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SIGNALING SYSTEM

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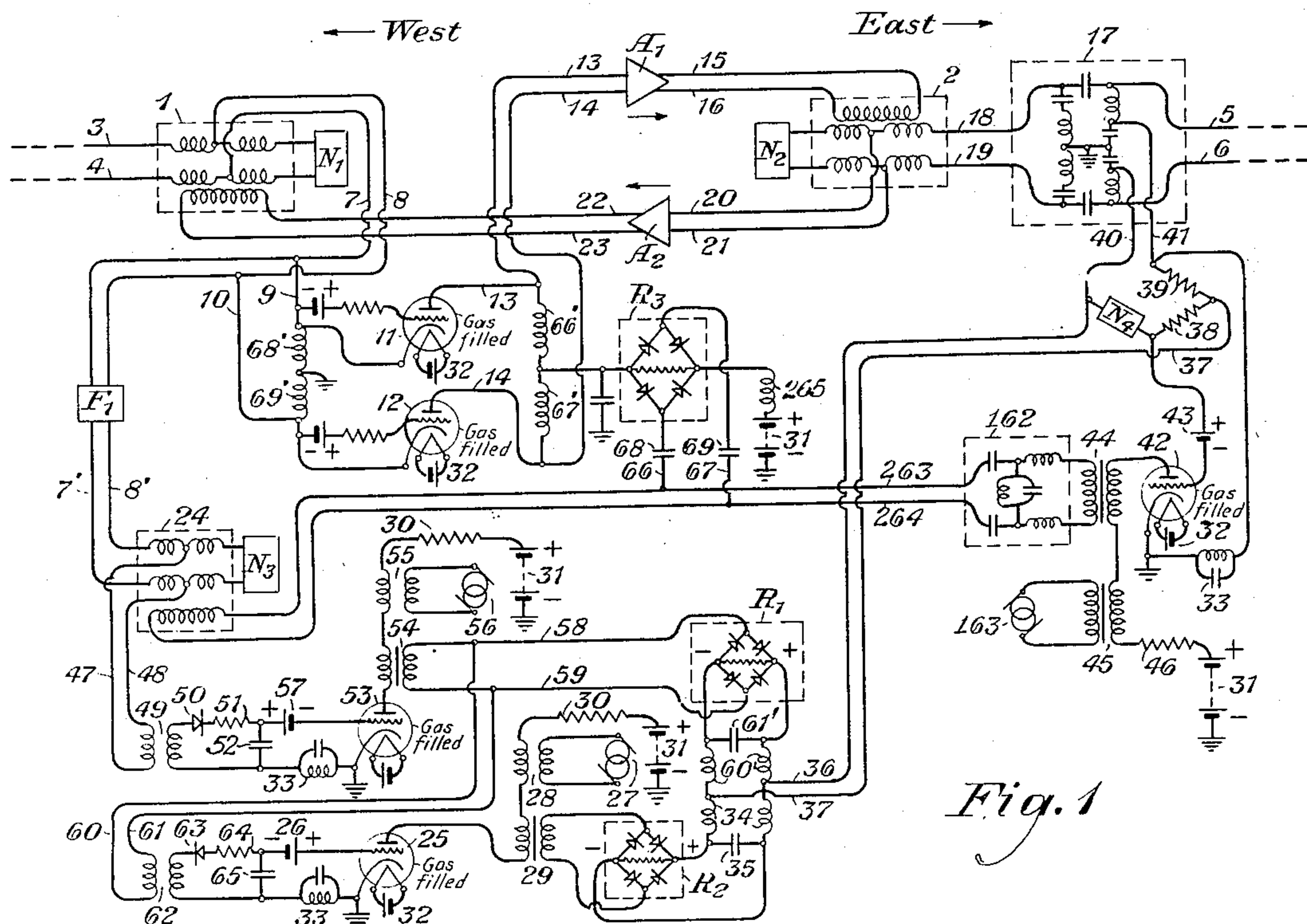


