Oct. 2, 1923. 1,469,254

R. W. DEARDORFF

CARRIER TELEGRAPH CIRCUITS

Filed Oct. 21, 1920 4 Sheets-Sheet 1

Fig. 1

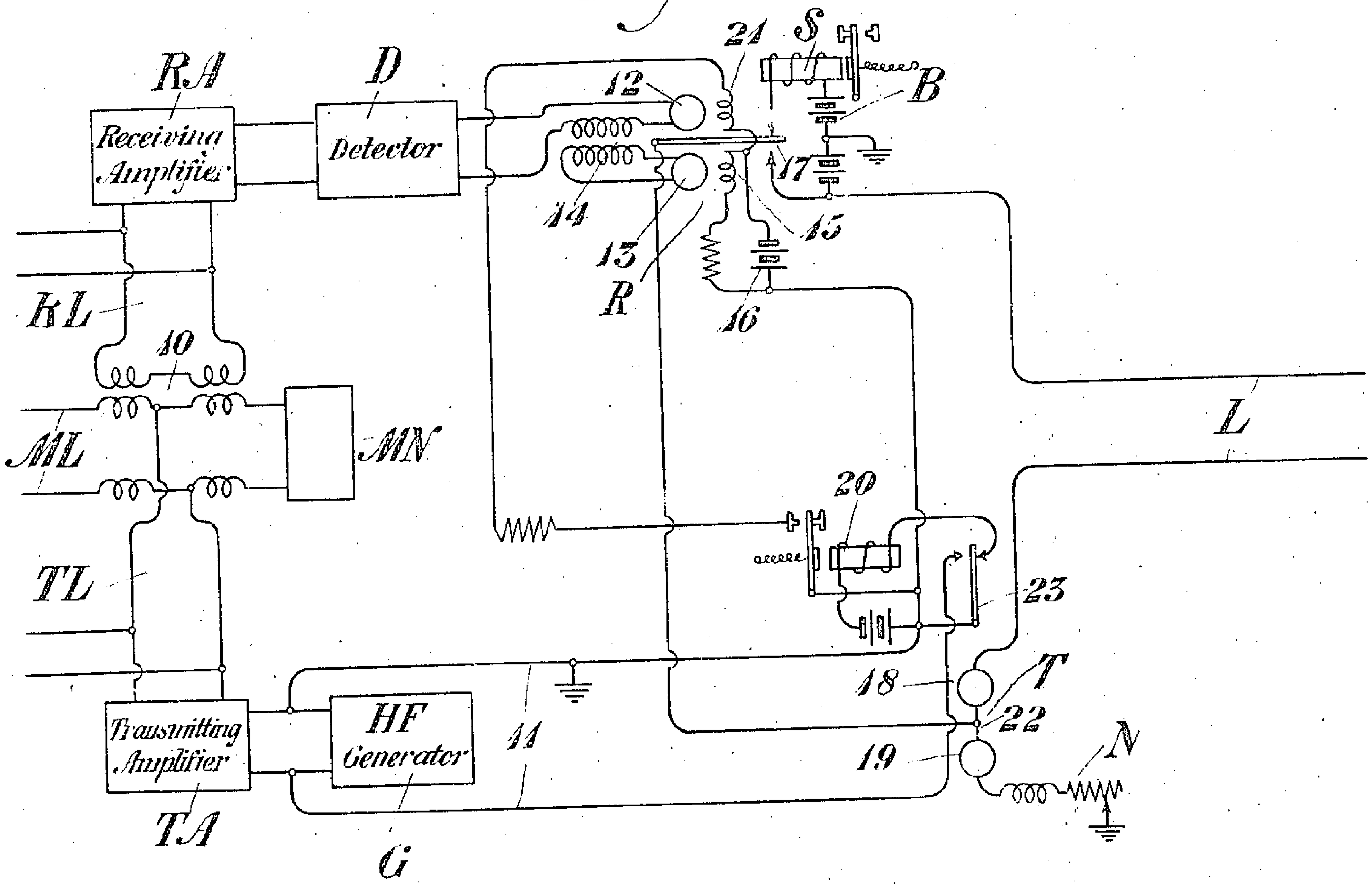

