

June 16, 1925.

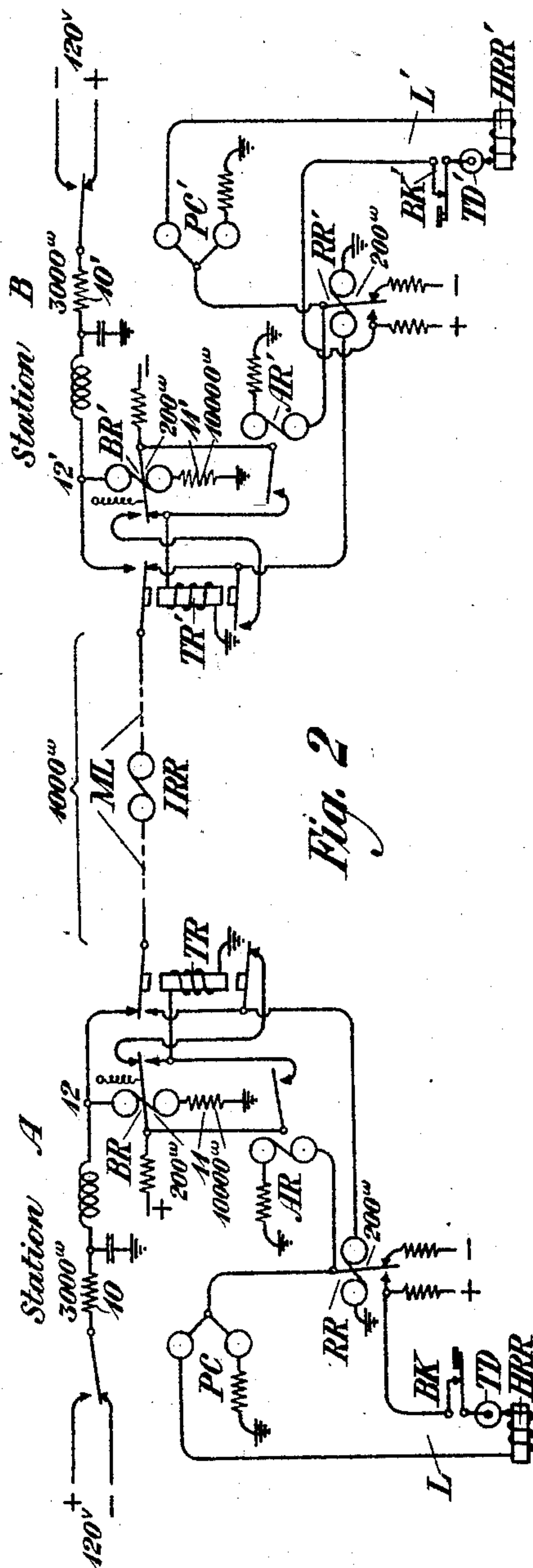
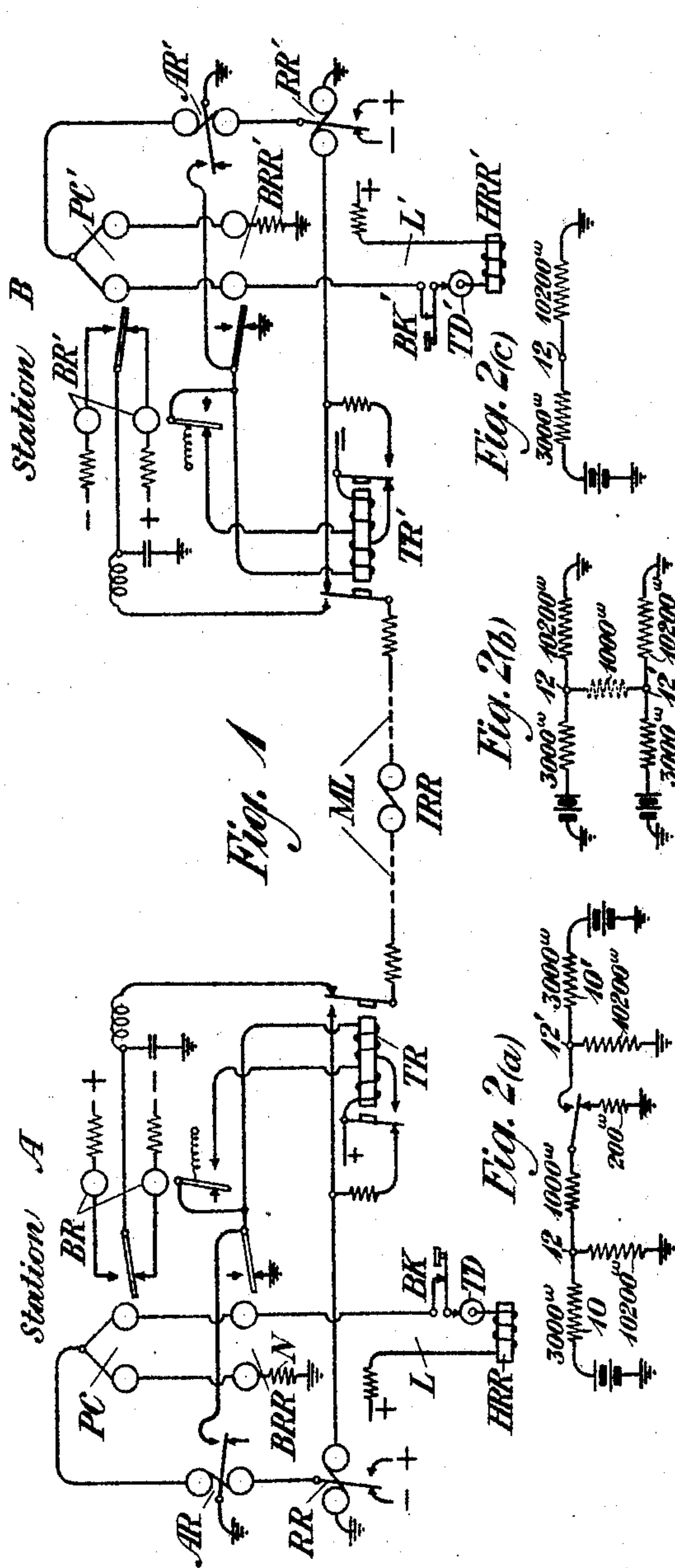
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E. F. WATSON

