Jan. 13, 1931. H. W. O'NEILL 1,788,736

ECHO SUPPRESSING AND ENERGY LIMITING CIRCUITS

Filed Feb. 2, 1927 2 Sheets-Sheet 1

Fig. 1.

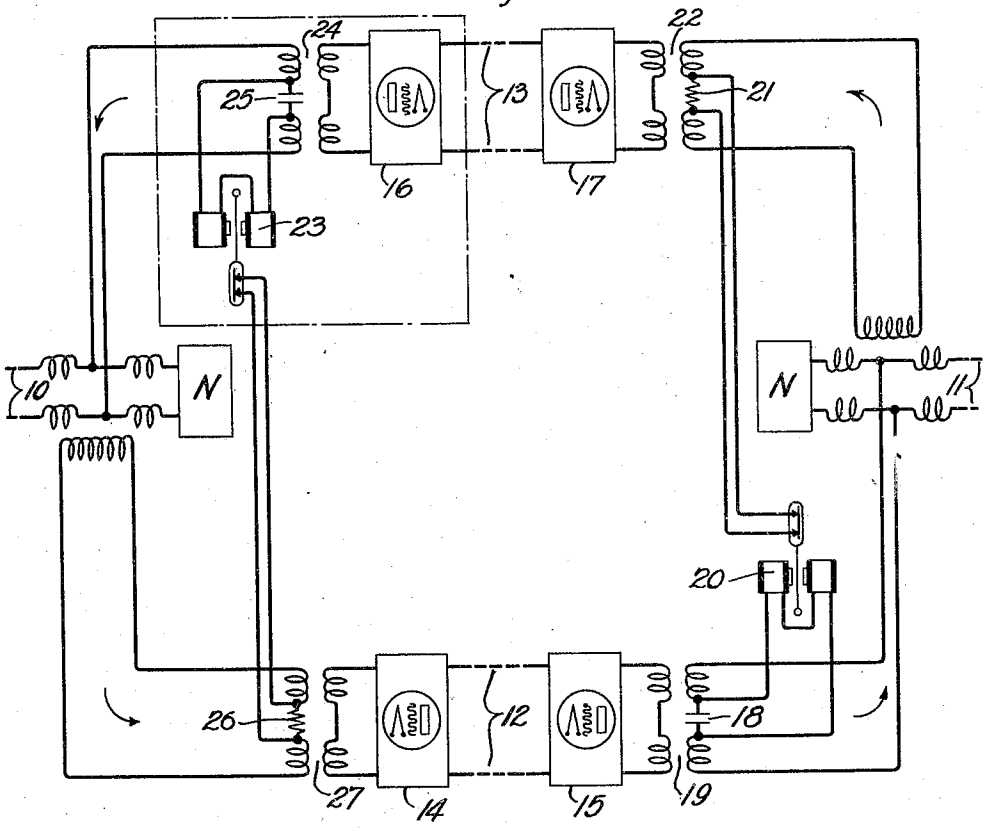

Fig. 2.

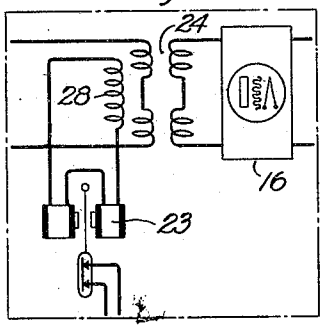

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Fig. 3.

