March 20, 1934. S. B. WRIGHT ET AL 1,951,465

ECHO SUPPRESSOR

Filed Aug. 19, 1930 2 Sheets-Sheet 1

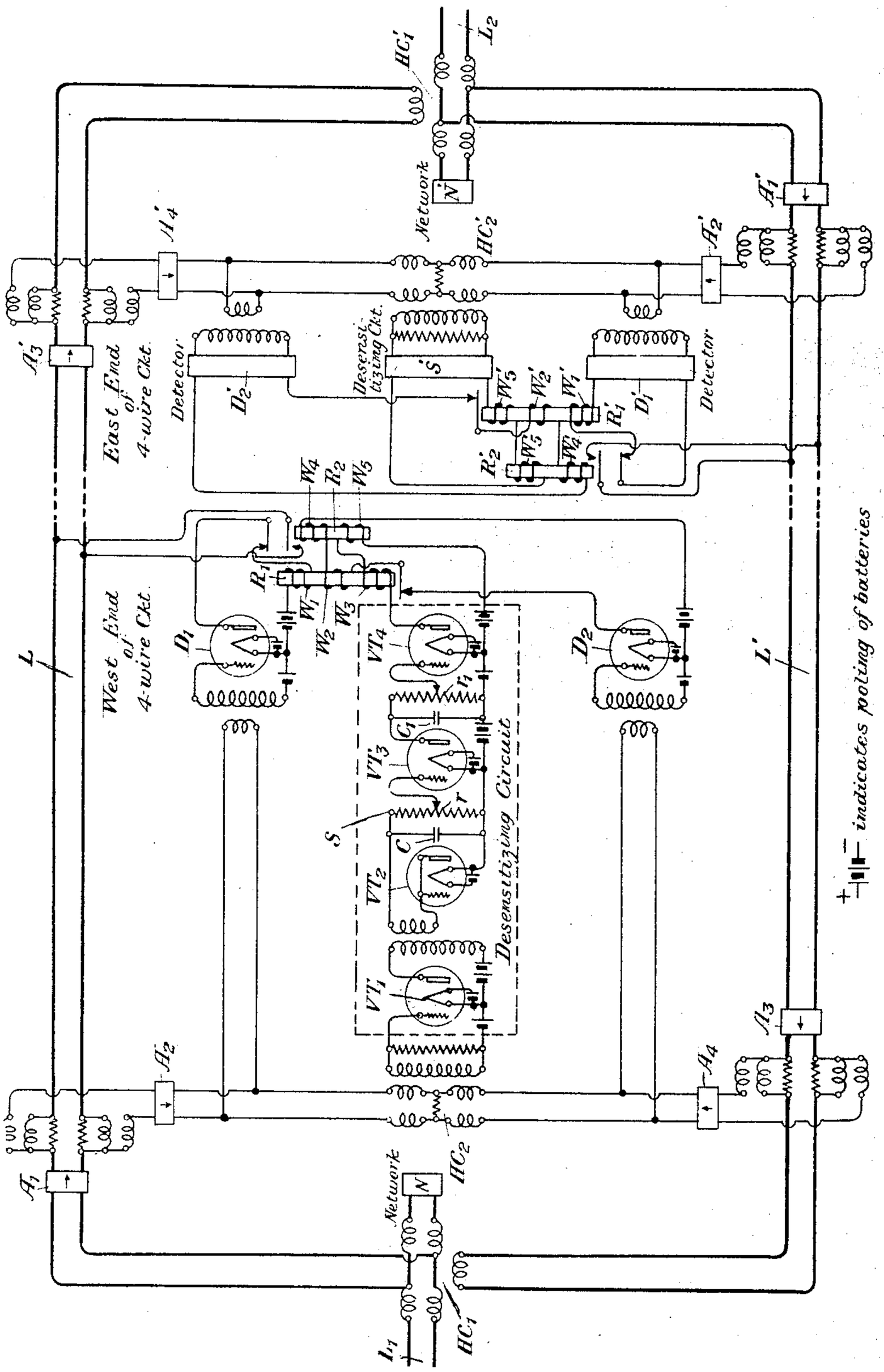

Fig. 1

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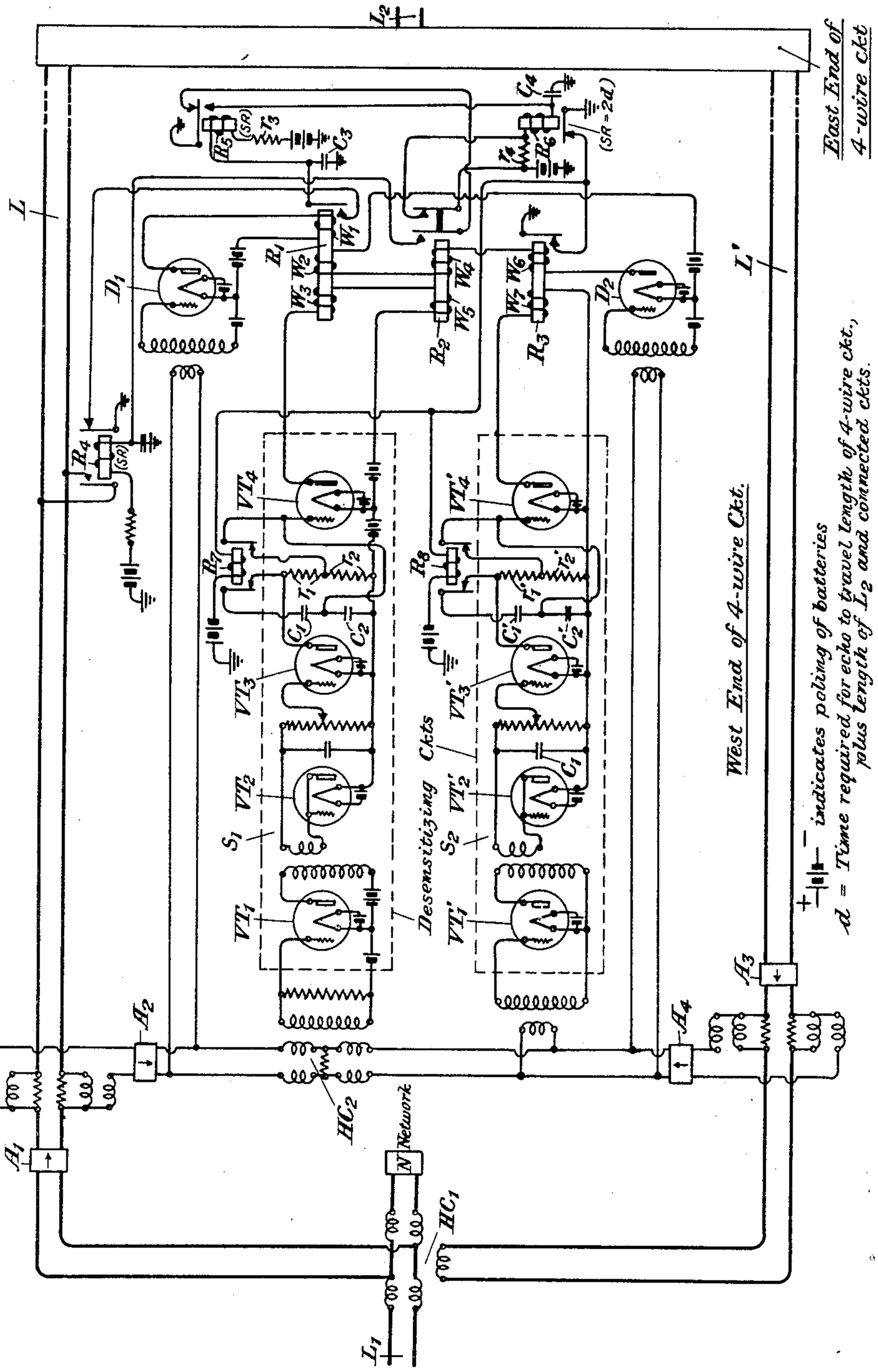

Fig. 2

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Patented Mar. 20, 1934 1,951,465

UNITED STATES PATENT OFFICE

1,951,465

ECHO SUPPRESSOR

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Application August 19, 1930, Serial No. 476,422

4 Claims. (Cl. 179—170)

This invention relates to two-way transmission circuits, and more particularly to four-wire circuits and the arrangements often associated therewith for suppressing echoes.