Fig. 2

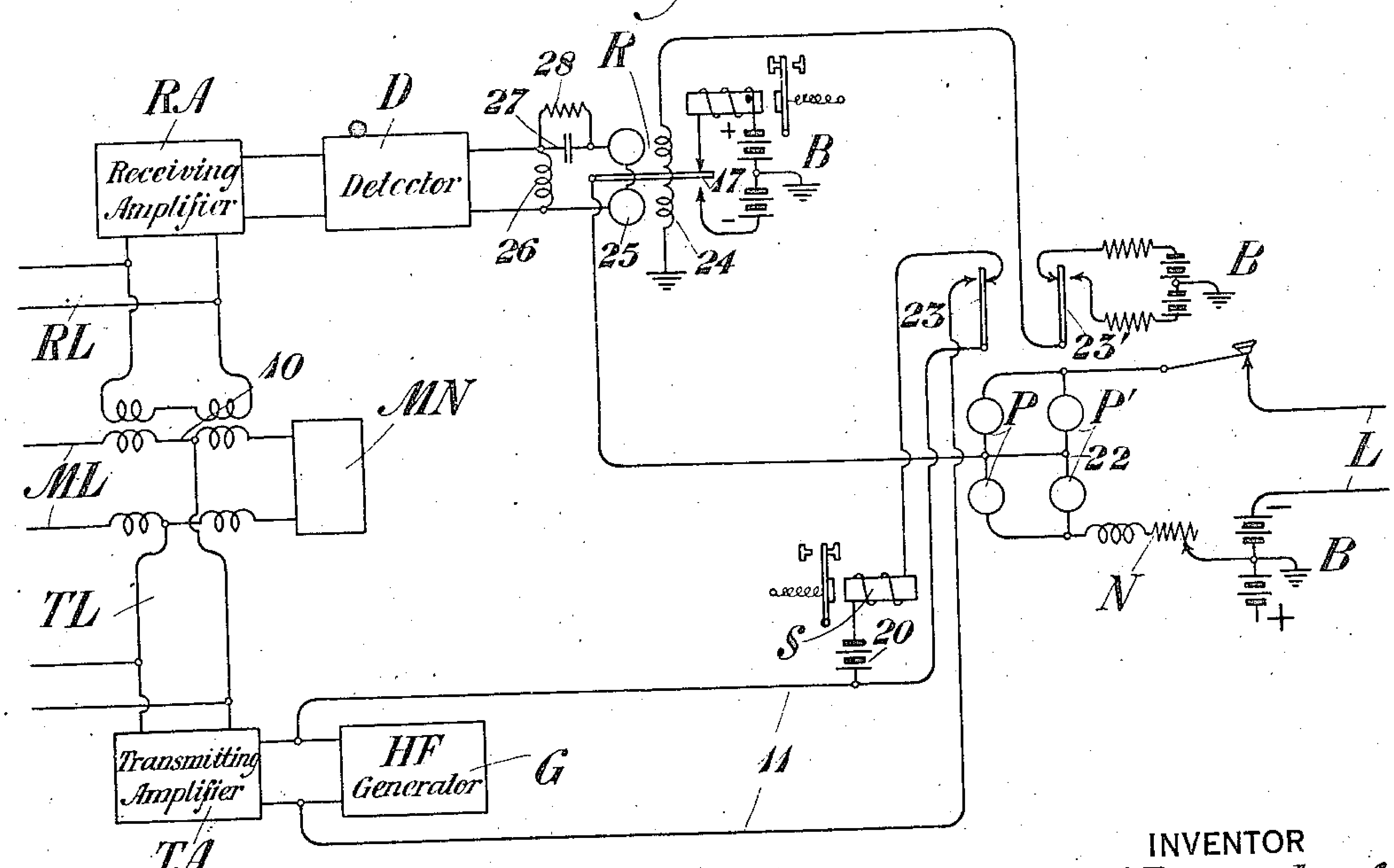

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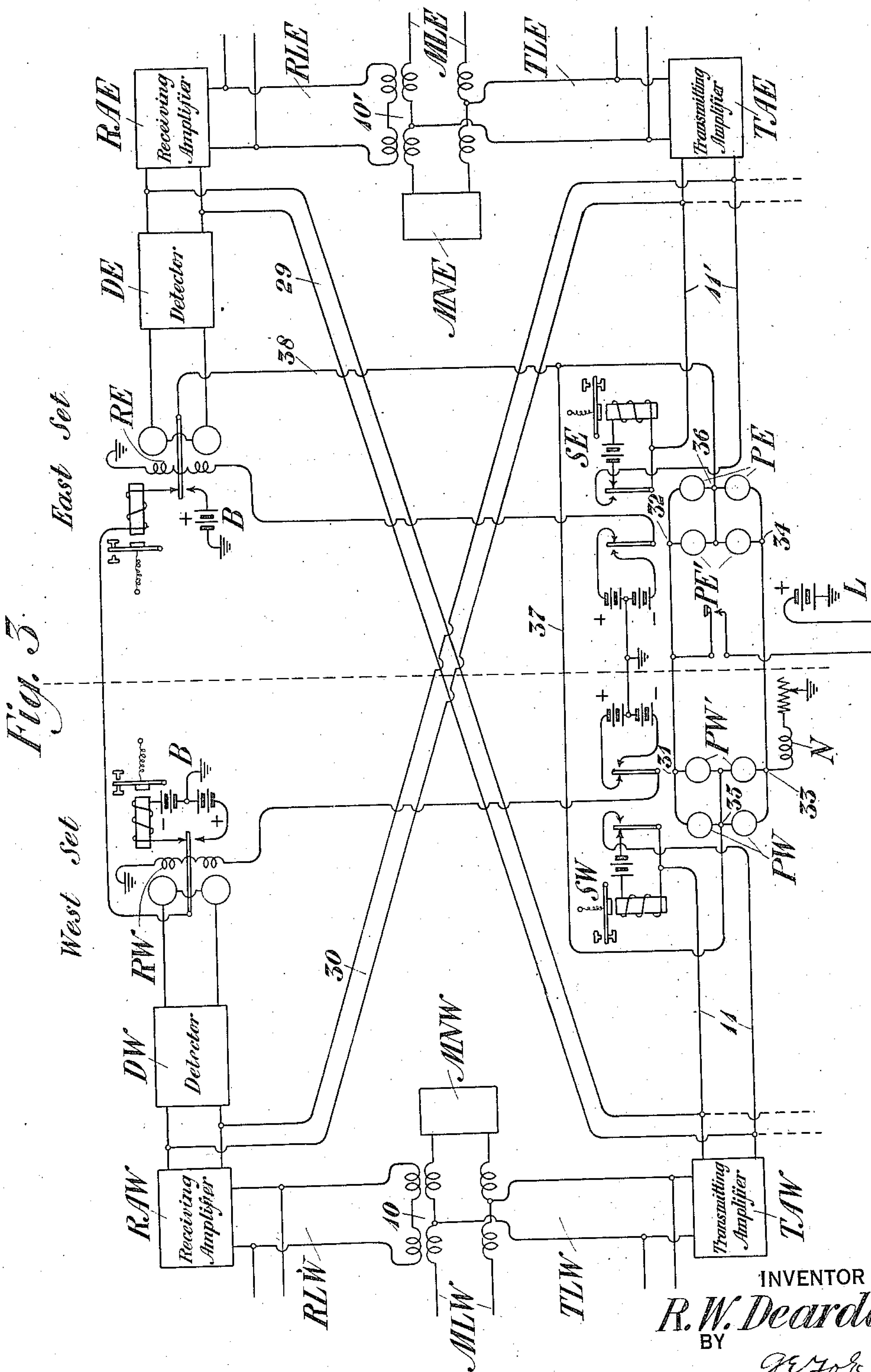
Fig. 3



