

April 16, 1929.

E. T. BURTON

1,708,934

ELECTRIC SIGNALING

Filed Nov. 6, 1926

2 Sheets-Sheet 1

Fig. 1.

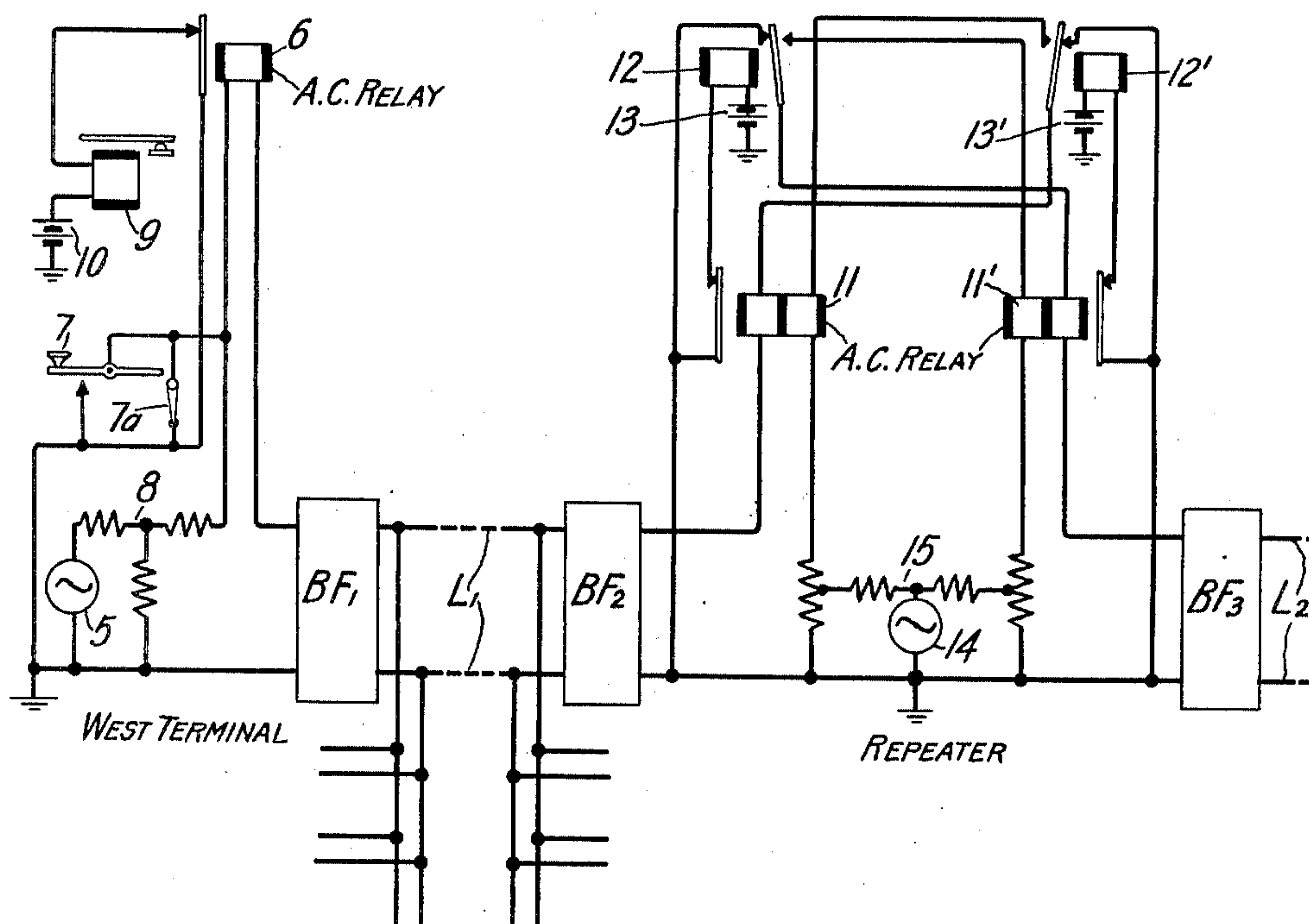
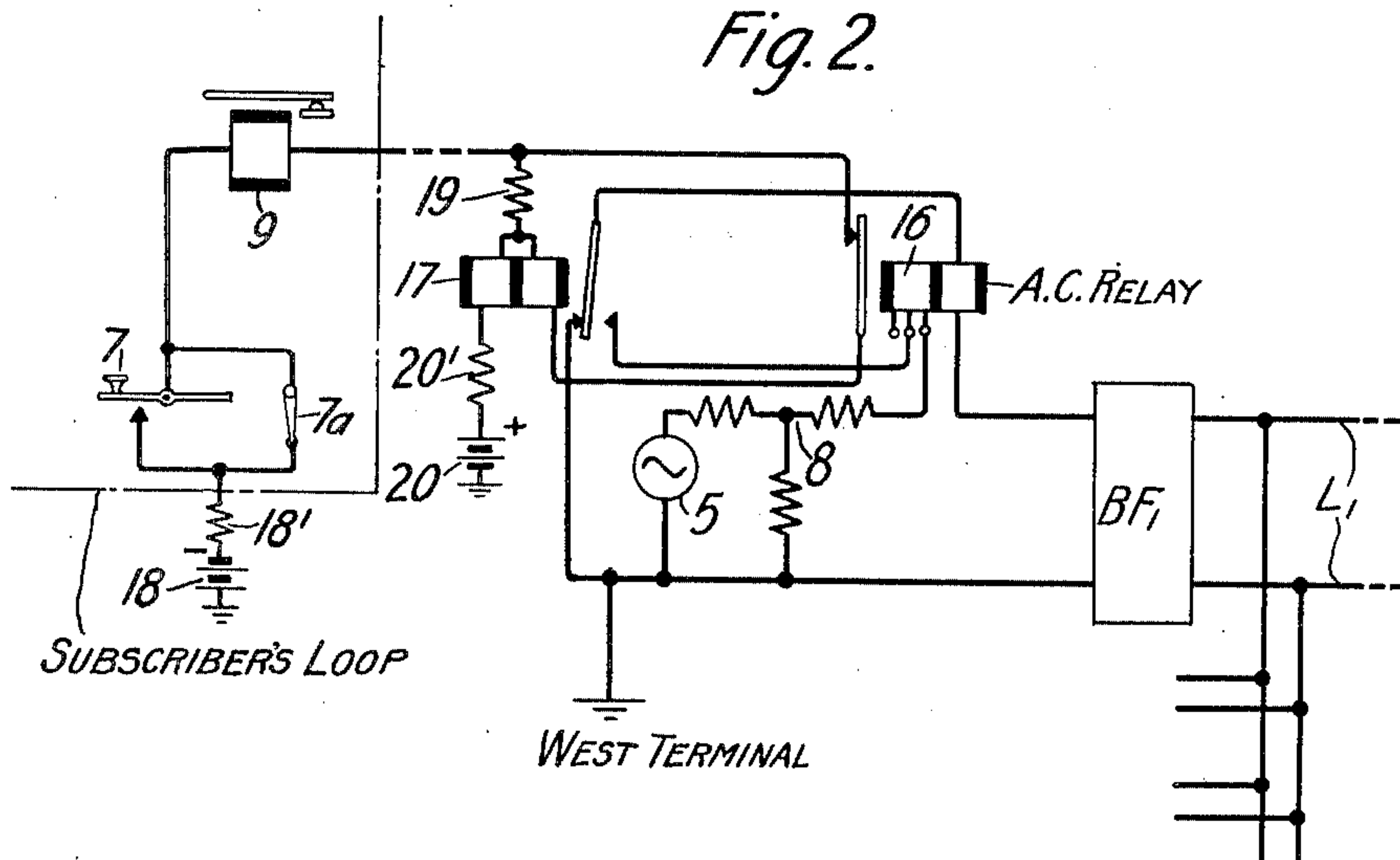


