Jan. 6, 1925. 1,521,674

L. ESPENSCHIED

CARRIER TELEGRAPH CIRCUITS

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Fig. 1

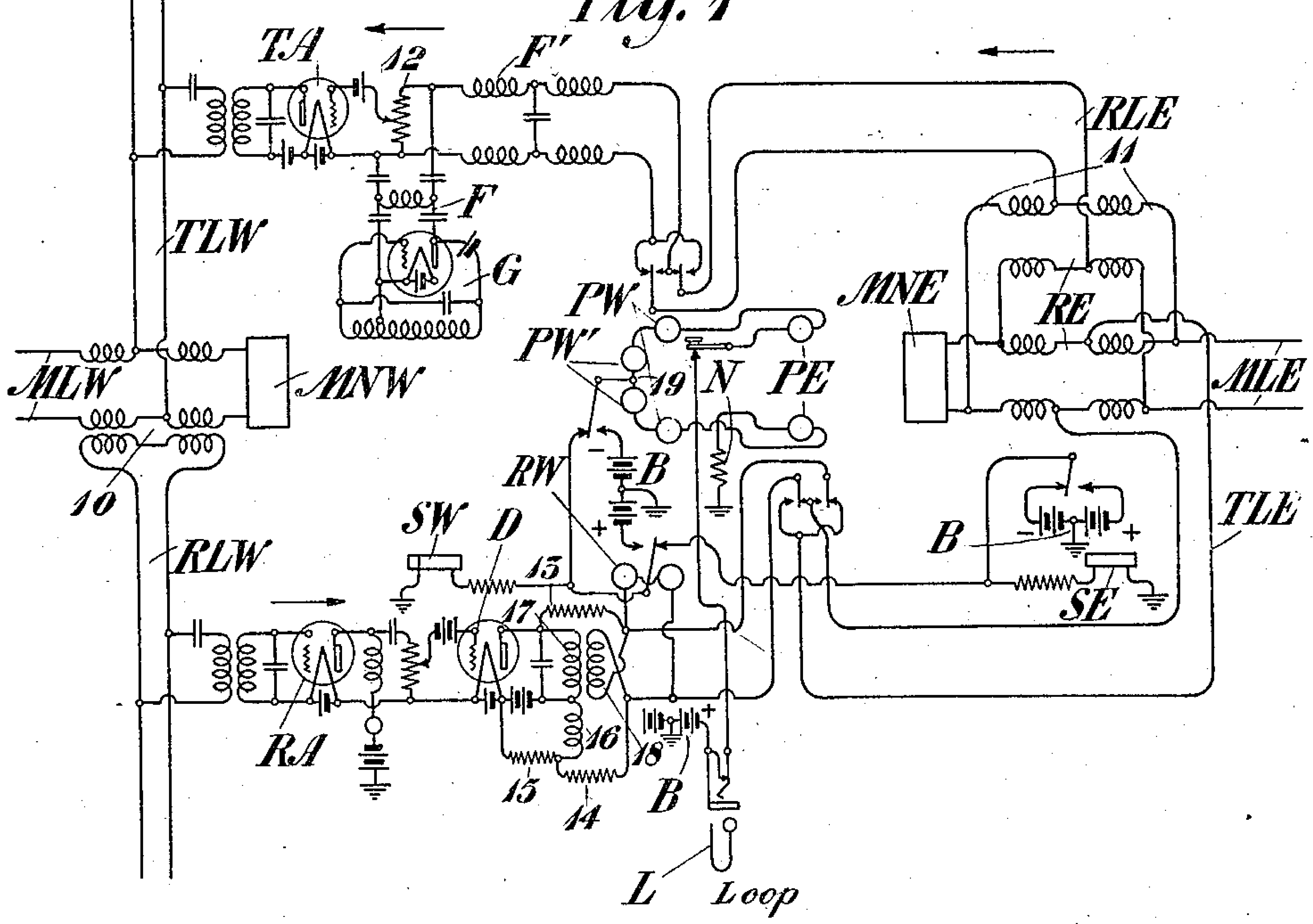
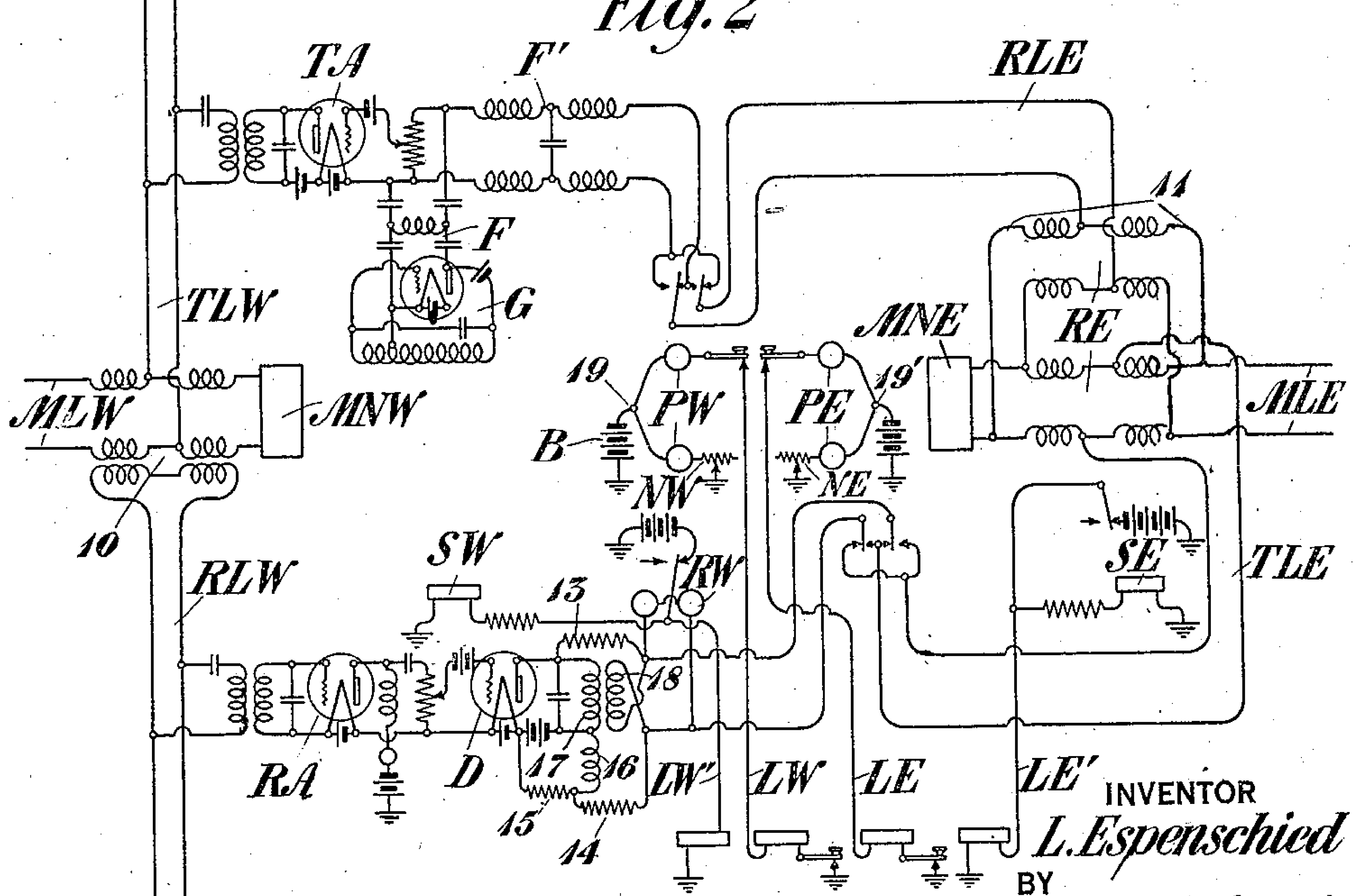