Fig. 1

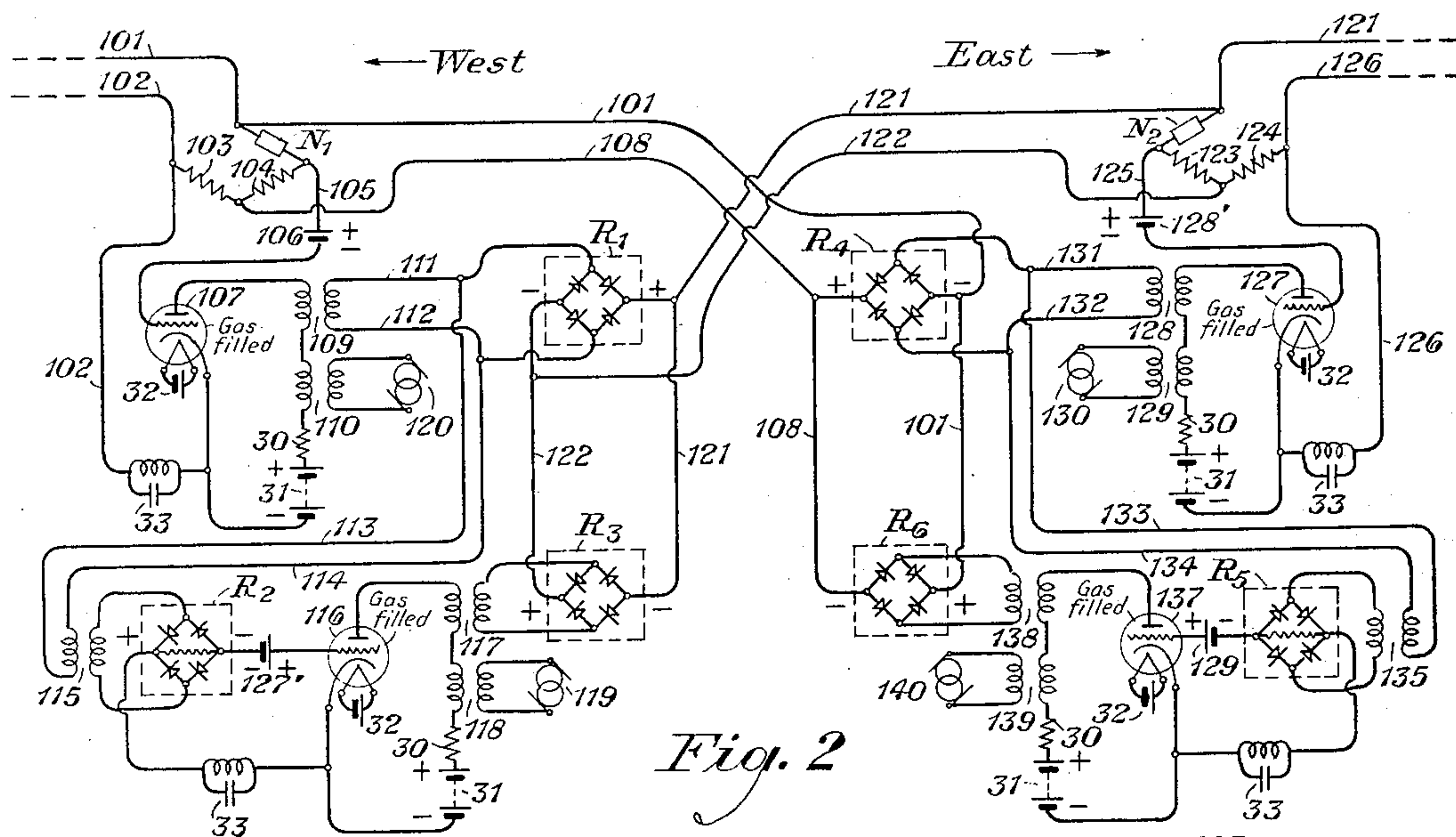


Fig. 2

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## UNITED STATES PATENT OFFICE

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## SIGNALING SYSTEM

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This invention relates to electrical circuits and more particularly to those circuits used for repeating or relaying signaling currents.