Fig. 2.



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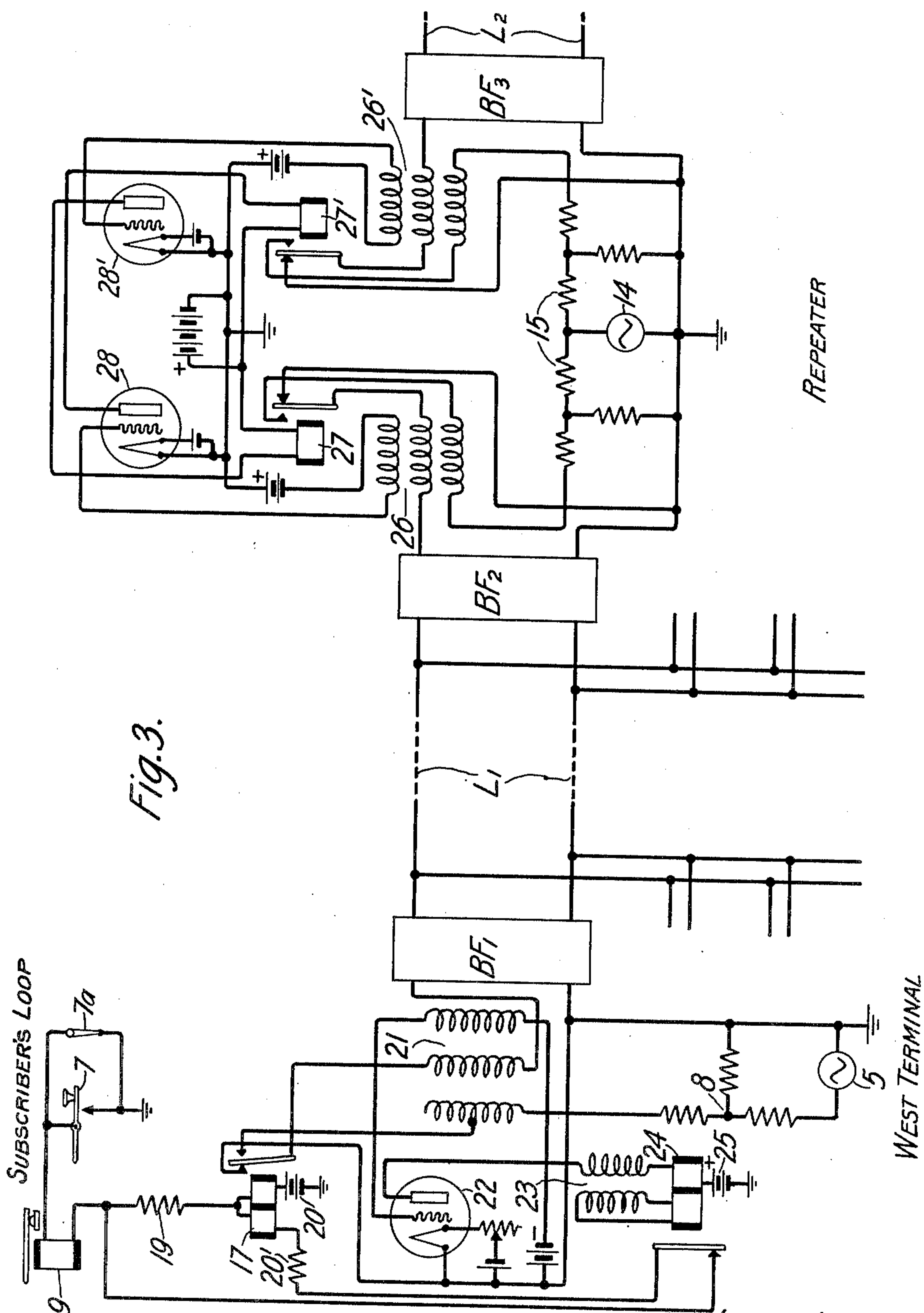
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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE.

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ELECTRIC SIGNALING.

Application filed November 6, 1926. Serial No. 146,693.

The invention relates to electric signaling and particularly to carrier current telegraphy.

An object of the invention is to simplify the operation and maintenance of carrier current telegraph systems.

Another object of the invention is to reduce distortion in telegraph signals at terminal and repeater points.

The invention provides a simple and efficient telegraph system in which a single carrier frequency is employed for alternate transmission in two directions over each communication channel. In transmitting signals, the carrier current is impressed upon the line during a spacing interval and is cut off during a marking interval. A vacuum tube receiving circuit or an alternating current receiving relay in each channel responds directly to the incoming and outgoing carrier currents.