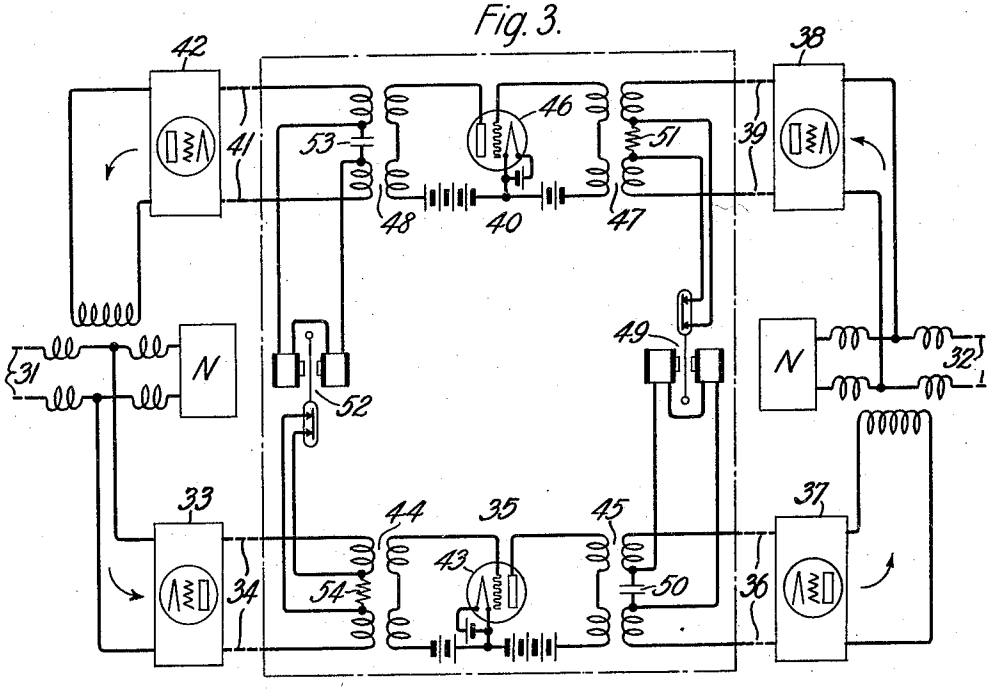
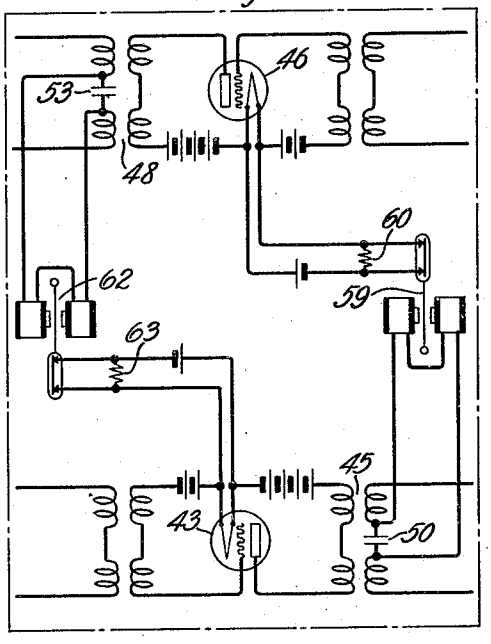


Fig. 4.



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Patented Jan. 13, 1931 1,788,736

UNITED STATES PATENT OFFICE

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ECHO-SUPPRESSING AND ENERGY-LIMITING CIRCUITS

Application filed February 2, 1927. Serial No. 165,288.

This invention relates to wave transmission systems and particularly to two-way signaling transmission systems.

An object of the invention is to provide a simple echo suppressing circuit.

Another object of the invention is to provide a simple circuit arrangement for limiting the energy transmitted over a circuit.

Another object of the invention is to provide a combined echo suppressing and energy limiting circuit.

In long distance telephone systems employing repeaters, particularly those in which the repeaters are adjusted to give high gains, objectionable echo effects are sometimes encountered due to reflection points on the side of the repeater remote from the speaker, whereby the echoes are highly amplified. A similar effect which is ordinarily more pronounced is due to imperfections in balancing at the repeater on the side remote from the speaker. Objectionable disturbances are produced by these echoes, which may be accentuated by sudden increases of energy due to abnormal stress of words or syllables in speaking, inadvertent striking of a transmitter, side tone effects from extraneous noises, surges due to switch hook manipulations, and the like. These abnormally high energy conditions may also directly affect transmission by producing acoustic shock and confusion in the ear of the listening party.

Circuit arrangements for reducing the efficiency of transmission in one direction while waves are being transmitted in the other direction have been used to limit the echo effects. Other arrangements have been used to automatically limit the direct effect at the receiver of sudden increases of transmitted energy.