Fig. 2



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UNITED STATES PATENT OFFICE.

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CARRIER TELEGRAPH CIRCUITS.

Application filed October 21, 1920. Serial No. 418,482.

To all whom it may concern:

Be it known that I, LLOYD ESPENSCHIED, residing at Queens, in the county of Queens and State of New York, have invented certain Improvements in Carrier Telegraph Circuits, of which the following is a specification.

This invention relates to signaling systems and more particularly to systems in which telegraph signals may be transmitted by means of carrier currents.

One of the objects of the invention has reference to the provision of arrangement whereby signals may be repeated from a carrier circuit to a low frequency telegraph circuit without the use of mechanical repeating relays.

Another object of the invention has reference to the provision of an arrangement of the character just described in which a local subscriber's circuit or loop may be associated with the repeating apparatus to receive signals repeated from the carrier circuit to the low frequency telegraph line or vice versa, and to transmit signals to either of said circuits through the repeater.

Another object of the invention is to provide a detector arrangement for association with a receiving carrier channel, said detector arrangement being so organized that carrier frequencies may be translated into the signaling currents of opposite sign.

Other and further objects of the invention will be clear from the following description when read in connection with the accompanying drawing, Fig. 1 of which constitutes a circuit diagram embodying a form of invention adapted for half duplex operation and Fig. 2 of which is a circuit diagram of a form of the invention adapted for full duplex operation.

Referring to Fig. 1, MLW designates a transmission line over which carrier currents may be transmitted, said line being associated through the transformer 10 with the common transmitting circuit TLW and the common receiving circuit RLW, an artificial line or network MNW being provided to balance the main line. In practice a plurality of carrier transmitting and receiving channels will be associated with each of the circuits TLW and RLW. For purpose of illustration, however, but a single transmitting channel is shown associated with the circuit TLW and but a single receiving channel is shown associated with the circuit RLW. The transmitting channel includes a transmitting amplifier TA which may be of any known construction as, for example, a vacuum tube amplifier. A source of carrier frequency G is illustrated as being connected with the input circuit of the amplifier through a suitable filter F. The source G may be of any suitable arrangement for producing alternating current of any desired frequency but is preferably a vacuum tube oscillator. The receiving channel includes a receiving amplifier RA similar to the amplifier TA and the detector D which may be of any known construction as, for example, a vacuum tube detector.

A metallic telegraph circuit is indicated at MLE, said metallic telegraph circuit being balanced by an artificial line of network MNE. A receiving polar relay RE of the balanced bridge type is associated with the line MLE. A transmitting channel TLE is connected at the junction point of the line MLE and the balancing circuit MNE. A receiving channel RLE for the main line MLE is connected to the midpoints of the bridge circuit 11. The polar receiving relay RE comprises windings included in the main line MLE and the balancing circuit MNE on either side of the junction point of said circuit with the transmitting circuit TLE and said relay also includes windings in the bridge circuit 11 on either side of its junction with the receiving circuit RLE.

The balanced bridge arrangement, above described, is such that the circuits TLE and RLE will be substantially conjugate. The receiving channel RLE is directly connected to the carrier transmitting channel illustrated in such a manner that the telegraph currents of opposite sign received from the metallic line MLE will modulate the carrier frequency transmitted from the generator G to the main carrier line MLW. For this purpose the channel RLE is connected to the terminals of the potentiometer 12 in the input circuit of the amplifier TA and the terminals of the oscillator G are connected to the same points. The modulating amplifier TA has such a potential normally impressed upon its grid by means of a grid battery that the metallic Morse current of marking polarity received from the metallic line MLE, when superposed upon the normal grid potential will cause the tube to operate on a point of its characteristic curve corresponding to maximum amplification while the spacing polarity when superposed upon the normal grid potential shifts upon the point of operation to the lower knee of the curve. In this manner metallic Morse currents of opposite signs modulates the carrier frequency supplied by the generator G to produce considerable changes in the amplitude of the carrier currents transmitted over the main line MLW.