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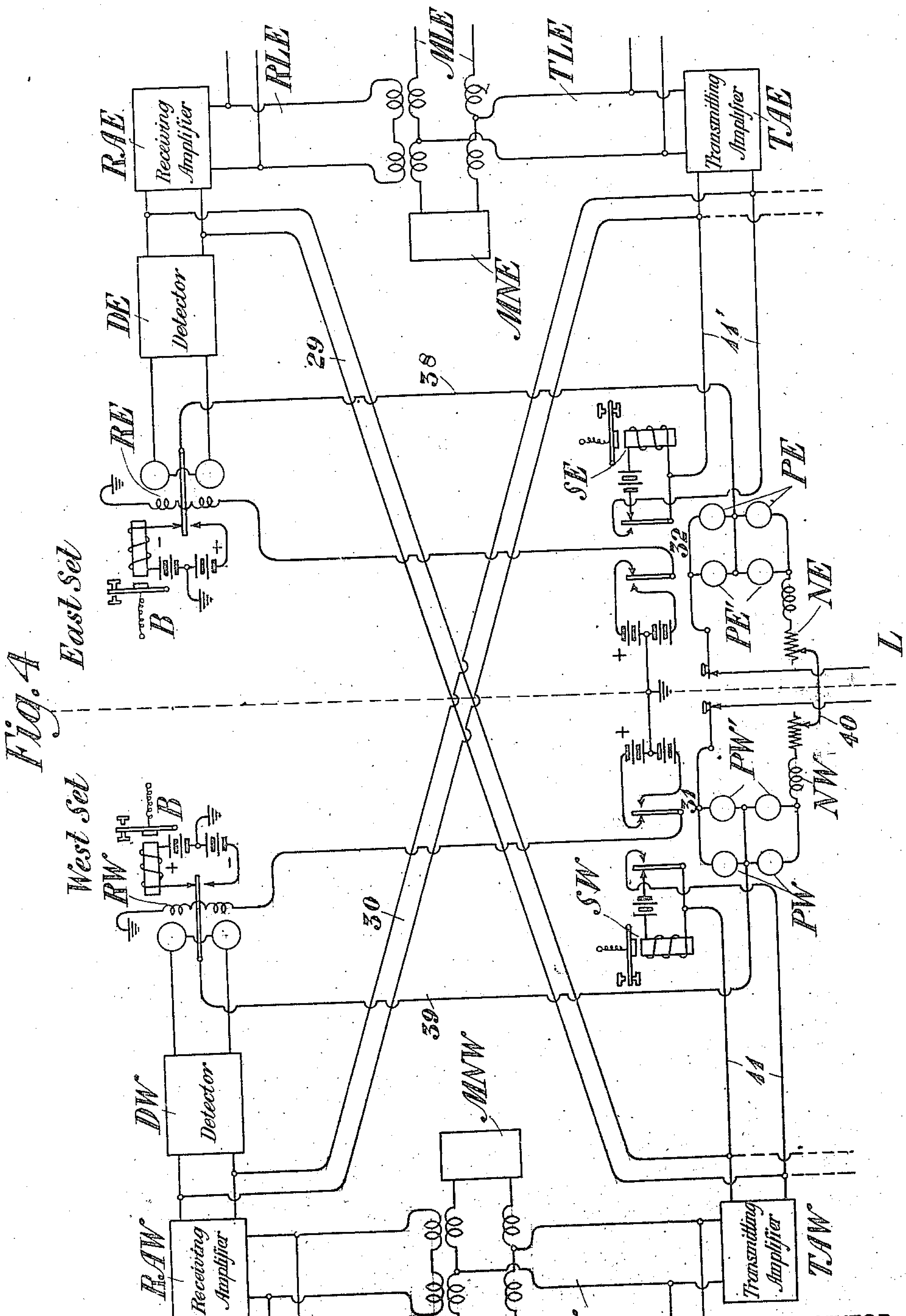