Heretofore, in transmitting telegraph signals it has been customary to control the receiving relay at the transmitting terminal from the local direct current circuit rather than from the carrier transmission circuit, and in receiving signals to rectify the incoming carrier currents to operate the receiving relay. By operating the receiving relay directly in response to incoming and outgoing carrier currents the invention effects a material saving in signaling apparatus. Furthermore, operation of the near end sounder from the outgoing carrier allows the sending operator to monitor directly on the line current rather than on the local circuit only.

The invention also provides means for repeating signals in two directions without distortion. This is accomplished in one form of the invention by means of a bilateral repeater having two alternating current line relays each of which controls a direct current relay for connecting a local source of carrier current to a succeeding line section. The circuits are so arranged that the spacing signals lag on the make by the time of travel of the direct current relays and lag on the break by the time of travel of the alternating current relays. According to the invention, the time lag between make and

break signals is made uniform, thus eliminating distortion in the signals such as is commonly caused by the time of armature travel in the operation of repeater relays.

The invention will be described in connection with the accompanying drawings in which similar reference characters designate similar parts in the several figures, and in which:

Fig. 1 is a diagrammatic illustration of a carrier current telegraph system including terminal and repeater circuits embodying the invention;

Fig. 2 is a diagrammatic illustration of a terminal circuit which may be used in place of the terminal circuit shown in Fig. 1; and

Fig. 3 is a diagrammatic illustration showing modified terminal and repeater circuits.

Reference will first be made to the multiplex carrier current telegraph system shown in Fig. 1, which includes the west terminal and a mid-line repeater inter connected by the transmission line section L_1 .

The usual east terminal, which is identical to the west terminal shown in Fig. 1, is omitted for the sake of simplifying the showing, but in practice may be connected to the repeater by means of line section L_2 .

The terminal and repeater circuits may include a plurality of two-way communication channels. Since these channels are identical except as to the frequencies which they employ, only one channel is shown in detail and additional channels are merely indicated by the leads connected in parallel with the line section L_1 at the terminal and repeater.

Carrier currents of different frequencies are transmitted over the several channels of the system. Each channel requires but one carrier frequency for complete two-way communication, and hence fewer selective circuits are needed to separate the different channel frequencies than are needed in systems employing different frequencies in each direction.

The carrier telegraph channel which is illustrated in detail at the west terminal includes a band filter BF_1 which passes currents of the frequency assigned to this channel and suppresses currents of other fre-

quencies. Similar band filters BF_2 and BF_3 are associated with this channel at the repeater. The filters employed throughout the system may be of the type disclosed in U. S. Patent No. 1,227,113 to G. A. Campbell, issued May 22, 1917.

The apparatus at the west terminal includes a carrier frequency generator 5 which is connected to the band filter BF_1 through the winding of an alternating current relay 6 which matches the impedance of the band filter. When no signals are being transmitted, the carrier oscillator is short-circuited at the closed contacts of an auxiliary switch 7, through a resistance network 8. When no signals are being transmitted or received the relay 6 is deenergized, or in the "marking" position shown in the drawing. In this condition the sounder 9 is energized over a circuit extending from grounded battery 10, through the winding of sounder 9, contact and armature of relay 6 to ground. Incoming carrier currents pass through the upper conductor of line section L_1 , filter BF_1 , winding of relay 6, switch 7, filter BF_1 , to the lower line conductor. The current in this circuit causes the relay 6 to attract its armature, opening the circuit of sounder 9. When the switch 7 is opened and key 7 open, the outgoing currents from the generator 5 flow through relay 6 to line section L_1 , also causing the operation of the sounder 9. The sounder is thus operated in accordance with incoming and outgoing spacing and marking signals.

In case either terminal key is open, that is, when the oscillators at the respective terminals are not short circuited, carrier current flows through relay 6. If, therefore, the receiving operator at the east terminal wishes to break in on the transmission from the west terminal, he opens his key and the transmitting sounder 9 fails to follow the operation of transmitting key 7 because relay 6 will be continually actuated.