In a telephone system, it is necessary to provide means for transmitting speech currents and also for the transmission of signaling currents of various types. The most commonly used signal is the ringing signal, used to call a subscriber or operator at the remote end of the circuit from that at which the signal originates. Other signals may be found desirable, such as signals indicating lines busy or out of order, and also so-called supervisory signals, which may be used to indicate to the operators the status of a connection which has been established through the switchboard.

For local plant uses, on the lines connecting subscribers to a central office, and also over short distance trunk circuits between offices, low frequency alternating current is commonly employed for ringing, while direct current is used for operating supervisory signals. On long distance circuits, however, it is impracticable to use low frequency alternating currents or direct current for these purposes, first, because such circuits are ordinarily composited to permit simultaneous telephony and telegraphy, and second, because the vacuum tube amplifiers or repeaters used to offset the transmission losses for speech currents are incapable of amplifying direct currents and are very inefficient for low frequency alternating currents.

It is therefore necessary to provide means for converting signals from the form used in the short haul circuits and subscribers' lines of the local telephone plant to a form adapted to transmission over composited and repeated long distance circuits. The signaling currents in the latter case usually lie in the voice band, and are of course not transmitted simultaneously with speech, yet in some cases currents just below or just above the voice band may be used so that signaling or supervisory functions can be performed simultaneously with speech transmission.

The signal repeating and relaying means used heretofore have consisted of electromagnetic relays, of types adapted to operate on direct current and, in some cases, on alternating currents of signaling frequency, and also, in some cases, vacuum tube amplifiers and detectors. The adjustment of these relays has involved difficulty and expense, and false operation is apt to cause disagreeable noises or clicks if the circuit is in use for telephony. It is one of the objects of this invention to provide signal relaying or re-

peating means which will be free from mechanical moving parts and especially of electromagnetic relays of types requiring difficult or critical adjustments. It is also a further object to provide signal relaying means capable of duplex operation, so that signals may if desired be transmitted simultaneously in both directions. To accomplish the objects of this invention combinations of gas-filled discharge tubes are utilized in place of electromagnetic relays. Tubes suitable for use in this connection might, for example, be tubes filled with a gas such as neon or argon.

This invention may be more fully understood from the following description of one embodiment thereof, together with the drawing, in the Figures 1 and 2 of which the invention is illustrated.

Figure 1 illustrates the invention as applied to the problem of providing a signaling current repeating and translating unit arranged to be bridged around a two-wire repeater, in which alternating current is used for signaling on the west side of the repeater and direct current signaling is employed on the east.

Voice currents pass through the repeater in the following manner: Considering transmission in the west-east direction, voice currents will come in over the line conductors 3, 4 to three winding transformer or hybrid coil 1. One half the incoming energy will be absorbed in network N<sub>1</sub>, the balance passing over conductors 7, 8 to conductors 9, 10 to the cathodes of gas-filled tubes 11 and 12, through the arc paths thereof, these tubes being normally operated, to conductors 13 and 14 to the input of west to east amplifier A<sub>1</sub>, to the output thereof and thence over conductors 15 and 16 to hybrid coil 2, at which point one half of the energy will be absorbed in balancing network N<sub>2</sub>, the remainder passing over conductors 18 and 19 to composite set 17 and there through to east line conductors 5 and 6. In the reverse direction speech currents will enter on conductors 5, 6, through composite set 17, over conductors 18 and 19 to hybrid coil 2, one half being absorbed in balancing network N<sub>2</sub>, the balance going over conductors 20 and 21 to the input of east to west amplifier A<sub>2</sub>, and from the output thereof over conductors 22 and 23 to hybrid coil 1. At this point, one half of the energy is absorbed in balancing network N<sub>2</sub>, the remainder being transmitted over line conductors 3, 4 to the west.