SINGLE POLAR TELEGRAPH CIRCUITS

Filed Nov. 21, 1921

2 Sheets-Sheet 1



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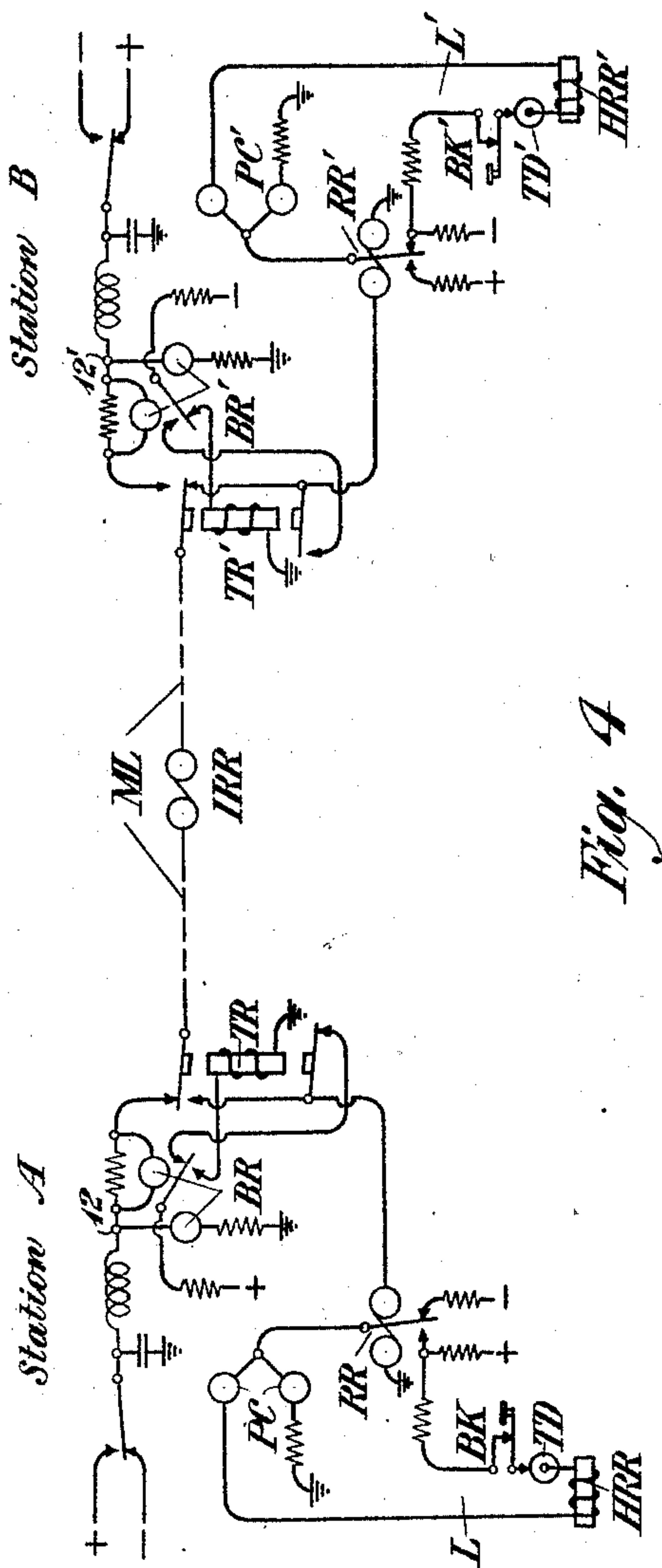
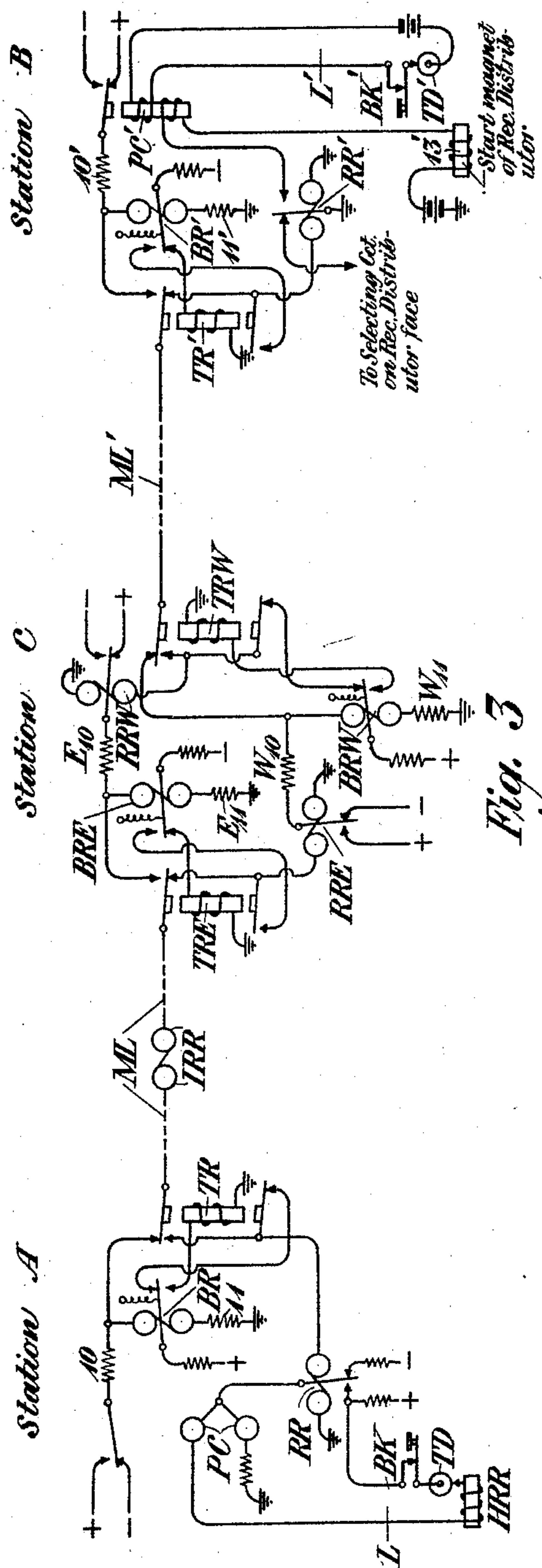
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UNITED STATES PATENT OFFICE.

EDWARD F. WATSON, OF YONKERS, NEW YORK, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

SINGLE POLAR TELEGRAPH CIRCUITS.

Application filed November 21, 1921. Serial No. 516,869.

To all whom it may concern:

Be it known that I, EDWARD F. WATSON, residing at Yonkers, in the county of Westchester and State of New York, have invented certain Improvements in Single Polar Telegraph Circuits, of which the following is a specification.

This invention relates to telegraph circuits and more particularly to the type of telegraph circuit known as single Morse circuits in which signals are transmitted in but one direction over the same line at one time, although the system is so arranged that signals may be transmitted in either direction.

One of the objects of the invention is to produce a signaling system in which signals may be transmitted in either direction over a line wire without balancing the wire.