The transmitting channel TLE is directly connected to the circuits of the detector D independently of any mechanical relay arrangement for repeating the signals and hence the circuits of said detector must be arranged to translate the received modulated carrier currents into Morse currents of opposite signs. In order to accomplish this result the two conductors of TLE are connected through resistances 13 and 14 to opposite points of a Wheatstone bridge of which the plate filament impedance of the detector D forms one arm, a resistance 15 forms a second arm and the coils 16 and 17 of a transformer form the remaining arms. The plate battery of the detector D is connected across alternate points of the bridge circuit from the points to which the circuit TLE is connected. As is well known the impedance of the detecting tube D will change with the amplitude of the carrier frequency impressed upon it and its input circuit is so adjusted that when a carrier frequency of maximum amplitude is impressed upon the tube, its output impedance will be less than that of the resistance arm 15 so that current will flow from the bridge points to the circuit TLE in one direction; when a carrier frequency of minimum amplitude is impressed upon the tube, its output impedance becomes greater than that of the resistance arm 15 and a current of the opposite sign flows to the circuit TLE. A secondary winding 18 is associated with the coils 16 and 17 of the bridge and is in effect associated with the bridge as regards the alternating current components of the detecting current in the same manner as the circuit TLE. By a proper adjustment of the transformer and the resistances 13 and 14 a desired ratio between the direct current component and the alternating current component of the detected signals supplied to the circuit TLE may be obtained.

In practice, it is desirable that means be provided whereby signals transmitted through the repeater arrangement may be received in a local circuit and signals may be sent form the local circuit through the repeater to the carrier line and the metallic line. For this purpose a loop L is provided, said loop being balanced at one end by means of a balancing circuit N. Polar transmitting relays PE, PW and PW′ are associated with the loop in such a manner that one winding will be included in the loop circuit and another in the balancing circuit. A polar receiving relay RW is bridged across the circuit TLE and responds to the detected currents of opposite sign to transmit signals to the loop. The polar receiving relay RE associated with the metallic line MLE is also arranged to repeat signals to the loop through its armature. For this purpose, the junction point 19 between the loop L and the balancing circuit N is connected over a normal contact of the polar relay PW′ and normal contact of the receiving relay RW and normal contact of the receiving relay RE to one pole of the divided battery B, and the opposite end of the loop is connected to the opposite pole of the battery. By means of this connection a greater current flows through the loop than flows through the balancing circuit and the loop windings of the polar relays PE, PW and PW′ become effective to hold the armatures of said relays against their normal contacts. The alternate contact of the relays RW and RE are connected to the opposite pole of the battery B from that connected to their normal contacts so that if the armature of either relay is shifted the battery connections at the opposite ends of the loop will be opposed and no current will flow in the loop. The alternate contact of the polar relay PW′ is connected directly with the same pole of the battery as that normally connected with the point 19 so that when the armature of said relay is shifted the loop circuit is maintained in its normal condition and is unaffected by the operation of the receiving relay RE or RW.

The polar transmitting relays PE and PW associated with the loop are so arranged that in response to the opening and closing of the loop the connections of the conductors of the circuits TLE and RLE may be reversed, thereby changing the polarity of the current which normally flows from the detector D over the circuit TLE to the metallic line MLE and also changing the polarity of the current which normally flows from the metallic line MLE over the receiving circuit RLE to the modulating amplifier TA. If desired, a filter F′ may be included in the circuit RLE to curb or round off the pulses of opposite sign transmitted to the modulating arrangement, thereby eliminating some of the higher harmonics of the low frequencies in order to narrow the transmitted modulated band of frequencies.

The operation is as follows: the signals from a distant station associated with the metallic line MLE are transmitted by changing the polarity of the current flowing over said line. Each time the polarity is changed the polar relay responds and shifts its armature from negative to positive battery. As a consequence positive battery is connected to both ends of the loop L and the sounders (not shown) in the loop are deenergized by reason that no current flows in the loop. The upper windings of the relays PE, PW and PW′ are deenergized but the current flowing in the lower windings is in the opposite direction from that normally flowing and consequently the armatures of said relays are held against their normal contacts.

The change in the polarity of the current incoming from the line MLE produces a similar change in the receiving circuit RLE. Assuming that the normal current transmitted over the line MLE is of marking polarity and that a current of spacing polarity is transmitted, the change in the grid potential of the amplifier TA is such that the tube works near the knee of its characteristic curve instead of at its point of maximum amplification. The amplitude of the oscillations transmitted from the generator G to the amplifier TA through the carrier line MLW is, therefore, greatly decreased when a current of spacing polarity is received by the circuit RLE. In this manner signals may be transmitted from the metallic line MLE to the carrier circuit MLW, and it will be noted that no mechanical repeating is necessary, the action being purely one of modulation.