The repeater includes an alternating current relay 11 associated with line section L_1 and a similar relay 11' associated with line section L_2 . When no carrier currents are incoming at the repeater from either line section the circuits are as shown in the drawing. In this condition a relay 12, controlled by the relay 11, is energized over a circuit extending from grounded battery 13, through winding of relay 12 to ground, and a similar relay 12' associated with the relay 11' is energized over a similar circuit. A local carrier generator 14 is connected in circuit with resistance network 15 when no signals are received at the repeater, and is arranged to be connected to either line section whenever carrier current is received from the opposite line section.

Carrier currents incoming at the repeater from line section L_1 are transmitted through

the upper line conductor, filter BF_2 , left hand winding of relay 11, armature and front contact of relay 12', filter BF_2 , to the lower line conductor. The relay 11 thereupon operates, and upon opening its contact releases the armature of relay 12 by breaking the local battery circuit previously traced. The relay 12 in deenergizing closes its back contact, connecting the local oscillator 14 to the line section L_2 , so that carrier current flows over a circuit extending from the upper conductor of line section L_2 , through filter BF_3 , right hand winding of relay 11', armature of back contact of relay 12, left hand winding of relay 11', resistance network 15, oscillator 14, filter BF_3 , to the lower line conductor. In this condition the windings of relay 11' are connected in series opposing relation and hence this relay is not operated by the carrier current from the oscillator 14. When the carrier current on line L_1 is cut off at the end of a spacing signal, the relay 11 is deenergized and its armature returned to the marking position shown in the drawing, thus completing the energizing circuit of relay 12 which disconnects the oscillator 14 from line section L_2 . It will be seen that the repeated spacing signals lag on the make by the time of travel of the armature of relay 12 since the carrier source 14 is not connected to line section L_2 until the armature of relay 12 reaches its back contact. It will also be seen that the spacing signals lag on the break by the time of travel of the armature of relay 11, since the source 14 is disconnected from line section L_2 when the armature of this relay reaches its contact. These relays are so constructed that the times of travel of their armatures are identical and hence there is no bias in the repeated signals. The repeater is symmetrical in respect to the line sections L_1 and L_2 , signals transmitted from east to west being repeated in the same manner as the signals transmitted from west to east.

Fig. 2 shows a modified terminal circuit arranged for connection to a subscriber's loop. This circuit includes an alternating current receiving relay 16 having two windings, and arranged to respond equally to the transmitted and received carrier currents. Only the right hand winding of this relay is connected to the line section L_1 when signals are being received, and both windings are connected in series opposing relation with the line section when spacing signals are being transmitted. The left hand winding of relay 16 is tapped at an intermediate point so that the differential magnetizing force produced by the transmitted carrier current in both windings is approximately equal to that produced by the weaker received current in the right hand winding. Hence this circuit arrangement eliminates

inequality in the operation of the relay which would otherwise result from the difference in value of the transmitted and received currents.

5 A direct current relay 17, also having two windings, is arranged to connect the carrier generator 5 to the line section L_1 , during a spacing interval and to disconnect the oscillator from the line section during a marking interval. When the circuit is in the condition shown in the drawing the left hand winding of relay 17 is connected to the subscriber's loop over a circuit extending from the negative side of grounded battery 18, through a battery series resistance 18', closed contacts of switch 7_a, winding of sounder 9, high resistance 19, left hand winding of relay 17, battery resistance 20' to the positive side of grounded battery 20. The current flowing in this circuit is sufficient to operate the relay 17 but is insufficient to operate the sounder 9. However, under such condition the right hand winding of relay 17 is connected to the subscriber's loop over a low resistance circuit extending from the negative side of grounded battery 18, through resistance 18', closed contacts of switch 7_a, winding of sounder 9, contact and armature of relay 16, right and left hand windings of relay 17, resistance 20' to the positive side of grounded battery 20. This circuit carries an increased current sufficient to operate the sounder 9. The windings of relay 17 are wound in opposition and are so related in the number of turns that the effect of the additional current flowing through the subscriber's loop during a marking interval, which is the condition shown in the drawing, is substantially neutralized in the relay 17, thus protecting the core of this relay from excessive magnetizing forces.