Fig. 4

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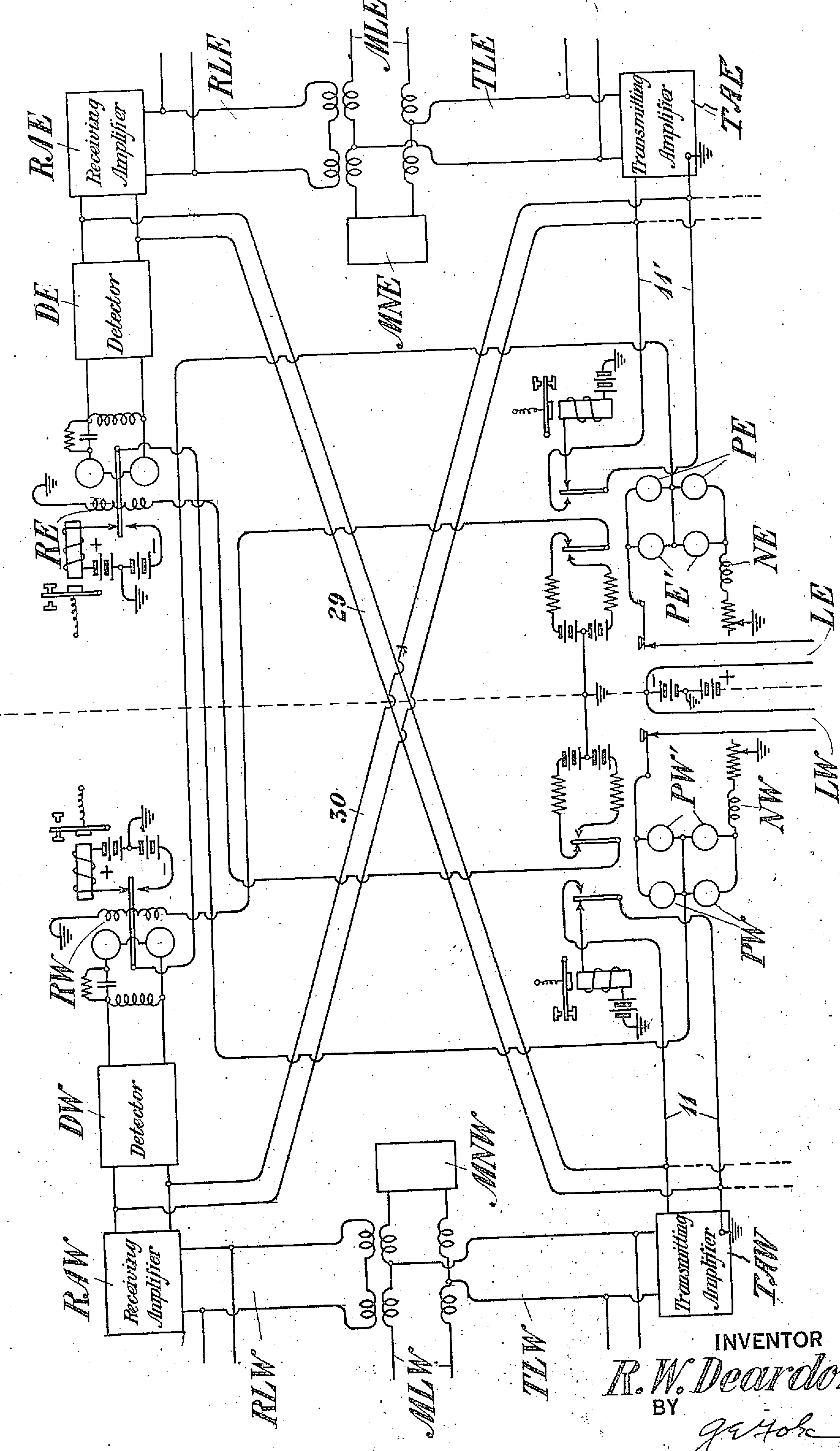
Fig. 5



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Patented Oct. 2, 1923. 1,469,254

UNITED STATES PATENT OFFICE.

RALPH WARNER DEARDORFF, OF BROOKLYN, NEW YORK, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

CARRIER TELEGRAPH CIRCUITS.

Application filed October 21, 1920. Serial No. 418,479.

To all whom it may concern:

Be it known that I, RALPH W. DEARDORFF, residing at Brooklyn, in the county of Kings 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 signaling systems in which telegraphic signals are transmitted by means of carrier currents.

One of the objects of the invention has reference to the provision of means for associating a local telegraph circuit or loop with the channels of a carrier telegraph system.

Another object of the invention has reference to the provision of means for associating an ordinary telegraph circuit or loop with the channels of a repeater arrangement for a carrier telegraph system.

Another object of the invention has reference to the prevention, in a system of the character above described, of the response of the receiving relay of a carrier channel when signals are being transmitted from the local circuit or loop to the transmitting carrier channel, an auxiliary winding of the relay being preferably employed for this purpose.

Another object of the invention has reference to the provision of two polar relays associated with the subscriber's loop for transmitting purposes, one of the polar relays controlling the carrier transmitting channel, the other relay serving to render the receiving relay inoperative when signals are being transmitted.

Another object of the invention is to provide a transmitting and receiving circuit in connection with the channels of a carrier system in which the low frequency loop circuit is provided with a balanced polar relay at each end, with such an organization of sources of current that the polar relays may be operated by changing the current flow in the loop circuit, which result may be accomplished either by opening and closing the loop circuit or by changing the polarity of the battery connections.

Another object of the invention is to provide an arrangement for associating a local telegraph circuit or loop with the channels of a carrier system in which the contacts of the receiving relays and windings of the transmitting relays are included directly in series with the loop.

Other and further objects of the invention will be clear from the following description when read in connection with the accompanying drawings, Figures 1 and 2 of which constitute circuit diagrams illustrating two methods of associating a loop circuit with the channels of a carrier system in such a manner as to operate upon a half duplex-basis, and Figs. 3, 4 and 5 of which constitute circuit diagrams illustrating three different methods of associating loop circuits with the channels of a repeater for a carrier telegraph system.