It will be obvious that this is the ordinary arrangement of the two-wire repeater, except for the presence in the input circuit of amplifier A<sub>1</sub> of gas-filled tubes 11 and 12. These tubes are arranged so that normally there will be an arc

discharge therein, but means are provided for quenching these arcs, which opens the voice path in the west-east direction. This is required in order to prevent difficulties in signaling as will be hereinafter explained.

Normally, when no alternating current signal is applied to the input from the west over conductors 3, 4, voice currents will not operate the signaling equipment, being suppressed by filter F<sub>1</sub>. Gas-filled tube 25 will pass an arc discharge, due to the positive grid bias from battery 26. Direct current will flow from ground through anode battery 31, current limiting resistance 30, transformers 28 and 29 to the anode of tube 25, through the arc path to the cathode and thence to ground. Reference character 31 has been used to designate anode batteries in the case of all tubes in Figs. 1 and 2, and similarly reference character 30 designates current limiting resistance in the anode circuits. Reference character 32 identifies the cathode heating battery, for all tubes of both Figs. 1 and 2, while reference character 33 identifies an anti-resonant element provided to keep alternating currents out of direct current portions of the circuit. When the arc is established in tube 25, alternating current will flow from source 27 through transformers 28 and 29 and around through the d. c. path previously described. As a result, an alternating potential will be established across the winding of transformer 29 which is connected to the input of rectifier R<sub>2</sub>. Direct current will flow from the output of this rectifier through the low pass filter made up of inductances 34 and condenser 35 to conductors 36 and 37, in such a manner that conductor 37 will be positive, and to the balancing circuit consisting of network N<sub>4</sub>, resistances 38 and 39. Direct current will flow out over conductors 40 and 41 to composite set 17 and thence to line conductors 5 and 6, in such a manner that conductor 5 will be positive. There will be no direct current input to tube 42 due to the action of the above mentioned balancing circuit. If new signaling current be applied from the west, entering over conductors 3 and 4, such currents will pass through hybrid coil 1, filter F<sub>1</sub> to signaling hybrid coil 24, half being absorbed in the network N<sub>3</sub>, the balance passing over conductors 47 and 48 to transformer 49. The alternating voltage induced in the secondary of transformer 49 is rectified in rectifier 50 and charges condenser 52 through resistance 51 in such a manner as to override the negative bias of battery 57 and causing an arc to strike in tube 53. This completes an alternating current path from the secondary of transformer 55, to the primary of which alternating current source 56 is connected. This path is through the primary of transformer 54, arc path in tube 53, ground, battery 31, resistance 30 and thence back to the secondary of transformer 55. Alternating current will pass from the secondary of transformer 54 over conductors 58 and 59 and also conductors 60 and 61 to transformer 62. The alternating voltage rectified by rectifier 63 will charge condenser 65 through resistance 64 in the reverse polarity to that due to battery 26, applying a negative bias to the grid of tube 25, which will stop the arc therein on the next negative half cycle of the alternating voltage superposed on the direct voltage in the anode circuit of this tube. This direct voltage is that of battery 31, while the alternating voltage is that in the secondary of transformer 28 due to the source of alternating current 27 connected to the primary thereof. Stoppage of the arc in tube 25 inter-

rupts the supply of alternating current to rectifier R<sub>2</sub>. At the same time, the starting of the arc in tube 53 completes an alternating current circuit over conductors 58 and 59 to rectifier R<sub>1</sub>. This rectifier delivers its direct current output through a filter made up of inductances 60' and condenser 61' to leads 36 and 37, as does R<sub>2</sub>. But rectifier R<sub>1</sub> is connected with the reverse polarity to R<sub>2</sub>, so that wire 5 now receives a negative direct potential. Thus it may be seen that the application of signaling frequency to leads 3 and 4, in other words the presence of signaling current on the alternating current signaling side of the device results in a reversal of polarity of the direct current signal sent out from the direct current signaling side. As before, this will not affect tube 42 because of the balancing circuit consisting of network N<sub>4</sub> and resistances 38 and 39.