Incoming carrier currents which are passed by the band filter BF_1 pass through the right hand winding of alternating current relay 16, causing this relay to attract its armature and open the low resistance energizing circuit of the sounder 9. The current which still flows from grounded battery 18, through resistance 18', switch 7_a, sounder 9, resistance 19, left hand winding of relay 17, and resistance 20' to grounded battery 20, is sufficient to maintain the relay 17 energized but, as previously noted, is insufficient to operate the sounder 9. The sounder 9 is therefore deenergized during the spacing interval when carrier currents are received from the line section L_1 . At the termination of a spacing signal the relay 16 is deenergized, closing its contact and again establishing the energizing circuit for the sounder 9 around the resistance 19.

In order to transmit signals, the transmitting key 7 is closed and the switch 7_a opened. The key 7 is then actuated, the opening of this key opening the energizing circuits of

sounder 9 and relay 17. The relay 17 in releasing its armature connects the generator 5 to the line section L_1 , permitting carrier current to flow over a circuit extending from the lower line conductor, through filter BF_1 , generator 5, resistance network 8, left hand winding of relay 16, back contact and armature of relay 17, right hand winding of relay 16, filter BF_1 , to the upper line conductor. The current flowing in this circuit causes the relay 16 to attract its armature. When the transmitting key 7 is again closed, the relay 17 is energized over a circuit similar to that previously traced through the left hand winding of this relay and resistance 19, but including the contacts of key 7 instead of switch 7_a which is now open. The current in this circuit, however, is insufficient to attract the armature of the sounder 9. The relay 17 in attracting its armature opens its back contact, thus disconnecting the generator 5 from the line section L_1 , and deenergizes the relay 16, to complete the low resistance energizing circuit of the sounder 9. The front contact of relay 17 is also closed, conditioning the circuit to transmit or receive further signals. When no signals are to be transmitted, switch 7_a is closed.

This circuit also allows the receiving operator to break in on the transmission by opening his local circuit and sending carrier over the line. If the east terminal operator breaks in, the sounder 9 will not follow the operation of the west terminal key 7 since relay 16 remains actuated, preventing sufficient current from reaching the sounder to operate it. Relay 16 remains actuated because current will be supplied to it either from the receiving station through the right hand winding of the relay or from the generator 5 through both windings of the relay.

In the modification of the invention shown in Fig. 3 space discharge tube detectors are employed in place of the alternating current relays at terminal and repeater points. The operation of the system in receiving signals at the west terminal will first be described. Incoming carrier currents passed by the band filter BF_1 pass through the upper line conductor of line section L_1 , central winding of balanced transformer 21, armature and front contact of relay 17, filter BF_1 , to the lower line conductor of line section L_1 . The current flowing in this circuit induces a voltage in the right hand winding of transformer 21 connected in the input circuit of a three-element space discharge tube detector 22. Space current is thus caused to flow in the output circuit of this tube from grounded battery 25, through the right hand winding of relay 24, primary winding of transformer 23, to the plate of tube 22, and thence through the space discharge path to the grounded filament, thus operating relay 24. The second-

any winding of transformer 23 is connected to an auxiliary winding of relay 24, and a change of current in this circuit causes a building up of flux which accelerates the operation of the relay, as is common practice in telegraphy. The relay 24 attracts its armature, opening the low resistance energizing circuit of the sounder 9 and causing the sounder to release its armature. As in the circuit of Fig. 2, the current flowing from grounded battery 20, through the right hand winding of relay 17, resistance 19, winding of sounder 9, closed contacts of switch 7_a to ground, is insufficient to operate the sounder. When the incoming carrier currents are cut off space current ceases to flow in the output circuit of the detector tube 22 and the relay 24 is deenergized, re-establishing the energizing circuit of the sounder 9.