Referring to Fig. 1, ML designates the main transmission line over which telegraph signals may be transmitted by means of carrier currents. A transmitting channel TL and a receiving channel RL are associated with the main line ML. In order to render these two channels substantially conjugate the channel RL is associated with the line ML through a balanced transformer arrangement 10 of well known construction, and an artificial line or network MN is provided for balancing the main line. The transmitting channel TL is provided with an amplifying arrangement TA of any well known construction such as, for instance, a vacuum tube amplifier adapted to amplify carrier frequencies. A source of carrier current G is also associated with the transmitting channel. This source may be any known means for supplying alternating current of the desired frequency, as, for example, a vacuum tube oscillator. Signals may be transmitted by interrupting the carrier frequency through a short circuit connection 11.

The receiving channel includes an amplifying apparatus RA similar to the amplifying apparatus TA in the transmitting channel and a detecting arrangement D. The detecting arrangement may be of any known character such as, for instance, a vacuum tube detector, having one winding 12 of a polar receiving relay R in its output circuit and another winding 13 of said relay inductively connected with the output circuit through the transformer 14. The polar relay R may be used for receiving in an arrangement such as that described by adjusting the potential of the grid of the detector in a well known manner so that when carrier oscillations are not impressed upon the grid no current flows in the output circuit through the winding 12 of the relay. For each train of carrier oscillations however, a pulse of direct current flows through the winding 12. An auxiliary winding 15 energized by a direct current source 16 is provided for biasing the armature of the polar relay in a direction opposite to the pull due to the pulse of current flowing through the winding 12. The current through the winding 15 is adjusted so that the pull due to the winding 15 is but half as great as that due to the signal pulse flowing through the winding 12. The net effect of the windings 12 and 15 is that normally with no carrier transmitted the armature 17 is held against its lower contact but when a train of carrier oscillations is received the pulse through the winding 12 produces an effect in the opposite direction which when superimposed upon the pull due to the winding 15 gives a net pull in the opposite direction equal to that normally applied by the winding 15. This permits of a strictly polar relay action under the control of direct currents. The winding 13 inductively associated with the output circuit of the detector produces a kick at the beginning of each signal pulse to assist in shifting the armature to its marking position and another kick at the end of each signal pulse to assist in shifting the armature to its spacing position.

L designates an ordinary telegraph circuit or subscriber's loop which is arranged to serially include one winding 18 of a polar transmitting relay T, and the contacts of the receiving relay R. A second winding 19 of the polar relay T is included in a balancing circuit N for the loop L. The loop L may include the usual transmitting key and receiving sounder at the subscriber's station. A divided battery B is serially included in the loop circuit in such a manner that the two halves of the battery are series aiding with respect to the winding 18, but with the armature 17 of the receiving relay on its upper contact, only current due to the upper half of the battery flows through the winding 19, and with the armature 17 on its lower contact only current due to the lower half of the battery flows through winding 19. The winding 18 is therefore the effective winding of the transmitting relay with the loop closed so that a circuit is completed for the sounder relay 20. If the loop be interrupted or if the receiving relay R be operated to shift its contact to its lower position, no current will flow through the upper winding 18 for in the former case the circuit is open and in the latter case mutually opposing potentials are applied to the terminals of the winding 18. The lower winding 19 therefore becomes effective to shift the armature of the transmitting relay so as to close the short circuit connection 11 and open the circuit of the sounder 20. The sounder 20 controls the circuit of an auxiliary winding 21 with a receiving relay R and connects battery 16 in circuit with said winding, therefore producing a pull in a direction opposite that due to the winding 15 and of enough greater magnitude to overcome the pull due to the combined action of windings 15 and 13.

The operation is as follows:

In the normal condition of the circuit, when signals are not being transmitted, the carrier frequency generated by the generator G is transmitted continuously over the main line ML to the distant station. Similarly, if the distant station is not signaling, the carrier frequency assigned to the receiving channel illustrated is transmitted from the distant station over the main line into the receiving channel RL. The frequency thus continuously transmitted operates through the detector D to produce a steady flow of direct current through the winding 12, producing a pull upon the armature 17, tending to hold it against its upper contact with a force twice as great as that of the direct current flowing through the winding 15 which tends to pull it to its lower contact. With the armature 17 against its upper contact, current flows from the grounded point of the divided battery B, through the upper half of said battery, through the sounder S, over the upper contact of the relay R to point 22, where the circuit divides, and one path continues through the winding 19 of the polar relay T and through the balancing network N to ground, while the other path passes through the winding 18 and over the subscriber's loop L through the lower half of battery B to ground. Since current from the upper half of battery B flows through the winding 19 and current from both halves of the battery flows through the winding 18, the upper winding 18 of the transmitting relay T is effective to hold the armature 23 of the transmitting relay against its upper contact, maintaining the sounder 20 energized.

If now the subscriber in transmitting a signal, opens the loop circuit L by means of a key (not illustrated) no current flows through the winding 18 while the current flowing through the winding 19 over the path already described causes the transmitting relay to shift its armature 23, opening the circuit of the sounder 20 and short-circuiting the generator G through the conductors 11. The release of the sounder 20 closes the circuit from battery B through the winding 21 of the polar receiving relay R and causes current to flow through said winding to produce a pull upon the armature 17 in such a direction as to hold the armature against its upper contact, notwithstanding the pull due to the winding 15. Consequently, should the current flow through the winding 12 be interrupted due to a received signal, the armature 17 would not respond to the received signal and the sounder in the loop would not be affected. The short-circuiting of the generator G by the contact 11, as already described, results in the interruption of the transmission of the carrier frequency from the generator G through the amplifier TA to the main line ML, the carrier frequency being diverted through the shunt path. The receiving apparatus at the distant station will respond to the interruption of the carrier frequency and record the signal.