Signals may be transmitted from a distant station associated with the carrier circuit MLW by changing the amplitude of the carrier frequently transmitted. Assuming that when a current of maximum amplitude is transmitted a marking signal is being sent and when a carrier current of minimum amplitude is transmitted a spacing signal is being sent, the received carrier frequency will be amplified by the amplifier RA and impressed upon the detector D. The grid circuit of the detector D may be so arranged that when a carrier current of maximum amplitude corresponding to a marking signal is impressed thereon the output impedance of the detector is smaller than that of the resistance 15 so that a current flows from the bridge points of the Wheatstone bridge arrangement through the resistances 13 and 14 in one direction, and when carrier oscillations of minimum amplitude are impressed upon the grid circuit the impedance of the output of the detector D is greater than that of the resistance 15 and the current flows through resistances 13 and 14 in the opposite direction. The effect of the transformer arrangement comprising the coils 16, 17 and 18 is to accent the change in polarity at the beginning of each pulse by superposing the alternating components upon the direct current change impressed through the resistances 13 and 14 upon the circuit TE and the receiving relay RW.

When the normal or marking current flowing from the resistances 13 and 14 is changed to a current of spacing polarity the armature of the polar relay RW is shifted and positive battery is connected to the point 19 so that the battery connections at the two ends of the loop L are mutually opposed. Current, therefore, ceases to flow through the loop and the sounders in the loop respond. The current through the lower windings of the polar relays PE, PW and PW′ is now in the opposite direction so that, notwithstanding the deenergization of the upper windings, the armatures remain against their normal contacts. The change in polarity of the current flowing over the resistances 13 and 14 to the circuit TLE is impressed upon the midpoints of the lower set of windings of the polar receiving relay RE so that the change in polarity is transmitted to the metallic line MLE to actuate receiving apparatus associated therewith at a distant station. The polar relay RE, however, is balanced with respect to the current thus transmitted and is unaffected thereby.

Since normally a current of one polarity, say the marking polarity, is transmitted from the metallic line MLE over the circuit RLE and at the same time when signals are not being transmitted in the opposite direction a current of like polarity will be transmitted from the detector D over the circuit TLE to the metallic line MLE, it is possible to transmit signals in both directions by merely changing the connections of the circuits RLE and TLE thereby changing the polarity of the current normally flowing with respect to the modulating amplifier TA and with respect to the metallic line MLE. When the loop L is interrupted in transmitting signals the current flowing through the upper windings of the polar relays PE, PW and PW′ ceases and the current flowing through the lower windings being in normal direction said windings become effective to shift the armatures of the polar relays. The armatures of the polar relay PE change the connections of the circuit TLE thereby reversing the polarity of the current normally supplied by the detector D to the metallic line MLE so that a signal is transmitted to the latter. The polar relay PW reverses the connections of the circuit RLE thereby reversing the polarity of the current normally transmitted from the metallic line MLE to the modulator TA. Modulated carrier signals will consequently be transmitted to the circuit MLW. The polar relay PW′ at the same time shifts its armature thereby opening the battery connections controlled by the relays RE and RW and directly connecting negative battery to the point 19 independently of said polar receiving relays so that the loop circuit will be unaffected during the transmission of the signal, by the receiving relays.

If, while a signal is being received from either the metallic line MLE or the carrier circuit MLW, it is desired to interrupt for any purpose and transmit in the opposite direction a break signal may be transmitted by opening the loop L thereby causing the polar relays PE and PW to reverse the connections of the circuits RLE and TLE so that a continuous spacing signal will be transmitted to the main line MLE and the carrier circuit MLW. The sending operator who is at the moment transmitting over one of these lines will be informed upon the receipt of the continuous spacing signal that another operator desires to send and the sending operator will then cease transmitting. If the loop L should be transmitting and a break signal should be received, the armature of the receiving relay RE or the receiving relay RW, depending upon whether the break signal came from the line MLE or the line MLW, would be shifted to its alternate contact thereby connecting both ends of the loop to the same pole of the battery so that current ceases to flow in the loop. The operator transmitting over the loop circuit will be apprised of the break signal by noting that the sounder no longer follows the opening and closing of the loop by the sending key.