For a discussion of some of the fundamental problems connected with the presence of echoes in two-way transmission circuits and for a description of echo-suppressing devices which are among those better known in the art, reference may be had to an article by A. B. Clark and R. C. Mathes, Journal of the American Institute of Electrical Engineers, June 1925, pages 618–626.

In United States Patent No. 1,826,196, issued to L. G. Abraham October 6, 1931, there is disclosed the so-called "terminal echo suppressor," which accomplishes generally satisfactory suppression of echoes in long transmission circuits without the requirement of a "hangover" time of such length as to be undesirable.

In United States Patents Nos. 1,814,017 and 1,814,018, issued to S. B. Wright and D. Mitchell July 14, 1931, and in United States Patent No. 1,772,551 issued to D. Mitchell and H. C. Silent August 12, 1930, there is disclosed the so-called "noise desensitizing echo suppressor," in which noise is rendered ineffective to operate the echo suppressor relays and yet the sensitivity of the device to voice currents remains unimpaired when no noise is present.

One of the objects of the present invention is to combine in a satisfactory echo suppressor arrangement the advantages of the "terminal" and the "noise desensitizing" suppressors.

A further object of this invention is to provide an arrangement for suppressing echoes which is at once free from false operation and excessive "hangover" and sufficiently reliable to be satisfactory for use on transmission circuits having long four-wire sections.

These objects are attained by utilizing the "terminal echo suppressor" principle, employing one or more "noise desensitizing circuits" and employing a novel arrangement of relays and associated circuits, as will appear clearly from the description of the apparatus and its operation found hereinbelow. This description is to be read with reference to the accompanying drawings.

Figure 1 of the drawings show diagrammatically, and in part schematically, one arrangement of echo suppressor apparatus in accordance with the invention, while Fig. 2 shows in like manner a modification of the arrangement of Fig. 1 which may be preferable for some transmission circuits. The disclosure of Fig. 1, in addition to showing the first arrangement, helps to bring out the purpose, advantages and arrangement of the modified system of Fig. 2. Wherever such designation appears helpful to the reader of the diagrams, like reference characters are used in the two figures of the drawings to designate corresponding elements.

With reference to the details of the drawings, and first with particular reference to Fig. 1 thereof, there is shown a four-wire circuit having its upper two-wire path adapted for transmission from west to east, for instance, and its lower two-wire path adapted for transmission from east to west. At its west end the four-wire circuit is connected through the hybrid coil HC_1 to the two-wire line L_1, this line being balanced by the network N. At the east end the four-wire circuit is similarly connected through the coil HC'_1 to the two-wire line L_2, which is balanced by the network N'. It will be understood that the echo suppressing apparatus is located at or quite near the west end of the four-wire circuit in the one case, and at or near the east end of the four-wire circuit in the other case, and that the circuit may be very long, with no intermediate echo suppressing devices.

In the transmission line L there are disclosed two one-way amplifiers A_1 at the west end and A'_3 at the east end; likewise, in the line L' there are found the one-way amplifiers A'_1 at the east end and A_3 at the west end. It will be noted that on the output side of each of these four amplifiers there is an arrangement of resistances, which may be quite small, and repeating coils, and that the apparatus associated with these four amplifiers is also associated with the inputs of one-way amplifiers A_2, A'_4, A'_2 and A_4, respectively.

With reference to the above-identified disclosures of the terminal echo suppressor and the noise desensitizing echo suppressor, it will be seen that the arrangement of Fig. 1 of the present application combines the advantages of these two echo suppressing devices. When currents arrive at the west end of the circuit from the east end over line L', relay R_2 connected in the output of detector D_2 will operate to place a short circuit on the two-way line L unless earlier arriving currents flowing in the line L have broken the operating circuit through relay R_2 through the action of detector D_1 and relay R_1. Likewise, it will be seen that the desensitizing circuit S functions to prevent the operation of either the line shorting relay R_2 or the auxiliary control relay R_1 in response to noise currents in either side of the four-wire circuit.

