively by currents in the E—W and the W—E lines, each of these including a vacuum tube amplifier-detector, a baising resistance in a grid circuit of each of the latter, a cross-connection between the two circuits whereby blocking current through the resistance in the W—E and in the E—W suppressor will flow in proportion respectively to the current in the E—W line and in the W—E line, and an interlocking connection between the E—W and the W—E suppressors by which one loss bridge is opened when the other is closed.

10. In a four-wire signaling system subject to noise disturbances and provided with echo suppressors, the method which permits operation at a maximum sensitivity of the echo suppressors, which consists in causing each suppressor to react on the other and reduce the loss in one line and increase the loss in the other.

11. In a four-wire signaling system subject to noise disturbances and provided with an echo suppressor, the method which permits operation at a maximum sensitivity of the suppressor, which consists in reducing the echo in one line from noise originating in the other, reducing the loss in the first named line and increasing it in the second line when signals come over the first line.

12. A four-wire signaling system subject to noise disturbances and provided with an echo suppressor, said suppressor comprising means for applying loss of sufficient magnitude to reduce echo to an unobjectionable value and separately to prevent false operation.

13. In a telephone circuit including W—E and E—W lines and an echo suppressor associated therewith, having W—E and E—W suppressor elements, the method which consists in amplifying the telephone energy from the E—W line to a greater value than that from the W—E line before impressing it on the E—W suppressor element, and controlling the W—E suppressor element from its E—W suppressor element by the excess of the amplified energy from the E—W line over that from the W—E line.

In testimony whereof, we have signed our names to this specification this 22nd day of August, 1928.

DOREN MITCHELL.
HAROLD C. SILENT.