Fig. 2 illustrates an arrangement similar to Fig. 1 except that the circuit is arranged for full duplex operation. Since in full duplex operation signals may be simultaneously transmitted in both directions through the repeater between the metallic line and the carrier circuit, additional loops are necessary for local operation at the repeater station. Accordingly, a loop LE is provided for transmitting to the metallic line MLE and a loop LW for transmitting to the carrier circuit MLW. A loop LE′ is provided for receiving from the line MLE and a similar loop LW′ is arranged to receive from carrier circuit MLW. The receiving loops LE′ and LW′ are simply arranged so that their circuits are opened and closed by the armatures of the polar relays RE and RW respectively. The sending loops LE and LW are balanced by balancing circuits NE and NW respectively and battery is connected to the junction points 19 and 19′ of the loops and balancing circuits. The polar relays PE and PW each have a winding in the loop and corresponding balancing circuit and the balancing circuits are so proportioned with respect to the loops LE and LW, or the windings in the loop and balancing circuit are so proportioned with respect to each other that a greater pull in one direction is impressed upon the armature of the relays by the upper windings than is impressed in the opposite direction by the lower windings. The pull due to the upper windings tends to hold the armatures of these relays against their normal contacts but when the loops are interrupted the upper windings are deenergized and the lower windings become effective to shift the armatures to their alternate contacts.

Signals incoming from the metallic circuit MLE operate upon the amplifying modulator TA in exactly the same manner as in connection with Fig. 1 so that the low frequency signals are transmitted into modulated carrier currents. Likewise modulated carrier currents received from the carrier circuit MLW operate through the detector D to produce currents of opposite sign in the circuit TLW which currents are transmitted over the metallic line MLE. The signals received from the metallic line TLE in addition to actuating the modulator TA causes the polar receiving relay RE to shift its armature and open the loop LE′ so that the sounder responds. Likewise the currents of opposite sign impressed by the detector D upon the circuit TLE in response to modulated carrier currents actuate the receiving relay RW to open the loop LW′ so that the receiving sounder in said loop responds to the signal incoming from the line MLW.

Signals may be transmitted from the loop LE to the metallic line MLE by opening the loop so that the polar relay PE reverses the connections of the circuit TLE, thereby reversing the polarity of the current transmitted from the detector D to the metallic line MLE. In a like manner, signals may be transmitted from the loop LW to the carrier circuit MLW by interrupting the loop so that the polar relay LW through its armatures reverses the connections between the circuit RLE and the modulating amplifier TA thereby modulating the carrier frequency in the manner already described.

It will be obvious that the general principles herein described may be embodied in many other organizations widely different from those illustrated without departing from the spirit of the invention as defined in the following claims.

What is claimed is:

1. In a signaling system, a carrier transmission line, a low frequency telegraph line and a two-way repeater interconnecting said lines, said repeater having channels for transmission in opposite directions, one of said channels including vacuum tube means for modulating carrier currents in accordance with low frequency signaling currents directly impressed upon the grid of said

vacuum tube means from said low frequency line and the other of said channels including means for translating modulated carrier currents into low frequency signaling currents.

2. In a signaling system, a carrier transmission line, a low frequency telegraph line and a two-way repeater interconnecting said lines, said repeater having channels for transmission in opposite directions, one of said channels including means for translating signaling currents incoming from said telegraph line as currents of opposite sign into carrier currents of varying amplitude and the other of said channels including means for translating carrier currents of varying amplitude into low frequency signal currents of opposite signs.

3. In a signaling system, a carrier transmission line, a low frequency telegraph line and a two-way repeater interconnecting said lines, said repeater having channels for transmission in opposite directions, one of said channels including means for modulating carrier currents in accordance with low frequency signaling currents, the other of said channels including means for translating modulated carrier currents into low frequency signaling currents, and a local subscriber's circuit associated with one of said channels for transmitting signals thereto independently of said low frequency telegraph line.