Should the carrier frequency transmitted from the main line ML to the receiving channel RL be interrupted at the distant station in transmitting a signal, the direct current flowing through the winding 12 would cease to flow; owing to the fact that the vacuum tube detector D is so adjusted that current flows in its plate circuit only when the carrier frequency is applied to the grid. Owing to the interruption of the current flowing through the winding 12, the winding 15 becomes effective to pull the armature from the upper contact of the relay R to the lower contact thereof. The armature is given additional impetus in this direction by the momentary current induced through the transformer 14 in the winding 13. As soon as the armature is shifted, current flows from the grounded midpoint of battery B, through the lower half of said battery, over the lower contact of the receiving relay R and through winding 19 of the transmitting relay T and the balancing net-work N to ground. No current flows through the upper winding 18 of the transmitting relay as the loop is short-circuited over the lower contact of the receiving relay. The current flowing through the winding 19 of the transmitting relay T is in the direction opposite to that which normally flows therethrough and consequently, the lower winding is so energized as to hold the armature 23 against its upper contact. Consequently, the received signal can not be transmitted back through the transmitting channel to the main line ML. The short-circuiting of the loop L causes the sounders therein to be deenergized with each interruption of the received carrier frequency so that the sounders record the transmitted signals.

If, while signals are being received in the loop L, it is desired to transmit a "break" signal to the distant sending operator, in order that signals may be transmitted in the reverse direction, the transmitting key in the loop L will be held open, thereby causing the transmitting relay T to shift its armature 23 to its lower contact. The short-circuiting of the generator G interrupts the transmission of the carrier frequency to the distant station while the deenergization of the sounder 20 by closing the circuit of the winding 21 of the receiving relay R holds the armature 17 of the receiving relay against its upper contact, thereby preventing the receiving relay from responding to the received signals during the continuance of the "break" signals.

The effect of the "break" signals at the distant sending station may be understood from a consideration of the effect produced by transmitting a "break" signal from the distant station to the station illustrated, when the operator at the latter station is sending. The interruption of the carrier frequency received by the channel RL, due to the "break" signal, causes the detector D to interrupt the current flow through the winding 12 of the receiving relay R. If at that moment, the loop L is opened to transmit a space signal, the armature 23 of the transmitting relay T will have opened the circuit of the sounder 20 so that the winding 21 of the receiving relay will be energized to hold the armature 17 in its upper position. As soon as the loop is again closed, however, to transmit a dot or a dash, the circuit of sounder 20 will be again closed by the armature 23 of the transmitting relay, and the current flow through the winding 21 will be interrupted. As current flows neither through the winding 12 nor the winding 21, the winding 15 is effective to pull the armature 17 of the receiving relay to its lower contact, at which position it will remain during the continuance of the "break" signal. As the loop is now short-circuited, the operator, who is attempting to transmit over the loop L will recognize that a "break" signal has been sent from the distant station by reason of the fact that the sounder (not illustrated), in the loop, does not follow the transmitting key.

A slightly modified arrangement is shown in Fig. 2. The circuit in this figure differs from that illustrated in Fig. 1, mainly in the details of the transmitting and receiving relays. In this instance, the transmitting relay arrangement comprises two polar relays P and P′, each having windings in the circuit of the loop L and in the balancing circuit N. The windings of the two polar relays are each connected in parallel to the junction point 22. The armature 23 of the polar relay P controls the circuit of the sounder 20 and short-circuits the connection 11 of the generator G, while the armature 23′ of the polar relay P′ controls the auxiliary winding 24 of the receiving relay R, to prevent response of the receiving relay to received signals while signals are being transmitted from the loop L. Separate polar relays are used as illustrated for the reason that commercial polar relays are usually only provided with one armature and two polar relays therefore become necessary to perform all of the functions demanded. The battery connections over the armature 17 of the receiving relay R to the windings of the polar relays P and P′ of the loop L, are similar to those illustrated in Fig. 1, so that the armatures 23 and 23′ are normally held in their upper position due to the fact that the current flow through the upper windings of the polar relays is greater than that through the lower windings.

The receiving relay R comprises a main winding 25 and an auxiliary winding 24, the main winding 25 being included in the output circuit of the vacuum tube detector D. An inductance 26 is bridged across the output circuit to form a by-path for the direct current component of the detected signal pulses, while the condenser 27 permits the alternating current component to pass through the main winding 25 of the relay R while excluding the direct current component. If it is desired that a certain portion of the direct current component be permitted to pass through the winding 25, the condenser 27 may be shunted by the resistance 28. The armature 23′ of the polar transmitting relay P′ which controls the energization of the winding 24 of the receiving relay R, permits current to flow from the upper half of battery B, through the winding 24 when said armature is in its upper position. Current therefore flows through said winding of such strength and in such direction as to produce a pull tending to draw the armature 17 to its lower contact. The pull due to the direct current passing through the resistance 28 to the winding 25, however, is twice as great in the opposite direction as long as the carrier frequency transmitted to the receiving channel RL is being received. The winding 24 is only effective to shift the armature 17 to its lower position when the received carrier frequency is interrupted in the transmission of signals. The alternating component of the received signals causes kicks at the beginning and end of each signal impressed in such direction through the winding 25 as to shift the armature 17 from one position to the other. When the armature 23′ of the polar relay P′ is in its lower position, current flows from the lower half of the battery B through winding 24 of the receiving relay R in the opposite direction so as to hold the armature 17 against its upper contact regardless of the received impulses through the winding 25.