Another object of the invention is to produce a signaling system in which signals consisting of positive and negative impulses may be transmitted in either direction over a line wire without balancing the wire.

Another object of this invention is to produce a system in which the line will be switched into connection with the transmitting apparatus at one end and the receiving apparatus at the other end, but, under suitable conditions, may be switched into connection with the receiving apparatus at the first mentioned end and into connection with the transmitting apparatus at the other end for transmitting signals in the reverse direction.

Another object of the invention is to provide a system in which the stations at each end of the line are provided with a transmitting and a receiving apparatus, the transmitting apparatus at one station being connected with the line and the receiving apparatus at the other station being connected with the line when signals are transmitted in one direction, the system being so arranged that, by transmitting a break signal from the station which is receiving, the connections may be interchanged to connect the transmitting apparatus with the line at the receiving station and the receiving apparatus with the line at the transmitting station, whereby signals may be transmitted in the opposite direction.

Another object of the invention is to produce a system having the characteristics

above referred to and which is adapted for the transmission of printing telegraph signals.

A still further object of the invention is to provide a system having the characteristics above referred to in which the switching apparatus for determining whether the line will be connected to the transmitting or to the receiving apparatus at a given station will be under the control of a relay responsive only to abnormal current conditions in the line.

The above objects, as well as other objects of the invention, will be clear from the following description of the invention when read in connection with the accompanying drawing, Figures 1, 2 and 4 of which illustrate three different embodiments of the invention, Fig. 3 of which illustrates the application of a repeating arrangement to the modification illustrated in Fig. 2, and Figs. 2^a, 2^b and 2^c of which are schematic diagrams to indicate different operating conditions of the apparatus of Fig. 2.

Referring to Fig. 1, ML designates a main transmission line for a telegraph circuit terminating at opposite ends at two stations indicated as A and B respectively. At station A a local loop L extends to a subscriber's station at which suitable transmitting and receiving apparatus may be provided, for example, the loop L is illustrated as including a schematically indicated transmitting distributor TD of a printing telegraph set and a home recording relay HRR of such a set.

The loop L at station A is balanced by means of a balancing circuit or resistance N, and windings of a polar pole changing relay PC and a polar break release relay BRR are included in the loop L and balancing circuit N. At the junction point between the loop L and the balancing circuit N a connection extends to the armature of a polar receiving relay RR, which relay may, under certain conditions, be associated with the main line ML for transmitting signals to the loop. The connection to the armature of the receiving relay may also include an auxiliary polar relay AR for a purpose which will appear hereinafter.

A transfer relay TR is so arranged that it may switch the main line ML either into connection with the receiving relay RR or

into connection with the transmitting apparatus controlled by the armature of the pole changer PC. The armature of the pole changer PC is adapted to make contact with
 5 either positive or negative sources of current for transmitting signals, and in circuit with these sources are the two individual windings of a polar break relay BR. The direction of these windings are such that
 10 the signaling current flowing through either winding tends to open the contact controlled by the armature of the relay. The armature is provided with a spring, however, which tends to bias the armature to its closed
 15 position with a force less than that produced in either winding by a normal signaling current, so that during the transmission of signaling impulses the contact controlled by the break relay BR is held open by the
 20 signaling current. When, however, during the transmission of a break signal, as hereinafter described, no current flows over the line, the armature will be shifted to close its contact under the influence of the biasing spring. The transfer relay TR has two
 25 windings, one of which is controlled by the armature of BR for initially energizing the transfer relay, and the other of which is a locking winding whose circuit is completed through a locking contact of the
 30 transfer relay. The circuit of the locking winding is controlled by the armature of the break release relay and also by the armature of the auxiliary relay AR previously described.

The apparatus at station B is identical with that at station A, except for the reversal of the line batteries and corresponding elements are represented by the same
 40 reference characters primed. Further details of the apparatus will be clear from a description of the operation, which is as follows:

As illustrated, the apparatus at stations
 45 A and B is in condition for transmitting from station A to station B. Under these conditions, transfer relay TR' at station B is locked up to connect the line ML to the receiving relay RR'. At station A the
 50 transfer relay TR is deenergized, so that the line ML is connected to the armature of the pole changer PC. The apparatus is so arranged that in transmitting from station A to station B negative impulses are
 55 transmitted for marking signals, while in transmitting in the opposite direction positive impulses are transmitted for the same purpose. When the transfer relay TR is deenergized, a positive battery is connected
 60 over the back left-hand contact of the transfer relay to the winding of the receiving relay RR, so that the armature of the latter relay is maintained against its negative contact. Under these conditions, when the
 65 loop L is closed, current flows from the

positive battery through the winding of the home recording relay HRR, through the transmitting distributor TD, through the loop windings of the break release relay
 70 BRR and pole changer PC and through the windings of the auxiliary relay AR over the contact of the receiving relay RR to negative battery. Current also flows from ground through the balancing resistance N
 75 balancing windings of the break release relay BRR and pole changer PC, through the winding of the auxiliary relay AR and over the contact of the receiving relay to negative battery.

Obviously the current flowing through
 80 the loop windings of the pole changer and the break release relay is substantially twice as great as that flowing through the balancing windings owing to the fact that the
 85 positive and negative batteries are connected in series with respect to the loop circuit. The tendency of the current flowing through the balancing windings is to shift the armature of the pole changer PC and the break
 90 release relay BRR to their upper contacts, but owing to the greater pull in the opposite direction, due to the loop windings, said relays and armatures are held to their lower
 95 contacts, so that negative battery is connected through the lower winding of the polar break relay BR over the lower contact of the pole changer PC and over the
 100 right-hand back contact of the transfer relay TR to the main line ML. The resultant line current flows over the front left-hand contact of the transfer relay TR' at station
 105 B and through the winding of the receiving relay RR' to ground. The armature of the receiving relay RR' is therefore held against its negative contact, and the current conditions in the loop circuit L' are the same
 110 as described at station A, so that the armature of the break release relay BRR' is held against its lower contact thereby maintaining a locking circuit through the left-hand winding and over the right-hand front
 115 contact of the transfer relay TR'.