At the east end of the four-wire circuit the

echo suppressing apparatus is similar to that more fully disclosed in Fig. 1 as connected at the west end of the circuit. The detectors D'_1 and D'_2 corresponding to detectors D_1 and D_2 at the opposite end, are shown only schematically, and, likewise, the desensitizing circuit S', schematically shown, will be understood to correspond to the desensitizing circuit S at the opposite end.

The most satisfactory understanding of the arrangement of Fig. 1 will be obtained, it is believed, from the following description of the operation of the circuits of that figure:

Transmission from line L_1 at the west end of the four-wire circuit to line L_2 at the east end, passes through the amplifier A_1 and on over the two-wire line L. At the output of amplifier A_1 a voltage drop is caused in the small resistances connected in the line. This potential is stepped up through the repeating coils, is added to the voltage drop across the line, and is applied to the input of amplifier A_2. It will be understood that these transformer arrangements at the output of the line amplifiers are such that any transmission passing into the lower branch of the four-wire circuit, due to slight unbalance through the hybrid coil HC_1 will not affect amplifier A_4.

From the output of amplifier A_2 the energy passes into the detector D_1 and into the desensitizing circuit S through the hybrid coil HC_2. This coil, however, is so arranged that the output energy of amplifier A_2 cannot pass through the coil in any appreciable amount to affect detector D_2. Detector D_1 without the intervention of the other elements would, of course, operate in response to either voice or noise energy of sufficient intensity passing through amplifier A_2 to actuate R_1. The winding W_1 of relay R_1 is included in the output circuit of detector D_1, and if this winding is energized without the energization of either one of the other windings W_2 and W_3, the relay will operate to break the output circuit of detector D_2 through winding W_2 of relay R_1 and winding W_4, the operating winding of relay R_2. Accordingly, given voice currents without considerable noise energy passing from west to east over line L, the disabling of the echo suppressor at the west end of the circuit is assured, and the talker connected with line L_1 has proper control of the transmission circuit. It will be understood, of course, that if before the voice currents from L_1 reach amplifier A_1, voice currents passing in the opposite direction have reached amplifier A_3, detector D_2 will have operated to energize winding W_4 of relay R_2, thus placing a short circuit on line L, and will have energized the winding W_2 of relay R_1 to bias this relay against operation by any current entering detector D_1.

If the energy passing through amplifier A_2 from the west end of the circuit or A_4 from the east end of the circuit is sustained noise, it causes the operation of the desensitized circuit S, described in some detail in the above-identified patent to Mitchell and Silent. It will be sufficient to state here that this circuit comprises the vacuum tubes VT_1, VT_2, VT_3 and VT_4, the plate filament circuit of the last tube VT_4 including the biasing windings W_3 of relay R_1 and W_5 of relay R_2. The condensers C and C_1 and the corresponding resistance arrangement r and r_1 operate in response to noise to cause an increased current flow in the output of tube VT_4, and the relays R_1 and R_2 are biased against operation by detector D_1 or detector D_2, respectively. It will be understood that if the energy is voice energy as distinguished from noise, the desensitizing circuit S operates in a manner to prevent the building up of a bias on the relays R_1 and R_2.

At the east end of the four-wire circuit the echo suppressor operation is quite similar to that described above in connection with the west end of the circuit. Voice currents arriving over line L and reaching the suppressor point before the arrival of voice currents from L_2, operate detector D'_2, energize the operating winding W'_4 of relay R'_2 and the biasing winding W'_2 of relay R'_1, and, without opposition, short-circuit the line L' at the east end of the four-wire circuit. If voice currents from L_2 reach the suppressor point first, detector D'_1 is operated, and the relay R'_1 operates to break the circuit through relay R'_2; thus control of the transmission circuit is assured to the talker connected with line L_2. Noise reaching the hybrid coil HC'_2 from either direction operates the desensitizing circuit S' to bias relays R'_1 and R'_2 against false operation.

Relay R_2 and relay R'_2 should each have a small hangover time provided, corresponding to the time required for echoes to pass over short terminal circuits which may be connected to the four-wire circuit and which may be unequipped with echo suppressors. It is one of the chief advantages of the terminal echo suppressor arrangement, however, that such hangover time is very short in comparison with that heretofore required.