The operation is as follows: In transmitting, the operation of the key, by opening the loop, causes current flow only through the lower windings of the polar relays P and P′ so that the armatures 23 and 23′ are shifted to their alternate position, the former short-circuiting the generator G and opening the circuit of the sounder S as in Fig. 1. The armature 23′ on shifting to its alternate contact, interrupts the supply of biasing current to the winding 24 of the receiving relay R and causes current to flow through said winding in the other direction from the other half of battery B, thereby holding the armature 17 in its upper position to prevent the relay from responding to received signals.

The operation of receiving is similar to that described in connection with Fig. 1. The interruption of the receiving carrier frequency causes the cessation of the current flow through the winding 25, and the armature 17 is shifted to its alternate contact by the current flowing from the upper half of battery B through the winding 24. The shifting of the armature 17 to its alternate contact connects mutually opposed sources to the ends of the loop L so that no current flows in the loop and the sounders in the loop respond to the interruption of the carrier frequency. While no current flows through the upper windings of the polar relays P and P′, the current through the lower windings is in the direction opposite to their normal flow, so that the lower windings open and hold the windings 23 and 23′ against their contacts, thereby preventing received signals from being transmitted back to the main line.

In transmitting a "break" signal, the opening of the loop operates the polar relays P and P′ as before to interrupt the carrier frequency by short-circuiting the generator G, and to change the direction of the flow of current through the winding 24, thereby preventing the relay R from responding to received signals. If, on the other hand, the station illustrated is sending and a "break" signal should be received, the interruption of the carrier frequency in the receiving channel RL would result in the cessation of the current flow through the winding 25 of the polar receiving relay so that the armature 17 would be shifted to its alternate contact by the winding 24, and due to the mutually opposed sources at the ends of the loop, no current would flow in the loop during the continuance of the "break" signal. The sending operator would recognize the "break" signal by observing that the local sounder no longer followed the operation of the transmitting key.

Fig. 3 illustrates an arrangement for associating the subscriber's loop with the channels of a carrier telegraph repeater in such manner that the transmission of signals to and from the loop will be upon a half-duplex basis. Referring to Fig. 3, MLE and MLW designate transmission line sections over which carrier currents may be transmitted. A repeater interconnects said sections, said apparatus comprising receiving channels RLE and RLW associated with the line sections, and transmitting channels TLE and TLW, likewise associated with the line sections. Balanced transformers 10 and 10′ and artificial lines or networks NME and NMW are provided as indicated for the purpose of rendering each transmitting channel and the corresponding receiving channels substantially conjugate. The receiving channels include amplifying arrangements RAE and RAW respectively, these arrangements being similar to those described in connection with Fig. 1. Similarly, the transmitting channels include amplifying arrangements TAE and TAW of like construction.

In order to provide a direct path for the amplification of carrier currents from east to west, the output circuit of the amplifier RAE is connected through conductors 29 to the input circuit of the amplifier TAW. In a similar manner, a path for amplification from west to east is provided by connecting the output circuit of the amplifier RAW with the input circuit of the amplifier TAE through conductors 30. In order that carrier signals transmitted through the repeater from one line section to the other may be received in the local loop L, detectors DE and DW are associated with the receiving channels RLE and RLW respectively, polar relay arrangements RE and RW, similar to the polar relay R of Fig. 2. being included in the output circuits of the detector, and controlling the loop circuit by their contacts. In order to transmit signals from the loop to the line sections through the repeater apparatus, pairs of polar transmitting relays PE—PE′ and PW—PW′ respectively, are provided, these polar relays being similar in construction to the relays P and P′ of Fig. 2. The loop L is connected from one pole of the divided battery B to the terminals 31 and 32 of the transmitting polar relay arrangements so that the windings of the two sets of polar relays for transmitting in opposite directions will be connected in parallel with respect to the loop, and a common balancing network N is likewise connected to the terminals 33 and 34 of the two sets of polar relays so that the two sets will be in parallel with respect to the balancing circuit. Likewise the junction points 35 and 36 of the polar relay sets are joined together through a contact 37 to a common conductor 38, extending over the normal contacts on the receiving relays RE and RW to the pole of the divided battery B, opposite to that connected to the other end of the loop. It will be noted that the normal contacts of the receiving relays are connected in series in the circuit of the loop so that signals received through either line section will be repeated to the loop while the transmitting relay sets are connected in parallel with respect to the loop, so that signals from the loop will actuate both relay sets to repeat the loop signals to both main line sections.

In order to transmit the signals from the loop to the line sections, the short-circuit connections 11 and 11′ are controlled by the armatures of the polar relays PW and PE so that when the short-circuit connections are closed, the carrier frequencies which are normally transmitted in both directions over the circuits 29 and 30, are prevented from transmission to the amplifiers TAE and TAW, thereby interrupting the carrier frequency transmitted from each line section to the other. The contacts of the relays PE′ and PW′ control the auxiliary windings of the receiving relays RE and RW in a mannner similar to that described in connection with Fig. 2.

The operation is as follows: Normally, in the absence of signals, continous transmission form east to west takes place over the amplifying path through the receiving channel RLE, amplifier RAE, conductors 29, amplifier TAW and transmitting channel TLW. Likewise transmission in the opposite direction flows into the receiving channel RLW, through the amplifier RAW, over conductors 30, through the amplifier TAE and over the transmitting channel TLE to the line section MLE. These paths are high frequency amplification paths, whereby the carrier frequencies are amplified in their carrier state without detection, and the signals will be transmitted from one line section to the other by the interruption of the carrier frequencies. Where the repeater is operating on a half-duplex basis, signals will be transmitted in only one direction at a time. Consequently, interruptions in the carrier frequency will occur in only one of the amplification paths, the transmission of the carrier freqency through the other path being constant.