In its preferred embodiment, this invention, specifically stated, consists of a two-way signaling system employing repeaters of the four wire type—that is, the type in which the repeating path in one direction utilizes one pair of line wires and the repeating path in the opposite direction a second pair of line wires, the two repeating paths being associated with each other and with the two-way transmission circuit by a bridge connection having a vibratory relay operated by waves in the output of the amplifier at the terminal of each one-way line. Each of these relays is responsive to the amplified waves in the path to which it is connected to control a resistance in the oppositely directed path for reducing the efficiency of transmission of that path, thus reducing troublesome echo effects. Each of these relays also is made marginally responsive to unamplified waves of abnormally high energy levels, which in usual arrangements are dissipated in the amplifier output circuit, to limit the energy transmitted through the opposite path. Thus when waves are transmitted in one direction, the relay in one path acts as an echo suppressor and the relay in the other path as an energy limiter, and when transmission takes place in the opposite direction the functions of the two relays are reversed.

The relays are preferably of the high speed type capable of vibrating at speech frequencies, such as described in applicant's Patents No. 1,603,289 of October 19, 1926, and No. 1,607,910 of November 23, 1926.

The particular feature of this embodiment in which waves ordinarily wasted in a bridge connection are employed to operate a control device, also, may be found useful in other combinations.

In a modification of this invention, the relays are made undamped so as to maintain their vibration for the time required for the waves to traverse the echo path. The same hold-over effect may be produced by arranging the relay to reduce the cathode heating current of the repeater not in use. The efficiency of this repeater will not be restored to normal for some time due to the time required for the cathode to heat up again.

This invention can be more readily understood by reference to the following detailed description in connection with the drawing, in which:

Fig. 1 shows a four-wire transmission system embodying the combined echo suppression and energy limiting circuit of this invention;

Fig. 2 shows an alternative method of connecting the relays in the system of Fig. 1;

Fig. 3 shows a four-wire transmission system embodying the echo suppression circuit of this invention; and

Fig. 4 shows a modification of the circuit of Fig. 3.

Referring to Fig. 1 there are shown two two-way transmission lines 10 and 11 connected together through one-way transmission lines 12 and 13 by means of the usual hybrid or balanced transformer arrangements. Transmission takes place in the lines 12 and 13 in the directions indicated by the arrows. Terminal repeaters 14, 15, 16, and 17 are provided for the lines 12 and 13, respectively. Each of these lines may be provided with intermediate repeaters if the conditions so require. Connected across a condenser 18 associated with the output transformer 19 of repeater 15 in line 12 are the windings of a vibratory relay 20 which is preferably of the type described in O'Neill Patents No. 1,603,289 of October 19, 1926, and No. 1,607,910 of November 23, 1926, having a loose contact member vibrated in response to signal waves. The contacts of this relay are connected so as normally to short-circuit a resistance 21 connected to the primary winding of the input transformer 22 of the repeater 17 in line 13. The winding of a second vibrator relay 23 is connected to the output transformer 24 of the repeater 16 in line 13 across a similar condenser 25. The contacts of this relay normally short-circuit a resistance 26 connected to the primary winding of the input transformer 27 of the repeater 14 in line 12.

Waves transmitted from line 10 in the direction from west to east, for example, are divided between the circuits of repeaters 14 and 16 by the associated balanced transformer, one portion being dissipated in the output circuit of the repeater 16 and the other portion being amplified by repeaters 14 and 15 and impressed on the line 11 through the other balanced transformer. These amplified waves in the output transformer 19 of repeater 15 energize the relay 20 to open the short-circuit around the resistance 21 and thereby reduce the efficiency of transmission through the oppositely directed path including amplifiers 17, 16 and line 13. The relay 23 is so adjusted that it will not be operated by waves of normal energy from line 10. However, if the energy level of the waves exceeds a certain predetermined value, relay 23 will operate to open the short-circuit around resistance 26 in the main transmission path and lower the efficiency of transmission through the circuit including amplifier 14. In this way the energy level of the waves transmitted is maintained below this predetermined value. For transmission in the opposite direction, the functions of relays 20 and 23 are interchanged.

Since the relays are made responsive to amplified waves for suppressing echo effects and to unamplified waves for accomplishing the energy limiting function, they may be readily adjusted to selectively respond to produce both effects. The amount of loss introduced by the resistances 21 and 26 must be sufficient to prevent any appreciable quantity of energy, which due to residual unbalances in the associated balanced transformer may be impressed on the respective one-way line from the other, from traversing that line and setting up echo effects.