In transmitting signals from the west terminal, the key 7 is closed and the switch 7_a is opened. The key 7 is then opened, thereby deenergizing the sounder 9 and relay 17. The front contact of relay 17 is therefore opened and the back contact is closed, connecting the carrier generator 5 to the line section L₁. The outgoing carrier current flows over a circuit extending from the lower line conductor, through filter BF₁, generator 5, resistance network 8, left hand winding of transformer 21, back contact and armature of relay 17, central winding of transformer 21, filter BF₁, to the upper line conductor. The central and left hand windings of transformer 21 are connected in opposition and the back contact of relay 17 is connected to an intermediate tap of the left hand winding of the transformer so that the magnetizing forces produced by the transmitted and received currents in this transformer are approximately equal. The outgoing current produces an induced voltage in the right hand winding of transformer 21 which causes space current to flow through the relay 24 in the output circuit of the detector tube 22, causing the relay 24 to attract its armature and open the energizing circuit of the sounder 9, which is also broken at the open contact of transmitting key 7. When the key 7 is again closed the relay 17 is energized over a circuit similar to that previously traced through the right hand winding of this relay and the winding of sounder 9, but including the contacts of key 7 instead of switch 7_a which is now open, current flowing in this circuit, however, is insufficient to operate the sounder. The relay 17 thereupon attracts its armature, disconnecting the generator 5 from the line section L₁. Since space current ceases to flow in the output circuit of the detector tube 22, the relay 24 is deenergized, completing the low resistance energizing circuit of the sounder

9 through both windings of relay 17. Also, since relay 24 is operated by both the outgoing and incoming currents the break-in condition is identical with that described in connection with Fig. 2.

Carrier currents incoming at the repeater from line section L₁ are transmitted through the upper line conductor, filter BF₂, central winding of balanced transformer 26, armature and back contact of relay 27, filter BF₂ to the lower line conductor. The current flowing through the central winding of transformer 26 induces a voltage in the upper winding of this transformer which causes space current to flow in the output circuit of detector tube 28 which includes the winding of relay 27'. The relay 27' thereupon attracts its armature, opening its back contact and closing its front contact, thereby impressing carrier current from the generator 14 upon line section L₂ over a circuit extending from the upper line conductor, through filter BF₃, central winding of transformer 26', armature and front contact of relay 27', lower winding of transformer 26', resistance network 15, generator 14, filter BF₃ to the lower line conductor. In this condition the central and lower windings of transformer 26' are connected in series opposing relation and hence there is no increase in potential across the input circuit of the detector tube 28' and no current flows through the relay 27 in the output circuit of this tube. When the carrier current on line L₁ is cut off at the end of a spacing signal the relay 27' is deenergized and its armature returned to the marking position shown in the drawing, disconnecting the generator 14 from the line section L₂.

In order to prevent capacity coupling of the carrier current to the transmission line sections, the windings of relay 16 of Fig. 2 and the windings of balanced transformers 21, 26, and 26' of Fig. 3 may be separated by suitable shielding devices.

Although the invention has been described in connection with certain specific embodiments, it is also susceptible of numerous other modifications without departing from the scope and spirit of the invention as defined by the appended claims.

What is claimed is:

1. A carrier current telegraph system comprising a transmission line over which signals are transmitted in both directions, a terminal including a receiving relay and a source of carrier current connected in series with said line, and means for rendering said relay responsive only to incoming signals, said means including means for short circuiting said source.

2. A carrier current telegraph system comprising a transmission line over which signals are transmitted in both directions, a

terminal including a receiving relay and a source of carrier current connected in series with said line, and a transmitting key adapted to directly short circuit said source when no signals are transmitted from said terminal and to remove said short circuit to render said relay responsive to incoming signals.

3. A carrier current telegraph system comprising a transmission line, a terminal including an alternating current relay in series with said line and responsive to incoming signals, a transmitter including a source of sustained carrier current at said terminal, and means for connecting said source in series with said line and relay to actuate said relay in response to outgoing signals.

4. A carrier current telegraph system comprising a transmission line having two conductors, a terminal including an alternating current relay in series with said conductors and responsive to incoming signals, a transmitter including a source of carrier current at said terminal, and means including a transmitting key for directly connecting said source in series with said conductors to actuate said relay in response to outgoing signals.

5. A carrier current telegraph system comprising a transmission line over which carrier currents are transmitted in both directions, an alternating current relay having a winding in series with said line and responsive to current transmitted in one direction, a source of carrier current for transmission in the opposite direction, means for connecting said source to said line through said relay winding, and means for making the total magnetizing force of said relay produced by the current transmitted in one direction equal to the magnetizing force of said relay produced by the currents transmitted in the opposite direction.