If the potential applied from the remote end of the line on the direct current side be negative, tube 42 will not fire. But if the polarity of this signal be reversed as is done in sending a signal impulse, then an arc will strike in tube 42, completing an anode circuit similar to that described previously for tubes 25 and 53, and sending an alternating current output from generator 163 through transformers 45 and 44 and filter 162 over leads 263 and 264 to hybrid coil 24 and thence out over conductors 7', 8', 7, 8 through hybrid coil 1 to west line conductors 3 and 4. This current would also be fed back to the east through amplifier A<sub>1</sub> were it not that the arc in tubes 11 and 12 is extinguished by a branch circuit from conductors 263 and 264, over conductors 66 and 67, through condensers 68 and 69 to rectifier R<sub>3</sub> which produces a direct potential greater than that due to battery 31, through inductance 265, thus lowering the anodes of tubes 11 and 12 to zero or negative values and quenching the arc therein. These tubes will remain quenched as long as an alternating voltage is maintained across conductors 263 and 264 and thus open the input to A<sub>1</sub>, preventing signaling frequency from being sent back to the easterly side of the repeater. Inductances 66', 67', 68' and 69' serve to complete the direct current paths to grids and anodes of tubes 11 and 12 without introducing appreciable shunting loss at speech frequencies between conductors 9 and 10 or 13 and 14, by reason of the large inductances of these coils.

Figure 2 illustrates a second embodiment of this invention, in which the circuits are arranged to repeat direct current signaling impulses. This device is arranged for duplex operation and consists of two one-way devices connected to the lines through bridge elements, including a line balancing network, in the manner well known in the signaling art, so that impulses in one direction do not interfere with and are transmitted independently of impulses in the reverse direction.

The bridge elements consist of networks N<sub>1</sub> or N<sub>2</sub> and resistances 103, 104 or 123, 124 respectively. The line conductors to the west are 101 and 102, to the east, 121 and 126. The operation of the circuit may be understood from a consideration of the transmission of a signaling impulse from west to east. When no signal is transmitted wire 101 will be negative with respect to 102, and therefore wire 105 will be negative also with respect to 102, so that no arc can be established in tube 107. Tube 116, however, will pass an arc, owing to the positive grid bias applied by battery 127'. This arc will cause direct current to flow from battery 31 through resistance

30, the secondary of transformer 118, primary of transformer 117, arc path of tube 116 to the cathode thereof and back to battery 31. Superposed on this direct current will be alternating current, of such a magnitude that the current flow in the arc path is interrupted every negative half cycle, derived from generator 119 connected to the primary of transformer 118. Alternating current will therefore flow from the secondary of transformer 117 to rectifier R<sub>3</sub>, and from this rectifier direct current will flow over conductors 121 and 122 to the balancing circuit composed of N<sub>2</sub>, and resistances 123 and 124, to conductors 121 and 126, and in such a manner that a negative potential is applied to conductor 121. Thus the negative potential of wire 101 is repeated to wire 121. The negative potential output from R<sub>3</sub> will not affect tube 127 because of the balancing circuit.