Relays of the vibratory type described in the above mentioned patents may be made responsive to any frequencies in the voice range. Since these relays require little energy for their operation the condensers 18 and 25 may be of relatively large capacity causing little loss in the associated circuits. The response of this type of relay is practically synchronous with the impressed waves so that delay circuits to retard the returning waves are not required.

Fig. 2 shows an alternate method of connecting the relays to the transmission circuits. As shown in this figure, the winding of relay 23 is connected to the tertiary winding 28 of the output transformer 24. Since the relays are very sensitive this tertiary winding may have only a few turns so that practically no loss will be introduced by its use. In cases where a monitoring winding is used the relay winding may be designed to have a high impedance and to be bridged across the monitoring winding without the introduction of appreciable loss.

While the circuits of Figs. 1 and 2 illustrate the invention embodied in four-wire repeater circuits employing one-way transmission lines of considerable geographic extent, the invention is also applicable to other type of circuits, for example the ordinary two-way two-element (22 type) repeater circuit.

Fig. 3 shows a transmission system employing two two-way transmission lines 31 and 32 connected together by means of a four-wire transmission circuit associated with the lines 31 and 32 through the usual balanced transformer arrangement. Transmission takes place in the directions indicated by the arrows. Waves are transmitted from west to east through the terminal repeater 33, line 34, intermediate repeater 35, line 36, terminal repeater 37 to the line 32, and in the opposite direction through the terminal repeater 38, line 39, intermediate repeater 40, line 41, terminal repeater 42 to the line 31.

The intermediate repeater 35 comprises a vacuum amplifier tube 43, an input transformer 44 and an output transformer 45. The intermediate repeater 40 similarly employs a

vacuum tube amplifier 46, an input transformer 47 and an output transformer 48. The windings of a vibratory relay 49 of similar type to those employed in the circuit of Fig. 1 are connected across a condenser 50 associated with the secondary winding of the output transformer 45. The contacts of relay 49 are arranged to normally short-circuit a resistance 51 associated with the primary winding of the input transformer 47. This resistance may be of such value as to completely incapacitate the amplifier when the short circuit is opened. The windings of a similar relay 52 are connected to a condenser 53 associated with the secondary winding of the output transformer 48. The contacts of this relay are arranged to normally short-circuit a resistance 54 associated with the primary winding of the input transformer 44.

The relay 49 is actuated by the amplified waves being transmitted from west to east to open the short-circuit around resistance 51 and reduce the transmission efficiency of the repeater 40. In this way the energy transmitted over the east to west line due to waves impressed thereon from the west to east line as a result of unbalances in the balanced transformer circuit is prevented from attaining such a level as will produce serious echo effects. Relay 49 is so designed that its vibration is undamped so that the efficiency of the repeater 40 will remain low for the time required for the echo currents to traverse the path from the repeater 35 to repeater 40. Relay 52 acts in the same manner for transmission from east to west.

Fig. 4 shows an alternative arrangement for performing the same function as the arrangement of Fig. 3. In this embodiment the relay 59 is similar to the relay 49 except that its vibration may be damped. The windings of this relay are connected in the same way to the condenser 50 but the contacts are connected to normally short-circuit a resistance 60 connected in the cathode heating circuit of the tube 46. When the relay 59 is operated to open the short-circuit around the resistance 60 the amplification of the tube 46 will be lowered and will remain at this lower value for a considerable time after the contacts of relay 59 are closed, due to the time required for the cathode of the tube 46 to heat up to a point where its emission is again normal. Relay 62 is similarly arranged to normally short-circuit resistance 63 connected in the cathode heating circuit of the tube 43, and when operated to open the short circuit so as to decrease the cathode heating current of tube 43 and thus the amplification produced by that tube.

What is claimed is:

1. In combination in a signaling system, a two-way signal transmission circuit, two oppositely directed (eastward and westward), one-way signal transmission paths connected thereto so that eastward signal waves in said two-way circuit divide between said two paths, marginally operating means in the westward path responsive to the received eastward waves to reduce the transmission efficiency of the eastward path when the energy level of the eastward waves exceeds a certain level above the normal signaling level.