While the arrangement of Fig. 1 described above will in all probability meet the echo suppressing requirements of the greater number of circuits, there is the possibility that certain troubles in the operation of the suppressor apparatus will arise due largely to the fact that the control of the west suppressor, for instance, through the associated desensitizing circuit will be broken when noise is cut off by the operation of the suppressor relay at the east end. The desensitizing circuit during this quiet period will fall back to a condition in which no appreciable biasing current flows in the windings of the relays. Accordingly, when the short circuit is removed at the far end of the circuit and noise again comes on, the echo suppressing relay at the west end may be momentarily operated—before the desensitizing circuit has had a chance to build up again the biasing current in the relays, and the result will be a brief mutilation of speech. With this possibility of difficulty in mind, the applicants disclose in Fig. 2 of the drawings a modified arrangement which will remove the difficulty.

With particular reference to Fig. 2 of the drawings, at the west end of the four-wire circuit the transmission lines L_1, L and L', the hybrid coil HC_1, the balancing network N, the one-way amplifiers A_1, A_2, A_3 and A_4, and the transformer arrangements at the outputs of A_1 and A_3, are in arrangement identical with that shown in Fig. 1 and discussed hereinabove. It will readily be understood that at the east end of the four-wire circuit the arrangement of transmission lines and amplifiers and the arrangement of echo suppressor apparatus are similar to those disclosed in detail at the west end. Just as in Fig. 1, the two ends of the circuit correspond in these respects. Accordingly, the description of the arrangement and operation of the echo suppressor devices and circuits will, in general, be confined to the west end of the circuit without confusion to the reader.

It will be noted that in the arrangement of Fig. 2 there are two desensitizing circuits S_1 and

S_2, the former one being associated with the amplifiers A_2 and A_4 through the peculiar hybrid coil device HC_2. In addition there are employed a greater number of relays, with connections and functions to be described hereinbelow. As indicated above, the main object of the modification of the circuit of Fig. 1 is to permit the desensitizing circuits at the west end of the four-wire circuit, for instance, to remain at a setting determined by the value of steady noise which has been arriving at this west terminal during a period when the transmission from the east end is cut off due to the echo suppressor action at the east end. In other words, when the noise comes on again, the echo suppressor at the west end is found in the condition in which it was placed by the noise from the east end at the time of the break in the transmission, and so there is prevented the false operation of the west echo suppressor by a renewed transmission of noise. It will be noted that this is the only respect in which the action of the desensitizing circuit, as described above and in the patent to Mitchell and Silent, is changed or interfered with.

In view of the discussion of the circuits of Fig. 1 given above, it is believed that the arrangement and action of the circuits of Fig. 2 will be readily understood from the following description of their operation:

Transmission outgoing from the west terminal of the four-wire circuit passes through amplifier A_1, and energy is drawn off and passed through amplifier A_2 to detector D_1 and the upper desensitizing circuit S_1, it being understood that the hybrid coil HC_2 has the function of preventing energy coming to it from either direction from passing beyond it in any substantial amount. Thus, in the case now being considered, the lower desensitizing circuit S_2 and the detector D_2 are unaffected.

When detector D_1 operates, the operating winding W_1 of relay R_1 is energized. The energy passing into the desensitizing circuit S_1 has the action described above in connection with Fig. 1; that is, if it is voice energy it has no appreciable effect on the relays, while if it is noise energy it operates to bias the relays against actuation. Let it be assumed for the moment that the energy passing through amplifier A_2 is largely speech energy. Relay R_1 operates and closes a circuit through the winding of a relay R_5. This relay is given a suitable slow release time to prevent it from falling back between syllables. In the drawings this is shown accomplished by the action of the condenser C_3 and the resistance r_3. The function of relay R_5 is to remove, and hold removed for the proper period, the ground connection of the circuit including the winding of the suppressor relay proper R_4, which, incidentally, is provided with a slow release time to take care of delayed echo in circuits connected to L_1. The operation of relay R_5, in addition to removing ground from relay R_4, causes the discharge of a condenser C_4 and the consequent operation of a relay R_6. This relay R_6 is given a slow release time which equals $2d$, when d represents the time required for an echo to travel the length of the four-wire circuit plus the length of the connected two-wire line L_2 and any circuits connected thereto. The operation of relay R_6 removes one ground connection from the operating circuits of relays R_7 and R_8 associated with the desensitizing circuits S_1 and S_2, respectively. It will be noted that, as discussed more fully hereinbelow, a second ground is furnished for these relays R_7 and R_8 through the armature of relay R_3; relay R_6 in removing the ground through its armature provides for the release of relays R_7 and R_8 during the periods when noise energy from the east end of the circuit is cut off by the echo suppressor operation at the east end, and the lower desensitizing circuit S_2 is consequently not receiving energy from the line L'.