20 If now the potential of wire 101 with respect to wire 102 be reversed, in order to send a signaling impulse, the signaling voltage thus applied to conductors 105 and 102 through the balancing circuit consisting of network N<sub>1</sub> and resistances 103 and 104 will reverse and over-ride the voltage of battery 106, causing an arc discharge to begin in tube 107. This will complete both an alternating and a direct current circuit through the arc path of the tube, similar to that described previously in the case of tube 116, so that alternating current will flow from generator 120, through transformers 110 and 109, thus setting up an alternating voltage across conductors 111 and 112. Conductors 113 and 114, branches of 111 and 112, will convey this voltage to transformer 115, the secondary of which connects to rectifier R<sub>2</sub>. The direct current output of this rectifier over-rides the voltage of battery 127' and applies a large negative bias to the grid of tube 116. 40 The arc in tube 116 is thus extinguished on the next negative half cycle of the alternating voltage in the secondary of transformer 118, which removes the alternating current input to rectifier R<sub>3</sub>. At the same time, alternating current input is applied over conductors 111 and 112 to rectifier R<sub>1</sub> the direct current output is connected to the same points as that of rectifier R<sub>3</sub>, namely, conductors 121 and 122, but with polarity reversed. As a result the polarity of the voltage applied to conductors 121 and 126 reverses, thus repeating the reversal on conductors 101 and 102 which constituted the signaling impulse. This will be without effect on tube 127, due to the balancing circuit consisting of network N<sub>2</sub>, and resistances 123 and 124.

55 A reversal of the voltages normally applied from the east to conductors 121 and 126 will operate tube 127, tube 127 being normally extinguished and 137 operated. Tube 127 when an arc strikes therein extinguishes tube 137, just as tube 107 controlled 116 as previously described. Generators 130 and 140 supply the alternating current which is superposed on the direct current from batteries 31 in the anode circuits of the tubes 127 and 137 and rectifiers R<sub>4</sub> and R<sub>6</sub> alternately send the repeated direct current impulses to the line west.

70 It will be obvious that in both Figures 1 and 2 the frequency of the alternating current supplies must be large in comparison with the number of signaling impulses per second to be transmitted, if distortion of these impulses is to be avoided.

75 While this invention has been described in respect to certain embodiments thereof, it is not to be regarded as so limited, but to include any and

all organizations falling within the scope and spirit of the appended claims.

What is claimed is:

1. A transmission line comprising two interconnected line sections, a normally unoperated gas-filled discharge tube connected to the first of said line sections and adapted to be operated by the transmission of signaling current over said line section, a normally operated gas-filled discharge tube associated with said first tube and adapted to be extinguished when said first tube is operated by said signaling current, a signaling circuit connected to the second of said line sections, oppositely poled rectifiers connected to said signaling circuit, a source of alternating current means controlled by the operation of one of said tubes for connecting said source to one of said rectifiers, and means controlled by the operation of the other of said tubes for connecting said source to the other of said rectifiers.

2. A transmission line comprising two interconnected line sections, a gas-filled discharge tube connected to the first of said line sections, means for applying a negative biasing potential to the grid of said tube so that it will normally be in a non-discharging condition, means in the input circuit of said tube responsive to alternating current transmitted over said first line section for decreasing the negative biasing potential applied to the grid of said tube so that said tube will discharge, a second gas-filled discharge tube, means for applying a positive biasing potential to the grid of said second tube so that it will normally be in a discharging condition, means controlled by said second tube when discharging for applying direct current of a certain polarity to the second of said line sections, means controlled by said first tube when discharging for applying alternating current to the input circuit of said second tube, means in the input of said second tube responsive to said last mentioned alternating current for decreasing the positive biasing potential applied to the grid of said tube so that it will cease discharging, and means controlled by said first tube when discharging for reversing the polarity of the direct current applied to said second line section by the operation of said second relay.

3. A transmission line comprising two interconnected line sections, a normally unoperated gas-filled discharge tube connected to the first of said line sections, and adapted to be operated by the transmission of alternating signaling current over said line section, a normally operated gas-filled discharge tube associated with said first tube and adapted to be extinguished when said first tube is operated by said alternating signaling current means controlled by the operation of said second tube for applying direct current of a certain polarity to said second line section, means controlled by the operation of said first tube for reversing the polarity of the direct current applied to said second line section by the operation of said second relay, a third gas-filled discharge tube associated with said second line section and adapted to be operated by the application of direct current of a certain polarity to said second line section, and means controlled by the operation of said third tube for applying alternating current to said first line section.