The conditions just described obtain during the transmission of marking signals. When a spacing signal is to be transmitted,
 120 the loop L will be opened by means of the transmitting distributor TD at station A, so that no current flows through the loop windings of the pole changer PC and the break release relay BRR. As a consequence, the balancing windings of these relays become effective to shift their armatures to their upper contacts. The shifting of the
 125 armature of the break release relay BRR is without effect, but when the armature of the pole changer is shifted to its upper contact positive current flows through the upper winding of the break relay BR through the upper contact of the pole changer and
 130 over the back right-hand contact of the

transfer relay over the line ML and over the front left-hand contact of the transfer relay TR' through the winding of the receiving relay RR' to ground. The receiving relay RR' therefore shifts its armature to its positive contact, so that positive battery is connected to both ends of the loop L', and no current flows through the loop windings of the pole changer PC and break release relay BRR' and home recording relay HRR'. A positive current flows, however, from positive battery over the armature of the receiving relay RR' through the winding of the auxiliary relay AR' and through the balancing windings of the pole changer PC' and break release relay BRR' to ground. This current flow is in the opposite direction to that previously flowing through these windings, and consequently tends to hold the armatures of the relays PC' and BRR' against their lower contacts. The armature of the auxiliary relay AR' connects ground to the locking circuit of the transfer relay TR' to maintain it energized in case there should be any faulty operation of the break release relay BRR'. The home recording relay HRR' is deenergized under the conditions just described and releases its armature. Where the circuit is to be used for ordinary Morse signals, this relay may control a sounder, but where printing telegraph signals are to be transmitted, the home recording relay may be used to control the receiving printer in a well-known manner. As the receiving printer apparatus forms no part of the present invention, it is not illustrated.

If, now, while signals are being received from station A, it should be desired to transmit signals from station B to station A, the loop L' may be opened by means of the break key BK'. This deenergizes the loop windings of the pole changer PC' and the break release relay BRR', and as soon as a negative or marking impulse is received from the line ML, the receiving relay RR' shifts its armature to its negative contact. As a result of this action the armature of the auxiliary relay AR' is shifted to its open position, and the current flow through the balancing windings of the pole changer PC and break release relay BRR' will be in such a direction as to shift their armatures to their upper contacts. The break release relay BRR' by shifting its armature to its upper contact, opens the operating and locking circuits of transfer relay TR', which is deenergized, and disconnects the main line ML from the receiving relay RR' and connects it to the armature of the pole changing relay PC'. The armature of the pole changing relay PC', being in its upper position, is connected to negative battery, and, as a marking impulse is being transmitted from station A, the line is con-

nected to negative battery at the other end, so that no current flows over the line under these conditions. Consequently, the biasing springs of the break relays BR and BR' become effective to shift their armatures to their working contacts. The shifting of the armature of the relay BR' is without effect, as the energizing circuit of the transfer relay TR' is held open at the armatures of the break release relay BRR' and the auxiliary relay AR'. At station A, however, the loop L is closed while the marking impulse is being transmitted, and consequently the armature of the break release relay BRR is resting upon its lower contact. Current therefore flows from ground over the armature of the break release relay BRR, over the make contact of the break relay BR, and through the left-hand winding of the transfer relay TR. The latter relay is accordingly energized, and a locking circuit is completed over its right-hand winding and left-hand front contact. At its right-hand contact, the connection of the line ML is shifted from the armature of the pole changer PC to the winding of the receiving relay. Signals may now be transmitted from station B to station A by opening and closing the loop L' to the distributor TD', the break key BK' having been restored to its closed position.

When it is desired to again transmit signals from station A to station B, the break key BK will be actuated to open the loop L thereby causing the armatures of the pole changer PC and break release relay BRR to be shifted to their upper contacts. This opens the locking circuit of the transfer relay TR thereby connecting the line ML to the armature of the pole changer PC, so that the positive battery is connected to the end of the line at station A. As previously stated, positive battery is connected to the line ML during the transmission of marking impulses from station B, so that under these conditions the positive battery will be connected to both ends of the line thereby permitting the biasing springs of the break release relays BR and BR' to become effective. The action of the former relay is without effect, but the latter relay closes the initial energizing circuit of the transfer relay TR', which is locked up, and connects the main line ML to the receiving relay RR'.

Owing to the fact that in the arrangement previously described the marking and spacing signals are transmitted over the line in the same direction regardless of which terminal station is transmitting, it is possible to provide an intermediate receiving relay IRR at an intermediate station which will operate a local printer or other form of receiving device. Relay IRR will, of course, be a simple polar relay of the same type as the relays RR and RR'.

Fig. 2 shows an arrangement somewhat similar to that of Fig. 1 in that it employs a polar type of break relay and transmits marking and spacing signals over the line in the same direction regardless of which terminal station is transmitting. Break relay BR in this case is a polar relay which is arranged so that it will not operate under normal signaling conditions, but will operate when the same polarity of battery is connected to both ends of the line. The polar break relay BR and BR', as the case may be, is constructed with its armature biased to a normal position by some suitable means such, for example, as a spring whose tension is just sufficient to overcome the force tending to shift it to its abnormal position when ordinary signaling currents are transmitted. As the currents employed for ordinary signaling are of opposite polarity, it is evident that the effect of an impulse of one polarity is merely to neutralize the pull due to the spring without shifting the armature, while the effect of an impulse of opposite polarity is cumulative with respect to the force of the spring and therefore does not shift the armature. When, however, a battery of the same polarity is connected to the line at both terminal stations, an increased current will flow through the relay, as will be made clear later, and the increased current, if in the proper direction, will overcome the pull of the spring and shift the armature. The break relays BR and BR' have their windings so arranged that their armatures will be shifted in response to augmented currents of opposite polarities. The arrangement of Fig. 2 is also characterized by the fact that the break release relay is omitted, its function being performed by the auxiliary relay AR or AR'.

Further details of the apparatus will be clear from the description of the operation. As illustrated, the apparatus is arranged for transmission of signals from station A to station B. Under these conditions, the transfer relay TR at station A is deenergized to connect the line to the contacts of the pole changer PC, and the transfer relay TR' is energized to connect the line at station B with the polar receiving relay RR'. The relay TR' is maintained energized by the break relay BR', which receives sufficient current from the positive battery through the 3,000 ohm resistance 10' to overcome the tension of the biasing spring.

When the loop circuit L is open at station A, the polar relay PC holds its armature against its lower contact, so that negative battery is connected to the line, and negative current flows through the resistance 10 over the upper back contact of the transfer relay TR over the line ML, over the upper front contact of the transfer relay TR', through the winding of the polar receiving

relay RR' to ground. Current also flows through the break relay BR and through the high resistance 11 in series with the break relay to ground, but the current flowing through this path, while producing a pull upon the armature of the break relay in a direction opposite to that of its biasing spring, is insufficient, for reasons which will be made clear later, to shift the armature. When the loop L is opened to transmit a spacing signal, the pole changer PC shifts its armature to its upper contact, and positive current is transmitted over the line to actuate the receiving relay RR'. The positive current flowing through the break relay produces a pull in the same direction as the biasing spring and is therefore ineffective to shift the armature of said relay. As the receiving relay RR' vibrates its armature in response to the marking and spacing signals thus transmitted it alternately establishes connection from the loop circuit L' to positive and negative battery. This causes the relay HRR' in the loop to respond in the manner described in connection with Fig. 1, but the pole changer PC' is not affected by the changes thus produced in the loop circuit, and its armature remains connected to positive battery.