The relays R_7 and R_8 are arranged so that normally they are in operated condition and through their armatures provide for the normal connection of condensers C_1 and C_2 with the resistance arrangement r_1 and r_2 in the one case, and the normal connection of condensers C'_1 and C'_2 with resistances r'_1 and r'_2 in the case of the lower circuit. When, however, relays R_7 and R_8 are in any way released, these condensers are disconnected from their respective resistances, and, as will be understood by those skilled in the art, the voltages on the grids of the tubes VT_4 and VT'_4 will be maintained at their last values. Accordingly, while these two relays are released no change of any appreciable amount can be made in the biasing current furnished by the two desensitizing circuits to the relays.

It has been stated above that the operation of relay R_6 removes one ground from the operating circuits of relays R_7 and R_8, and that the other ground is furnished through the armature of relay R_3. Relay R_3 has two windings W_7 and W_6. Winding W_7 is included in the output circuit of tube VT'_4 of the lower desensitizing circuit and causes a bias to be applied to the relay which is normally not quite sufficient to release the armature and break the ground contact. Winding W_6 is included in the output circuit of the lower detector D_2 and is normally sufficiently energized to hold relay R_3 operated. It should be stated at this point that, preferably, provision is made for the operation of relay R_3 when no noise whatever is present in the line L'; as will be understood by those skilled in the art, this bias may be provided by suitable voltage on the grid of the detector tube D_2, or by any other suitable means.

Let it be assumed now that noise is coming over the line L' from the east end of the four-wire circuit. This noise energy passes through amplifier A_4 and enters both of the desensitizing circuits. Through the operation of the circuit S_1 a bias is built up in the winding W_3 of relay R_1 and winding W_5 of relay R_2. Likewise, through the operation of the circuit S_2 the biasing action described above it set up in windings W_7 of relay R_3. These noise currents, of course, affect detector D_2 as well as the desensitizing circuits, and the current in winding W_6 of relay R_3 will be sufficient to hold that relay operated. The current in the other winding of the D_2 output circuit, W_4 of relay R_2, however, will not be sufficient to cause the operation of that relay. When speech energy passing from west to east over line L reaches the east end of the four-wire circuit, the echo suppressing relay (corresponding to R_4) will disable the line L', and the noise energy passing toward the west end of the four-wire circuit will be momentarily cut off. Relay R_6, however, has been operated as described above and is held in operated condition by the hangover action described above; accordingly, the right-hand ground for the operating circuits of relays R_7 and R_8 is removed. When the noise in line L' ceases, the current from detector D_2 will cease immediately. The current from VT'_4 will not drop down so quickly, and

relay R_3 will then release removing the left-hand ground from the operating circuit of relays R_7 and R_8, and these two relays release. The breaking of the contacts at their armatures disconnects the condensers and the resistances of the two desensitizing circuits S_1 and S_2, and the proper bias is maintained from these circuits on relays R_1, R_2 and R_3. It will be understood that relays R_7 and R_8 release before the condensers C_1 and C_2 charge up to an appreciable extent, because the action of detector D_2 and relay R_3 takes place in a time which is short compared to the time required for the charging of condensers C_1 and C_2.

From the above discussion, and from a consideration of the hangover time of relay R_6, it will be understood that during a period of time equal to the longest quiet interval which can occur due to the suppression of noise by the speech passing over line L, relays R_7 and R_8 will be released, and the proper bias to prevent subsequent false operation of the echo suppressor by noise will be maintained on the relays at the west end of the four-wire circuit.