4. In a signaling system, a carrier transmission line, a low frequency telegraph line and a two-way repeater interconnecting said lines, said repeater having channels for transmission in opposite directions, one of said channels including means for modulating carrier currents in accordance with low frequency signaling currents, the other of said channels including means for translating modulated carrier currents into low frequency signaling currents, and a local subscriber's circuit associated with the channel including said modulated means, said subscriber's circuit including means for actuating said modulating means independently of said low frequency telegraph line.

5. In a signaling system, a carrier transmission line, a low frequency telegraph line and a two-way repeater interconnecting said lines, said repeater having channels for transmission in opposite directions, one of said channels including means for translating signaling currents incoming from said telegraph line as currents of opposite sign into carrier currents of varying amplitude, the other of said channels including means for translating carrier currents of varying amplitude into low frequency signal currents of opposite sign, and a local subscriber's circuit associated with said first mentioned channel, said subscriber's circuit including means for reversing the connections of the low frequency portion of said channel to produce independent reversals of polarity to actuate said modulator.

6. In a signaling system, a carrier transmission line, a low frequency telegraph line and a two-way repeater interconnecting said lines, said repeater having channels for transmission in opposite directions, one of said channels including means for modulating carrier currents in accordance with low frequency signaling currents, the other of said channels including means for translating modulated carrier currents into low frequency signaling currents, and a local subscriber's circuit associated with the channel including said translating means, said subscriber's circuit including means for producing low frequency signals in said channel independently of said low frequency telegraph line.

7. In a signaling system, a carrier transmission line, a low frequency telegraph line and a two-way repeater interconnecting said lines, said repeater having channels for transmission in opposite directions, one of said channels including means for translating signaling currents incoming from said telegraph line as currents of opposite sign into carrier currents of varying amplitude, the other of said channels including means for translating carrier currents of varying amplitude into low frequency signal currents of opposite sign, and a local subscriber's circuit associated with said second mentioned channel and means in said subscriber's circuit for reversing connections of the low frequency portion of said channel to transmit currents of opposite sign to said telegraph line.

8. In a signaling system, a carrier transmission line, a low frequency telegraph line and a two-way repeater interconnecting said lines, said repeater having channels for transmission in opposite directions, one of said channels including means for modulating carrier currents in accordance with low frequency signaling currents, the other of said channels including means for translating modulated carrier currents into low frequency signaling currents, and a local subscriber's circuit for receiving signals transmitted through one of said channels from one of said lines and independently of the other.

9. In a signaling system, a carrier transmission line, a low frequency telegraph line and a two-way repeater interconnecting said lines, said repeater having channels for transmission in opposite directions, one of said channels including means for modulating carrier currents in accordance with low frequency signaling currents, the other of said channels including means for translating modulated carrier currents into low frequency signaling currents, and a local

subscriber's circuit for receiving signals transmitted over the channel including said demodulating means independently of said low frequency telegraph line.

10. In a signaling system, a carrier transmission line, a low frequency telegraph line and a two-way repeater interconnecting said lines, said repeater having channels for transmission in opposite directions, one of said channels including means for modulating carrier currents in accordance with low frequency signaling currents, the other of said channels including means for translating modulated carrier currents into low frequency signaling currents, and a local subscriber's circuit for receiving signals transmitted over the channel including said translating means independently of said low frequency telegraph line.

11. In a signaling system, a carrier transmission line, a low frequency telegraph line and a two-way repeater interconnecting said lines, said repeater having channels for transmission in opposite directions, one of said channels including means for translating signaling currents incoming from said telegraph line as currents of opposite sign into carrier currents of varying amplitude, the other of said channels including means for translating carrier currents of varying amplitude into low frequency signal currents of opposite sign, a local subscriber's circuit and means associated with said circuit whereby said circuit responds to currents of opposite polarity transmitted over said first mentioned channel.

12. In a signaling system, a carrier transmission line, a low frequency telegraph line and a two-way repeater interconnecting said lines, said repeater having channels for transmission in opposite directions, one of said channels including means for translating signaling currents incoming from said telegraph line as currents of opposite sign into carrier currents of varying amplitude, the other of said channels including means for translating carrier currents of varying amplitude into low frequency signal currents of opposite sign, a local subscriber's circuit and means associated with said circuit whereby said circuit responds to currents of opposite polarity transmitted over said second mentioned channel.