In order to understand why the armature of the break relay BR is unaffected by marking impulses, it will be necessary to analyze the circuit conditions existing, for the action of the break relay is dependent upon marginal current conditions due to a proper coordination of the values of the resistance of the line ML, the resistances 10 and 11 and the resistances of the winding of the break relay BR and of the receiving relay RR'. As a typical case, it is assumed that the resistance of the line is 1,000 ohms, the resistance of element 10 is 3,000 ohms, that of the element 11 is 10,000 ohms and that break relay BR and receiving relay RR', have a resistance of 200 ohms each, it being understood, however, that these values are given solely for purposes of illustration, and that in practice other values than those given may be utilized. The circuit conditions during the transmissions of a negative marking impulse over the line are shown in simplified form in Fig. 2^a. As shown, negative battery is connected through the 3,000 ohm resistance 10 to the point 12 from which a branch extends to ground through a 10,200 ohm resistance, which is equivalent to the resistance of the break relay and the resistance 11. A parallel branch also extends through the 1,000 ohm resistance of the line and over the contact of the transfer relay at station B through the 200 ohm resistance of the receiving relay RR' to ground. In short, from the point 12 to ground there is a resistance of 1,200 ohms in parallel with the

resistance of 10,200 ohms, which is equivalent to a resistance of 1,072 ohms, so that the total resistance in circuit with the battery is 4,072 ohms. Under these circumstances, the potential drop from the point 12 to ground through the branch including the winding of the break relay BR will be directly proportional to the ratio of the combined resistance of the two paths from point 12 to ground (1,072 ohms) to the total resistance in the circuit (4,072 ohms). Assuming that a 120 volt battery is used, the drop through the branch, including the break relay, will be approximately 31.6 volts. By making the pull of the spring or other biasing means equal to or greater than the current flow through the winding of the break relay BR, due to this drop of potential, the armature of the break relay will not respond to a marking signal. Obviously, it will not respond to a spacing signal as the current is in the opposite direction, so that its effect is cumulative to that of the biasing means.

Suppose, now, it is desired to transmit signals from station B to station A. By operating the break key BK' the loop L' is opened, so that when a marking signal is transmitted from station A the armature of the receiving relay RR' is connected to negative battery thereby energizing the lower winding of the pole changer PC' in such a direction as to shift its armature to its upper contact thereby connecting negative battery instead of positive battery to the break relay BR'. Current now flows through this relay in such a direction as to shift its armature to its upper contact, the pull due to this current being exerted in the same direction as that of the biasing spring. The shifting of the armature of the break relay BR' opens the circuit of the transfer relay TR' which, at its upper armature, connects the main line ML to the armature of the pole changer PC' and at its lower back contact completes a circuit from negative battery over the upper contact of the break relay BR', lower back contact of the transfer relay TR' and through the winding of the receiving relay RR' to ground thereby holding the armature of the receiving relay against the contact connected with negative battery. Under these conditions the armature of the pole changer will remain against its upper contact so long as the loop L' is held open, and consequently negative battery will be connected through the 3,000 ohm resistance 10' to the point 12'.

As a marking impulse is being transmitted at station A, circuit conditions now existing will be as indicated in Fig. 2^a, assuming that the switch at the right of the 1,000 ohm resistance is shifted to its upper contact, this switch representing the upper armature of the transfer relay TR'. In other words, negative battery is con-

nected to the points 12 and 12' at either end of the main line ML through equal resistances 10 and 10'. The circuit condition existing when the switch in Fig. 2^a is shifted to its upper contact is represented in a still more simplified form in Fig. 2^b, and from this figure it will be apparent that the 1,000 ohm resistance representing the line is connected between equal potential points 12 and 12', the circuit being to all intents and purposes a balanced Wheatstone bridge arrangement. No current flows through the 1,000 ohm resistance of the line between points 12 and 12', so that the effect is the same as though the portions of the circuit at the two stations were isolated from each other. In the case of the break relay BR, we have, in effect, a simple series circuit from negative battery through a 3,000 ohm resistance 10 to point 12 and thence through the 200 ohm winding of the break relay BR and through the 10,000 ohm resistance 11. The total resistance in this circuit is 13,000 ohms, and the potential drop from the point 12 to ground will be proportional to the ratio between the resistance of the path through the break relay BR (10,200 ohms) and the total resistance of the circuit (13,200 ohms). Again assuming the voltage of the battery to be 120 volts, the drop between point 12 and ground will be 92.7 volts. This drop, it will be noted, is almost three times as great as that existing under normal signaling conditions, which, it will be remembered, was 31.6 volts, and, consequently, owing to the direction in which the break relay BR is poled, the current flow will be sufficient to overcome the pull of the spring, or other biasing means, and shift the armature of the break relay BR to its lower contact. The conditions with respect to the break relay BR' at station B are in all respects similar to those just described at station A and, consequently, a voltage drop of 92.6 volts exists between the point 12' and ground. As the break relay BR' is poled in the direction opposite to that of the relay BR, however, the current flow is in such a direction as to tend to hold its armature against its upper contact, so that no effective result follows from this condition at station B.

When the armature of the break relay BR at station A is shifted to its lower contact, a circuit is completed whereby the transfer relay TR at its upper armature shifts the connection of the line ML from the point 12 to the receiving relay RR. The disconnection of the line ML from the point 12 now produces an actual condition corresponding to the electrical condition previously discussed in connection with Fig. 2^b in which the local circuits at stations A and B are isolated from each

other. This condition, as regards the circuit of the break relay BR, is represented schematically in Fig. 2^c from which it will be apparent that the same current flows through the break relay BR after the transfer relay TR has been actuated as flows through said relay under the break condition previously described, and so long as the armature of the pole changer PC rests upon its lower contact, the break relay BR will hold its armature against its lower contact to maintain the transfer relay TR energized. This condition cannot be disturbed so long as the break key BK' at station B is held open, as negative spacing current is transmitted through the 3,000 ohm resistance 10' at station B over the upper back contact of transfer relay TR', over the line ML, over the upper front contact of transfer relay TR and through the winding of the receiving relay RR thereby shifting the armature of said relay to connect with positive battery, the locking circuit for the receiving relay having been previously opened at the lower contact of the transfer relay TR. When the armature of the receiving relay RR is connected to positive battery, the current flow through the lower winding of the pole changer PC is in such a direction as to tend to hold the armature of the pole changer against its lower contact, so that the operator cannot, by opening the loop, transmit signals or change the polarity of the battery connected to the point 12. Consequently, the conditions established remain as long as the break key BK' is held open.