2. In combination, a two-way transmission circuit, a pair of one-way transmission circuits, means for connecting said one-way circuits in conjugate relation to said two-way circuit whereby waves from said two-way circuit divide between said one-way circuits to be transmitted by one and dissipated in the other, and means controlled by the energy level of the waves in said other one-way circuit to control the efficiency of transmission through said first one-way circuit.

3. In combination, a two-way transmission circuit, a pair of one-way transmission circuits connected thereto, and means responsive to waves in one said one-way circuits for reducing the efficiency of transmission through the other of said one-way circuits while signals are being transmitted through said first one-way circuit, said means being also marginally operated to reduce the efficiency of transmission through said other one-way circuit when the energy of the signals impressed thereon is above a certain level.

4. In combination, two two-way transmission circuits, a pair of one-way transmission circuits connected between said two-way circuits, a repeater in each of said one-way circuits, means responsive to waves in one of said one-way circuits for reducing the efficiency of transmission through the other of said one-way circuits while waves are being transmitted through said first one-way circuit, said means being also marginally operated to reduce the efficiency of transmission of said other one-way circuit when the energy of the waves impressed on said other one-way circuit is above a certain level, and means similarly responsive to waves in said other one-way circuit.

5. In combination, two two-way transmission circuits, a pair of one-way transmission circuits connected between said two-way circuits, a one-way repeater in each of said one-way circuits, means responsive to waves in the output of the repeater in one of said circuits for reducing the efficiency of transmission through the other of said one-way circuits while waves are being transmitted through said first one-way circuit, said means being also marginally operated to reduce the efficiency of transmission of said other one-way circuit when the energy of the waves impressed thereon from the associated two-way circuit is above a certain level, and means

similarly responsive to waves in the output of the repeater in the other one-way circuit.

6. In combination in a signaling system, two two-way transmission lines, a pair of one-way transmission lines, means for connecting one terminal of each of said one-way lines in conjugate relation to each of said two-way lines, respectively, whereby signal waves from one of said two-way lines divide between said one-way lines to be transmitted by one and dissipated in the other and waves from the other of said two-way lines divide between said one-way lines to be transmitted by said other one-way line and dissipated in said one one-way line, a repeater in each of said one-way lines, marginally operated means responsive to waves in said one one-way line to reduce the transmission efficiency of said other one-way line while signal waves are being transmitted by said one one-way line and when the energy level of waves from said other two-way line exceeds a certain level above the normal signaling level, and marginally operated means similarly responsive to signal waves in said other one-way line.

7. In combination in a signaling system, two two-way transmission circuits, a pair of one-way transmission circuits, means for connecting one terminal of each of said one-way circuits in conjugate relation to each of said two-way circuits, respectively, whereby signal waves from one of said two-way circuits divide between said one-way circuits to be transmitted by one and dissipated in the other, and signal waves from the other of said two-way circuits divide between said one-way circuits to be transmitted by said other one-way circuit and dissipated in said one one-way circuit, a one-way repeater in each of said one-way circuits, marginally operated means responsive to signal waves in the output of the repeater in said one one-way circuit to reduce the transmission efficiency of said other one-way circuit when waves are being transmitted by said one one-way circuit, and when the energy level of waves from said other two-way circuit exceeds a certain level above the normal signaling level, and marginally operated means similarly responsive to signal waves in the output of the repeater in the other one-way circuit.

8. A combination, according to claim 7, and having an output transformer for the repeater in each one-way line, the output transformer having a primary winding connected to the output circuit of the repeater, a secondary winding connected to the associated two-way transmission circuit and a tertiary winding, the marginally operated means responsive to waves in the output circuit of each repeater being connected to said tertiary winding.

9. A pair of one-way transmission lines, a vibrating relay responsive to waves in one of said lines for reducing the efficiency of transmission of said other line while waves are being transmitted by said first line, said relay maintaining its vibration for sufficient time after the cessation of the transmission of waves in said first line to prevent the setting up of echo effects.

In witness whereof, I hereunto subscribe my name this 31st day of January, A. D. 1927.

HENRY W. O'NEILL.