13. In a signaling system, a carrier transmission line, a low frequency telegraph line and a two-way repeater interconnecting said lines, said repeater having channels for transmission in opposite directions, one of said channels including means for modulating carrier currents in accordance with low frequency signaling currents, the other of said channels including means for translating modulated carrier currents into low frequency signaling currents, and a local subscriber's circuit associated with said channels, said subscriber's circuit including means for transmitting signals to both channels independently of said low frequency telegraph line.

14. In a signaling system, a carrier transmission line, a low frequency telegraph line and a two-way repeater interconnecting said lines, said repeater having channels for transmission in opposite directions, one of said channels including means for translating signaling currents incoming from said telegraph line as currents of opposite sign into carrier currents of varying amplitude, the other of said channels including means for translating carrier currents of varying amplitude into low frequency signal currents of opposite sign, and a local subscriber's circuit, said subscriber's circuit including means for independently transmitting currents of opposite signs over said channels by reversing the connections of said channels.

15. In a signaling system, a carrier transmission line, a low frequency telegraph line and a two-way repeater interconnecting said lines, said repeater having channels for transmission in opposite directions, one of said channels including means for modulating carrier currents in accordance with low frequency signaling currents, the other of said channels including means for translating modulated carrier currents into low frequency signaling currents, and a local subscriber's circuit independent of said low frequency telegraph line, said circuit including means for transmitting signals to either of said channels and also including means responsive to signals transmitted over either channel.

16. In a signaling system, a carrier transmission line, a low frequency telegraph line and a two-way repeater interconnecting said lines, said repeater having channels for transmission in opposite directions, one of said channels including means for translating signaling currents incoming from said telegraph line as currents of opposite sign into carrier currents of varying amplitude, the other of said channels including means for translating carrier currents of varying amplitude into low frequency signal currents of opposite sign, a local subscriber's circuit, means associated with said circuit for reversing the connections of the low frequency portion of either of said channels and means associated with said subscriber's circuit responsive to signals transmitted over either of said channels.

17. In a signaling system, a detector circuit for translating carrier currents into direct currents of opposite sign, said detector circuit comprising a Wheatstone bridge having a detector element whose impedance varies with the amplitude of carrier currents forming one arm of said

bridge, and a circuit to be supplied with currents of opposite polarity connected to opposite points of the bridge.

18. In a signaling system, a detector circuit for translating carrier currents into direct currents of opposite sign, said detector circuit comprising a Wheatstone bridge arrangement, a vacuum tube element forming one arm of the bridge, said vacuum tube element being so constructed that in response to carrier currents of certain amplitudes its impedance is such as to unbalance the bridge in one direction and in response to carrier currents of other amplitudes its impedance is such as to unbalance the bridge in the other direction, and a circuit to be supplied with currents of opposite polarity connected to opposite points of said bridge.

19. In a signaling system, a modulating arrangement for translating direct currents of opposite sign into modulated carrier currents, said modulating arrangement comprising a modulating element and polarizing source for said element, said polarizing source having such a potential that when direct currents of one polarity are superposed upon said source the impedance of said modulating element becomes a minimum for carrier currents and when a direct current of the opposite polarity is superposed on said source the impedance of said element becomes a maximum for carrier currents.

20. In a signaling system, a modulating arrangement for translating direct currents of opposite signs into carrier currents, said modulating arrangement comprising a modulating vacuum tube amplifier, means to supply carrier currents thereto and a polarizing source for said amplifier, the potential of said source being such that when direct currents of one sign are superposed upon said source the amplification of said amplifier for carrier currents will be a maximum, but when direct currents of the opposite sign are superposed upon said source the amplification of said amplifier for carrier currents will be a minimum.

21. In a signaling system, means to transmit carrier currents of varying amplitudes, and a translating device to translate the carrier currents into direct current impulses of opposite polarity.

22. In a signaling system, means to transmit direct current signaling impulses of opposite polarity, and means to translate the direct current signaling impulses into a carrier frequency varying in amplitude.

In testimony whereof, I have signed my name to this specification this 19th day of October, 1920.

LLOYD ESPENSCHIED.