As soon as the break key BK' is restored, signals may be transmitted from station B to station A. The operator at station A is now able at any time, by operating the break key BK', to actuate the break relay BR' at station B to restore the circuit to the condition in which it was originally described for transmission from station A to station B. The operation of "breaking" from station A will be similar to that already described in connection with station B except in so far as the polarities are reversed and consequently may be understood without further description. The system just described, like that of Fig. 1, adapts itself to the provision of an intermediate receiving station at some intermediate point along the line ML owing to the fact that the marking and spacing currents will flow over the line in the same direction for transmission from either terminal station. Consequently, a simple polar relay IRR may be used to operate an intermediate receiving apparatus of any desired form.

Fig. 3 shows an arrangement similar to that of Fig. 2 with a through repeater station arranged at an intermediate point C. The repeater station C is provided with a

receiving relay RRE for receiving signals from the main line ML and repeating them to the line section ML' over the contact of the transfer relay TRW. A polar break relay BRW is associated with the armature of the receiving relay RRE and the armature of the transfer relay TRW in the same manner as the polar break relay BR in Fig. 2 is associated with the pole changer PC and the transfer relay TR. The break relay BR has associated therewith resistances W_{10} and W_{11} corresponding to resistances 10 and 11 of Fig. 2, and said relay functions in a manner similar to the relay BR to control the transfer relay TRW. A receiving relay RRW is also provided for receiving signals from the line section ML' and transmitting them over the contact of a transfer relay TRE to the line section ML. Polar break relay BRE and associated resistances E_{10} and E_{11} are provided, these elements being similar to corresponding elements of the repeater already mentioned.

The apparatus at station B is slightly different from that at station A, as it is intended for a station so arranged that the terminal apparatus and the printer will both be located at the printer station instead of having the printer at a local station connected with the terminal station by a loop as is the case at station A. The transfer relay TR', receiving relay RR', break relay BR' and resistances 10' and 11' at this station are the same as in Fig. 2. The receiving relay RR' has its armature so arranged, however, that in its marking position it closes the connection to the selecting circuit of a receiving distributor face (not shown). In its spacing position it closes the circuit to the starting magnet 13' of the receiving distributor, so that the first spacing impulse of a group causes the starting magnet to release the receiving distributor in a well-known manner. This circuit also includes the lower winding of a double wound pole changer PC', the upper winding being included in a local circuit with a break key BK' and a transmitting distributor TD' of the printing set.

Further details of the apparatus will be clear from a description of the operation, which is as follows:

As illustrated, the apparatus is in condition for transmitting from station A to station B, and the negative and positive marking and spacing signals transmitted from station A pass over the line ML to the receiving relay RRE. The receiving relay repeats corresponding negative and positive marking and spacing impulses which are transmitted through the resistance W_{10} and over the upper back contact of the transfer relay TRW to the line ML' from which they are transmitted over the upper front contact of the transfer TR' to relay RR'. 120

These impulses do not actuate the break relay BRW at the repeater station C for reasons similar to those discussed in connection with Fig. 2.

5 The first spacing impulse of a group, when the apparatus is employed for operating printers, will cause the receiving relay RR' to close a circuit through the starting magnet 13' to release the receiving distributor. Successive spacing impulses of the group, while they close the circuit of the starting magnet 13', are ineffective as the distributor is already rotating. The succeeding marking impulses, however, close the connection of the selecting circuit controlled by the receiving distributor face to distribute the marking impulses to the proper selecting apparatus in a manner well-known in the art.

20 If it should be desired to transmit from station B to station A, the break key BK' will be opened thereby deenergizing the upper winding of the pole changer PC'. If at this moment a spacing impulse is being received, the lower winding of the pole changer PC' will be energized, but as soon as a marking impulse is received the lower winding is also deenergized and the pole changer releases its armature to connect negative battery through the resistance 10' to the break relay BR'. This reversal in the polarity of current through the break relay causes it to shift its armature to its upper contact thereby releasing the transfer relay TR' and locking the receiving relay RR' in marking position. The transfer relay TR' upon releasing its upper armature connects the line ML' to the armature of the pole changer PC'. As a negative current is being transmitted from the repeater station C to the line ML', negative battery is now connected to both ends of the line thereby causing the break relay BRW to overcome the biasing effect upon its armature and shift the armature to its lower position to complete a circuit for the transfer relay TRW. The transfer relay TRW connects the line ML' to the receiving relay RRW which in turn shifts its armature to negative battery thereby causing the break relay BRE to release its armature. The break relay BRE in turn releases the transfer relay TRE, so that negative battery is connected to both ends of the line ML thereby actuating the break relay BR to shift the connections at station A. Signals may now be transmitted from station B to station A by the interruption of the circuit of the pole changer PC' under the control of the transmitting distributor TD'.

Should it be desired to break in the opposite direction, the break key BK will be actuated. This will connect positive battery over the contact of the pole changer PC to the winding of the break relay BR there-

by causing it to release its armature and release the transfer relay TR. When a marking signal is being transmitted from station B, positive battery will be connected to the line ML over the armature of the receiving relay RRW at station C, so that positive battery is connected to both ends of the line ML, and the break relay BRE is actuated against the tension of its biasing spring to close the circuit of the transfer relay TRE thereby connecting the line ML to the receiving relay RRE. The receiving relay RRE at once connects positive battery through the resistance W_{10} to the break relay BRW thereby shifting the armature of said relay to its upper position to release the transfer relay TRW which connects the line ML' to the armature of the receiving relay RRE. Positive battery is now connected to both ends of the line ML' thereby causing break relay BR' to shift its armature against the pull of the biasing spring and complete a circuit to the transfer relay TR'. This connects the receiving relay RR' to the main line ML', and as long as the break key BK is actuated at station A positive current will be transmitted over the line section ML' thereby shifting the armature of the receiving relay RR' to its spacing contact to complete and maintain a circuit through the lower winding of the pole changer PC' and through the winding of the starting magnet 12'. Thus operation of the receiving relay RR' operates to stop the transmitting distributor in a well-known manner, but until the distributor does stop transmitting, the circuit through the lower winding of the pole changer PC' locks the pole changer with its armature in its lower position thereby holding positive battery upon the circuit through the resistance 10' and preventing successive spacing impulses originated by the transmitting distributor TD' from being effectively transmitted.