6. A carrier current telegraph system comprising a transmission line over which carrier currents are transmitted in both directions, and an alternating current relay having a winding in series with said line and responsive to current transmitted in one direction and a second winding adapted to be connected in opposition to said first mentioned winding in response to current transmitted in the opposite direction, said windings being proportioned to maintain the magnetizing force produced by the current in both windings approximately equal to that produced by the current in said first mentioned winding.

7. A carrier current telegraph system comprising a transmission line over which carrier currents are transmitted in both directions, a circuit associated with said line and including a receiver responsive to incoming and outgoing currents, and a plurality of electrical windings in said circuit pro-

portioned to maintain the operating forces exerted upon said receiver by current in both directions approximately equal.

8. A carrier current telegraph system comprising a transmission line over which carrier currents are transmitted in both directions, a terminal including an alternating current relay having a winding in series with said line causing said relay to be responsive to incoming currents, and a second winding adapted to be connected in opposition to said first mentioned winding both of said windings causing said relay to be responsive to outgoing currents, said windings being proportioned to maintain the magnetizing forces produced by the incoming and outgoing currents therein approximately equal.

9. A carrier current telegraph system comprising a transmission line over which carrier currents are transmitted in both directions, a terminal circuit including a source of carrier current, a relay adapted when deenergized to connect said source to said line, a receiver connected in series with said relay, and means responsive to incoming carrier currents to actuate said receiver without deenergizing said relay.

10. A carrier current telegraph system comprising a transmission line over which signals are transmitted in both directions, a terminal circuit including a carrier current generator, a relay having two windings adapted when deenergized to connect said generator to said line, an energizing circuit for one winding of said relay including a receiver and a source of current sufficient to operate said relay but insufficient to operate said receiver, an energizing circuit for said receiver including said source and both windings of said relay, and means responsive to incoming signals to open and close said second mentioned energizing circuit.

11. A carrier current telegraph system comprising a transmission line over which signals are transmitted in both directions, a terminal circuit including a carrier current generator, a relay having two windings adapted when deenergized to connect said generator to said line, an energizing circuit including a receiver in series with one winding of said relay and a source of current sufficient to operate said relay but insufficient to operate said receiver, and an energizing circuit for said receiver including said source and both windings of said relay, the windings of said relay being proportioned to maintain the magnetizing force produced by the current in said first mentioned winding approximately equal to the magnetizing force produced by the current in both windings.

12. A carrier current telegraph system comprising two line sections over which carrier currents are transmitted in both di-

rections, a device having an armature responsive to carrier currents transmitted over one line section, a relay adapted to be deenergized upon the energization of said device, a source of carrier current, means to connect said source to the second line section upon the deenergization of said relay and to disconnect said source from said second line section upon the deenergization of said relay, and means including said first means and said armature of said device for making the interval between signals over said second line section of the same duration as the interval between signals over said first line section.

13. A carrier current telegraph system comprising two line sections over which carrier currents are transmitted in both directions, an alternating current relay responsive to carrier currents transmitted over one line section, a direct current relay adapted to be deenergized upon the energization of said alternating current relay, a source of carrier current, and means operative upon the deenergization of said direct current relay to connect said source to the second line section and operative upon the deenergization of said alternating current relay to disconnect said source from said second line section.

14. A carrier current telegraph system comprising two line sections over which carrier currents are transmitted in both direc-

tions, an alternating current relay having an armature operative in response to carrier currents transmitted over one line section, a direct current relay adapted to be deenergized to release its armature upon the energization of said alternating current relay, and a source of carrier current adapted to be connected to the second line section upon the deenergization of said direct current relay and adapted to be disconnected from said second line section upon the deenergization of said alternating current relay, said relays being so proportioned that the times of travel of their armatures are substantially equal.

15. A carrier current telegraph system comprising a transmission line over which signals are transmitted in both directions, terminal circuits each including a carrier current generator, a recorder of signals received and transmitted over said line, an alternating current relay operating said recorder, said incoming and outgoing signals actuating said alternating current relay, and means at each terminal for disabling the operation of said alternating current relay and said recorder at the opposite terminal when signals are being transmitted from the opposite terminal.

In witness whereof, I hereunto subscribe my name this 29th day of October A. D., 1926.

EVERETT T. BURTON.