4. A transmission line comprising two interconnected line sections, a normally unoperated gas-filled discharge tube connected to the first of said line sections and adapted to be operated by the transmission of alternating signaling current over said line section, a normally operated

gas-filled discharge tube associated with said first tube and adapted to be extinguished when said first tube is operated by said alternating signaling current, means controlled by the operation of said second tube for applying direct current of a certain polarity to said second line section, means controlled by the operation of said first tube for reversing the polarity of the direct current applied to said second line section by the operation of said second relay, a third gas-filled discharge tube associated with said second line section and adapted to be operated by the application of direct current of a certain polarity to said second line section, means controlled by the operation of said third tube for applying alternating current to said first line section, and means associated with said third tube for preventing its operation by the direct currents applied to said second line section by said first and second mentioned tubes.

5. A transmission line comprising a first line section terminating in a hybrid coil and a balancing network, a second line section terminating in a hybrid coil and a balancing network, two one-way circuits for transmission in opposite directions associated with said hybrid coils, repeater elements in each of said one-way circuits, means for completing the one of said one-way circuits adapted for transmission from said first line section to said second line section over the cathode-anode circuits of a set of normally operated gas-filled discharge tubes, a circuit selective for signaling currents transmitted over said first line section associated with said last mentioned one-way circuit, a normally unoperated gas-filled discharge tube associated with said selective circuit and adapted to be operated by said signaling currents, a normally operated gas-filled discharge tube associated with said first tube and adapted to be extinguished when said first tube is operated by said signaling currents, means controlled by each of said two last mentioned tubes for applying different signaling currents to said second line section, a third gas-filled discharge tube associated with said second line section and adapted to be operated by the application of signaling current to said second line section, and means controlled by the operation of said third tube for applying signaling current to said selective circuit and for deenergizing said first mentioned set of normally operated gas-filled discharge tubes.

6. A transmission line comprising a first line section terminating in a device comprising resistance elements and a balancing network so arranged that said elements and network together with said line section comprise a balanced Wheatstone bridge, a second line section terminating in

a device comprising resistance elements and a balancing network so arranged that said elements and network together with said line section comprise a balanced Wheatstone bridge, a normally inoperative gas-filled discharge tube having its input circuit connected across equipotential points of said first bridge and adapted to be operated by signaling current transmitted over said first line section, a normally operated gas-filled discharge tube associated with said first tube and adapted to be extinguished by the operation of said first tube, means controlled by the operation of said second tube for applying signaling current to equipotential points of said second bridge, and means controlled by the operation of said first tube for reversing the polarity of the signals applied to the equipotential points of said second bridge by the operation of said second tube.

7. A transmission line comprising a first line section terminating in a device comprising resistance elements and a balancing network so arranged that said elements and network together with said line section comprise a balanced Wheatstone bridge, a second line section terminating in a device comprising resistance elements and a balancing network so arranged that said elements and network together with said line section comprise a balanced Wheatstone bridge, a normally inoperative gas-filled discharge tube having its input circuit connected across equipotential points of said first bridge and adapted to be operated by signaling current transmitted over said first line section, a normally operated gas-filled discharge tube associated with said first tube and adapted to be extinguished by the operation of said first tube, means controlled by the operation of said second tube for applying signaling current to equipotential points of said second bridge, means controlled by the operation of said first tube for reversing the polarity of the signals applied to the equipotential points of said second bridge by the operation of said second tube, a normally inoperative gas-filled discharge tube having its input circuit connected across equipotential points of said second bridge and adapted to be operated by signaling current transmitted over said second line section, a normally operated gas-filled discharge tube associated with said third mentioned tube and adapted to be extinguished by the operation of said fourth mentioned tube for applying signaling current to equipotential points of said first bridge, and means controlled by the operation of said third tube for reversing the polarity of the signals applied to the equipotential points of said first bridge by the operation of said fourth tube.

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