The arrangement shown in Fig. 4 is similar to that of Fig. 2 except that in this case the break relays BR and BR' are not marginal as in Fig. 2, but are polar relays having one winding in series with the line and one winding in shunt with the line. When signaling impulses are transmitted from one end of the line, the current flows differentially through the two windings of the break relay at the transmitting end without affecting the armature. When the same polarity of current is connected to both ends of the line, more current flows through the winding in shunt with the line than through the winding in series with the line thereby operating one of the break relays when both ends of the line are positive, and the other break relay when both ends of the line are negative. As shown, the break relay BR is arranged to operate when negative bat-

tery is connected to both ends of the line and the break relay BR' when positive battery is connected to both ends of the line. This form of the invention also involves
 5 transmitting the signals over the line in the same direction regardless of which station is transmitting, so that an intermediate receiving relay IRR may be provided at an intermediate point on the line.

10 Further details of the apparatus will be clear from a description of the operation, which is as follows:

With the apparatus as shown, signals may be transmitted from station A to station B.
 15 The break relay BR at station A has its armature shifted to open the circuit of the transfer relay TR, which is deenergized, thereby connecting the line ML to the armature of the pole changer PC. At station B
 20 the break relay BR' has its armature shifted to close the circuit of the winding of the transfer relay TR' thereby connecting the line ML to the receiving relay RR'. The armature of the break relay BR' is main-
 25 tained in this condition by reason of the fact that positive battery is connected over the armature of the pole changer PC' to the junction point of the two windings of the break relay during the entire time that the
 30 apparatus is in receiving condition. As the circuit of the line winding of the break relay is opened at the contact of the transfer relay TR', this current flows only through the shunt winding of the break relay and is
 35 in such a direction as to hold the armature to the position indicated. Under these conditions the opening and closing of the loop circuit L causes the pole changer PC to transmit negative and positive marking and
 40 spacing currents to the junction point 12, where the current divides, a part flowing through the shunt winding of the break relay BR and a part through the line winding and a resistance in parallel therewith.
 45 The current flowing through the line winding and a resistance in parallel therewith passes over the upper back contact of the transfer relay to the main line ML and thence over the upper front contact of the
 50 transfer relay TR' to the receiving relay RR'. The circuit through the shunt winding of the break relay BR may be made of high resistance, so that very little current passes through this winding, and the greater por-
 55 tion of the transmitted current passes to the line ML. By shunting the line winding of the break relay as indicated, the current passing through the line winding may be just equal to that passing through the shunt
 60 winding, so that the effects upon the two windings are equal and opposing, and hence the armature of the break relay will remain against its upper contact to which it has previously been shifted. If necessary the
 65 relay may be sufficiently biased to insure this

result. The receiving relay RR', in response to the transmitted impulses, will connect positive and negative marking and spacing currents to the loop L' without operating the pole changer PC'. This causes current and
 70 no current conditions to be set up in the loop thereby causing the home recording relay HRR' to operate a sounder or to operate a receiving printer in a manner well known in
 75 the art.

If it is desired to transmit from station B to station A, the break key BK' will be actuated to open the loop L'. This causes the armature of the pole changer PC' to shift
 80 from positive battery to negative battery, so that current now flows through the shunt winding of the break relay BR' in the opposite direction causing the armature to be shifted to its upper contact. This results
 85 in opening the circuit of the transfer relay TR' and in closing the locking circuit for the receiving relay RR', so that the armature of the receiving relay will be locked to its marking contact. The transfer relay TR' at its
 90 upper back contact connects the line ML through the line winding of the break relay BR' to the armature of the pole changer PC'. Negative battery is now connected to the point 12' at station B, and when a mark-
 95 ing signal is transmitted from station A negative battery is connected to the point 12 at station A. Consequently, both points 12 and 12' will be at substantially the same potential, so that no current flows over the
 100 line, and, consequently, no current flows in the line windings of BR and BR'. Negative current flows through the shunt winding of the break relay BR' however, to hold its armature against its upper contact, and like-
 105 wise negative current flows through the shunt winding of the break relay BR causing it to shift its armature to its lower contact thereby completing a circuit for the transfer relay TR. This results in con-
 110 necting the main line ML to the receiving relay RR. As soon as this occurs a flow of current is set up through both windings of the break relay BR', but the effect is equal and opposing upon the two windings, so that
 115 the armature of said relay remains shifted to its upper position. The line winding of the break relay BR, however, is open-circuited, and a negative current flowing over the armature of the pole changer PC passes
 120 through the shunt winding to hold the armature to its shifted position. As soon as the transfer relay TR is energized, the receiving relay RR will receive current from station B as long as the break key BK' is held open.
 125 This shifts the armature of the receiving relay RR to its positive contact, so that current flows through the lower winding of the pole changer PC in such a direction as to hold the armature of the pole changer
 130 against its negative contact regardless of

whether the loop L is open or closed. The transmission of signals from the loop L is therefore ineffective so long as the break key BK' is held open. In the case of a printing telegraph apparatus, owing to the fact that the loop L is short-circuited under these conditions and the home recording relay HRR deenergized at the end of a cycle of the transmitting distributor, apparatus will be actuated to stop the transmitting distributor in a well-known manner, so that signals will be no longer transmitted. Accordingly, the break key BK' may be restored at station B and signals transmitted from station B to station A. The operation of "breaking" in the opposite direction will be obvious without further description.

It will be clear that the general principles herein disclosed may be embodied in many 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 line circuit, terminal stations at each end of said line circuit, each terminal station having transmitting apparatus and receiving apparatus thereat, switching devices at each station for connecting the transmitting apparatus to the line at one station and the receiving apparatus to the line at the second station, so that signaling currents may be transmitted over the line in one direction, said switching devices also functioning to connect the transmitting apparatus to the line at the second station, and the receiving apparatus to the line at the first station to transmit signaling currents over the line in the opposite direction and polar relays at each station for controlling said switching devices, said polar relays being unresponsive to normal signaling currents but being responsive to abnormal signaling conditions produced by the transmitting apparatus.

2. In a signaling system, a line circuit, terminal stations at each end of said line circuit, each terminal station having transmitting apparatus and receiving apparatus thereat, switching devices at each station for connecting a transmitting apparatus to the line at one station and a receiving apparatus to the line at the second station, so that signaling currents may be transmitted over the line in one direction, said switching devices also functioning to connect the transmitting apparatus to the line at the second station and the receiving apparatus to the line at the first station to transmit signaling currents over the line in the opposite direction, polar relays at each station for controlling said switching devices, said polar relays being unresponsive to normal signaling currents but being responsive to abnormal signaling conditions produced by

the transmitting apparatus and means to operate said polar relays at will from either station.