It should be noted that if noise energy passes from west to east over line L, it cannot cause the release of relays R_7 and R_8 by itself, even though relay R_6 has operated to remove the right-hand ground from the operating circuits of relays R_7 and R_8: this is true because no substantial amount of this noise energy can pass the coil HC_2 and enter the lower desensitizing circuit S_2 to release relay R_3 and remove the left-hand ground. This point makes it clear why it is desirable to use the two desensitizing circuits: if the circuit S_1 were made to perform the function of S_2 as well as its own, it would be possible for noise currents to build up a bias in the winding W_7 of relay R_3 which would cause the release of that relay during the operation of relays R_1, R_5 and R_6. This would result in the release of relays R_7 and R_8 while relay R_5 was held operated by the noise currents in L, and the ground connection over the armature of relay R_5 would be broken and the operation of the suppressor relay R_4 prevented in response to the voice currents in L'.

Furthermore, it should be noted that noise energy passing from east to west in line L' will never cause the operation of relay R_1 because the hybrid coil HC_2 prevents this energy from entering the detector D_1. Accordingly, even though relay R_3 is released because of the momentary decrease of noise, relays R_7 and R_6 will be held operated through the released condition of relay R_6 (controlled by relay R_1 through relay R_5) which maintains the right-hand ground connection for relays R_7 and R_8.

It remains to point out one other feature of the arrangement shown in Fig. 2. If the four-wire circuit shown is connected through the two-wire circuits to other four-wire circuits, it may be necessary to make the slow release time of relay R_6 quite long—for instance, .5 second. In such a case it may be desirable to provide for the cancellation of the slow release period of relay R_6 whenever the speech energy or the noise energy passing from east to west over line L' has an effect on the relays at the west end of the circuit which is stronger than that due to the biasing current built up by the desensitizing circuits. This cancellation may be accomplished with the arrangement shown in the drawings, whereby an extra armature and an extra contact are added to relay R_2. When relay R_2 operates due to the conditions just discussed, this right-hand contact places a short circuit around the resistance r_4 forming a part of the slow release circuit of relay R_6.

While the invention has been disclosed in two specific embodiments, the second being in the nature of a modification of the first, it is to be understood that such specific disclosure is not intended to limit the scope of the invention, which is determined by the appended claims.

What is claimed is:

1. In a four-wire circuit including paths adapted for transmission in opposite directions, an echo suppressor relatively near each terminal of the four-wire circuit adapted to disable the outgoing path in response to voice currents in the incoming path, means responsive to noise currents for desensitizing said echo suppressor, and means responsive to the disabling of the incoming path by echo suppressor operation at the distant end thereof for maintaining on the near echo suppressor the desensitized effect produced by said desensitizing means.

2. In a four-wire circuit including paths adapted for transmission in opposite directions, echo apparatus comprising means for disabling the suppressing and associated apparatus relatively near each terminal of the four-wire circuit, said outgoing transmission path in response to voice currents in the incoming path, controlling means responsive to voice currents in the outgoing path for preventing the operation of said disabling means by voice currents in the incoming path of later arrival, means responsive to noise currents in either path for desensitizing said disabling means and said controlling means, and means responsive to the disabling of the incoming path by echo suppressor operation at the distant end thereof for maintaining on said disabling means and said controlling means the desensitized effect produced by said desensitizing means.

3. In a four-wire circuit including paths adapted for transmission in opposite directions, the method of transmission control which consists in causing voice currents in the incoming path at either end of the circuit to disable the outgoing path at that end, provided said voice currents are of earlier arrival at that end than voice currents in the outgoing path at the same end, causing noise currents in either path to set up a counter action to prevent false interruption of transmission, and maintaining the counteracting effect at either end of the circuit during a period when transmission is cut off at the distant end thereof.

4. In a four-wire circuit including paths adapted for transmission in opposite directions, an echo suppressor relatively near each terminal of the four-wire circuit adapted to disable the outgoing path in response to voice currents in the incoming path, means responsive to noise currents for desensitizing said echo suppressor, means responsive to the disabling of the incoming path by echo suppressor operation at the distant end thereof for maintaining on the near echo suppressor the desensitized effect produced by said desensitizing means, and means responsive to substantial increase of amplitude of the incoming currents for terminating the operation of said maintaining means.

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