3. In a signaling system, a line circuit, terminal stations at each end of said line circuit, each terminal station having transmitting apparatus and receiving apparatus thereat, switching devices at each station for connecting the transmitting apparatus to the line at one station and the receiving apparatus to the line at the second station, so that signaling currents may be transmitted over the line in one direction, said switching devices also functioning to connect the transmitting apparatus to the line at the second station and the receiving apparatus to the line at the first station to transmit signaling currents over the line in the opposite direction, and polar relays at each station for controlling said switching devices, said polar relays being unresponsive to currents transmitted under ordinary signaling conditions, but being responsive to augmented currents produced by the transmitting apparatus under special conditions.

4. In a signaling system, a line circuit, terminal stations at each end of said line circuit, each terminal station having transmitting apparatus and receiving apparatus thereat, switching devices at each station for connecting the transmitting apparatus to the line at one station and the receiving apparatus to the line at the second station, so that signaling currents may be transmitted over the line in one direction, said switching devices also functioning to connect the transmitting apparatus to the line at the second station and the receiving apparatus to the line at the first station to transmit signaling currents over the line in the opposite direction, polar relays at each station for controlling said switching devices, said polar relays being unresponsive to currents transmitted under ordinary signaling conditions but being responsive to augmented currents transmitted under special conditions, and means controllable at will from either station for transmitting augmented currents to operate said polar relays.

5. In a signaling system, a line circuit, terminal stations at each end of said line circuit, each terminal station having transmitting apparatus and receiving apparatus thereat, switching devices at each station for connecting the transmitting apparatus to the line at one station and the receiving apparatus to the line at the second station, so that signaling currents may be transmitted over the line in one direction, said switching devices also functioning to connect the transmitting apparatus to the line at the second station and the receiving apparatus to the line at the first station to transmit

signaling currents over the line in the opposite direction, and polar relays at each station for controlling said switching devices, said polar relays being biased toward their normal position by a force at least equal to that created by a normal signaling current to prevent actuation thereof by normal signaling currents.

6. In a signaling system, a line circuit, terminal stations at each end of said line circuit, each terminal station having transmitting apparatus and receiving apparatus thereat, switching devices at each station for connecting the transmitting apparatus to the line at one station and the receiving apparatus to the line at the second station, so that signaling currents may be transmitted over the line in one direction, said switching devices also functioning to connect the transmitting apparatus to the line at the second station and the receiving apparatus to the line at the first station to transmit signaling currents over the line in the opposite direction, polar relays at each station for controlling said switching devices, said polar relays being biased toward their normal position by a force at least equal to that created by a normal signaling current to prevent actuation thereof by normal signaling currents, and means controllable at either terminal station for transmitting currents to overcome the biasing effect of said relays.

7. In a signaling system, a line circuit, terminal stations at each end of said line circuit, each terminal station having transmitting apparatus and receiving apparatus thereat, switching devices at each station for connecting the transmitting apparatus to the line at one station and the receiving apparatus to the line at the second station, so that signaling currents may be transmitted over the line in one direction, said switching devices also functioning to connect the transmitting apparatus to the line at the first station to transmit signaling currents over the line in the opposite direction, and polar relays at each station for controlling said switching devices, said polar relays being biased to a normal position by a force at least equal to that produced by normal signaling currents, said biasing effect being produced by an auxiliary winding of the polar relay whereby said relays are rendered unresponsive to normal signaling currents.

8. In a signaling system, a line circuit, terminal stations at each end of said line circuit, each terminal station having transmitting apparatus and receiving apparatus thereat, switching devices at each station for connecting the transmitting apparatus to the line at one station and the receiving apparatus to the line at the second station, so that signaling currents may be transmitted over the line in one direction, said switching de-

vices also functioning to connect the transmitting apparatus to the line at the second station and the receiving apparatus to the line at the first station to transmit signaling currents over the line in the opposite direction, polar relays at each station for controlling said switching devices, said polar relays being biased to a normal position by a force at least equal to that produced by normal signaling currents, said biasing effect being produced by an auxiliary winding of the polar relay whereby said relays are rendered unresponsive to normal signaling currents, and means controllable at will from either sub-station for transmitting augmented currents to said relays to overcome the biasing forces and actuate the same.

9. In a signaling system, a line circuit, terminal stations at each end of said line circuit, each terminal station having transmitting and receiving apparatus thereat, switching devices at each station for connecting the transmitting apparatus to the line at one station and the receiving apparatus to the line at the second station, means for maintaining said connections during times that no signals are being transmitted in either direction, said transmitting apparatus being arranged to transmit marking currents over the line in a given direction to actuate the receiving apparatus at the other station, said switching devices also functioning to connect the transmitting apparatus to the line at the second station and the receiving apparatus to the line at the first station in response to the actuation of the transmitting apparatus at said second station, said transmitting apparatus at the second station functioning to transmit marking currents over the line in the same direction as the marking currents transmitted by said first mentioned transmitting apparatus to actuate the receiving apparatus associated with the line at the first station.

10. In a signaling system, a line circuit, terminal stations at each end of said line circuit, each terminal station having transmitting and receiving apparatus thereat, switching devices at each station for connecting the transmitting apparatus to the line at one station and the receiving apparatus to the line at the second station, means for maintaining said connections during times that no signals are being transmitted in either direction, said transmitting apparatus being arranged to transmit marking currents over the line in a given direction to actuate the receiving apparatus at the other station, said switching devices also functioning to connect the transmitting apparatus to the line at the second station and the receiving apparatus to the line at the first station in response to the actuation of the transmitting apparatus at said second station, said transmitting apparatus at the second station

functioning to transmit marking currents over the line in the same direction as the marking currents transmitted by said first mentioned transmitting apparatus to actuate the receiving apparatus associated with the line at the first station, and a receiving relay at an intermediate point of the line responsive to marking currents transmitted from either station.

11. In a signaling system, a line circuit, terminal stations at each end of said line circuit, each terminal station having transmitting apparatus and receiving apparatus thereat, switching apparatus for connecting the transmitting apparatus to the line at one station and the receiving apparatus to the line at the other station for transmitting signals in one direction, and means whereby said switching apparatus will respond to a cessation of current upon the line circuit to reverse the connections for transmission in the opposite direction.

12. In a signaling system, a line circuit,

terminal stations at each end of said line circuit, each terminal station having transmitting apparatus and receiving apparatus thereat, switching devices at each station for connecting the transmitting apparatus to the line at one station and the receiving apparatus to the line at the second station, so that signaling currents may be transmitted over the line in one direction, said switching devices also functioning to connect the transmitting apparatus to the line at the second station and the receiving apparatus to the line at the first station to transmit signals in the opposite direction, said switching devices being non-responsive to normal signaling currents but responsive to a diminishing of the current on the line to perform their switching function.

In testimony whereof, I have signed my name to this specification this 19th day of November 1921.

EDWARD F. WATSON.