Signals may be transmitted from the loop L to both line sections MLE and MLW simultaneously by interrupting the loop by means of a key, so that no current flows through the upper windings of the two sets of polar transmitting relays. The lower windings are therefore energized, shifting the armatures to their lower contacts and closing the short-circuiting connections 11 and 11′, whereby the transmission of carrier frequencies through the oppositely directed amplifying paths is interrupted, the sounders SE and SW being caused to respond at the same time. The armatures of the polar relays PE′ and PW′, by changing the direction of current flow through the auxiliary windings of the receiving relays RE and RW, hold the armatures of said relays against their normal contacts to prevent the relays from responding to received signals.

If signals are being transmitted from east to west over the carrier repeater channel, including the conductors 29, the detector DE, in response to each interruption of the carrier frequencies, causes the receiving relay RE to shift its armature from its normal connection to negative battery over the contact of the receiving relay RW to positive battery. Mutually opposed sources are now connected to opposite ends of the loop L and no current flows through the upper windings of the two transmitting polar relay sets. The source connected over the alternate contact of the receiving relay RE to the windings of the polar relays of the two sets of transmitting relays, is of such polarity that the current flowing through the lower windings of relay PE and PE′ tends to hold the armatures of said relays in their normal positions, thereby preventing the detected signals from being transmitted back to the main line section MLE from which they came; also preventing the transmitting relays PW and PW′ from short-circuiting the conductors 29 to interfere with the transmission over the line section MLE to the line section MLW.

Similarly, if signals are transmitted from west to east over the amplification path 30, the relay RW responds to shift the polarity of the battery connected to the conductor 38, thereby connecting mutually opposed sources to the ends of the loop L to prevent all current flow in the loop. The current flow through the polar windings of both sets of transmitting polar relays is in such direction as to prevent the operation of the relays. The transmission of a "break" signal from the loop L or to the loop L will be readily understood without further description by reason of the fact that it is similar in principle to that described in connection with Fig. 2.

Fig. 4 illustrates an arrangement similar to that of Fig. 3 with the loop circuit connected in series with the polar transmitting relays and the contacts of the receiving relays. The apparatus is in general similar to that of Fig. 3, and need not be described in detail. The essential difference in the two circuits resides in the fact that the loop L is serially connected between points 31 and 32, while separate conductors, 38 and 39, extend from the junction points 35 and 36 of the windings of the polar transmitting relays, to the armatures of the receiving relays RE and RW respectively. The armatures of the receiving relays, when resting upon their normal contacts, are connected to positive and negative poles of the divided battery B, the alternate contacts of the relays being oppositely connected to the poles of said battery so that if the armature of either relay is shifted, conductors 38 and 39 are connected to the same pole of the battery. Two artificial lines or networks, NE and NW, connected by metallic conductor 40, are provided for balancing the polar transmitting relay sets with respect to the loop L.

Signals may be transmitted from the loop by interrupting its circuit so that no current flows through the upper windings of either set of polar transmitting relays. The lower windings of the two sets of polar relays operate to shift the armatures to their alternate contacts thereby opening the circuits of the sounders SE and SW, short-circuiting the conductors 29 and 30 to interrupt the carrier frequency and change the direction of current flow through the auxiliary windings of the polar receiving relays to prevent the response of said relays to signals.

Signals received from the line section MLE operate the receiving polar relay RE, thereby connecting the conductor 38 to the positive pole of the battery instead of to the negative pole thereof. Since both conductors 38 and 39 are now connected to the positive pole of the battery, no current flows through the loop and the sounders in the loop therefore release their armatures.

It will be observed that in this operation, the direction of the current flowing through the lower windings of the relays PE and PE′ was changed so that the armatures of these two relays are not shifted. With respect to the polar relays PW and PW′, however, the condition is different upon interruption of the loop L. Since no current flows through the upper windings and the current flowing in the lower windings is in the normal direction, the armatures of these two relays are shifted, the armature of the relay PW short-circuiting the conductors 29 and the armature of the relay PW′ changing the direction of current flow through the lower winding of the receiving relay RW to prevent its operation. The short-circuiting of the conductors 29 is in this instance without effect, since at the time the conductors are short-circuited, the carrier frequency incoming from the line section MLE to be transmitted through the repeater channel to the line section MLW, is already interrupted.

The operations attending the transmission of a "break" signal either to or from the loop, will be obvious without description, and consequently, description thereof will be omitted.

Fig. 5 illustrates an arrangement similar to those shown in Figs. 3 and 4 except that in this instance, the system is arranged to operate upon a full-duplex basis, that is, signals may be transmitted through the carrier channels simultaneously in both directions. This necessitates the provision of two loops, LE and LW, of which the loop LE is arranged to receive signals transmitted through the repeater channel from west to east, and to transmit signals east, while the loop LW is arranged to receive signals transmitted through the repeater channel from east to west and to transmit signals west. The loop LW is associated with the polar receiving relays PE and PE′ in a manner similar to that described in the other figures, and one end of the loop passes over the contacts of the receiving relay RW. The loop LW is associated with the transmitting polar relays PW and PW′, and one end of the loop passes over the contacts of the receiving relay RE. The various parts of the apparatus are otherwise similar to the elements described in connection with previous figures and need not be considered in detail. The operation is as follows:

Signals transmitted over the carrier channel from east to west pass into the receiving channel RLE, through the amplifier RAE, over conductors 29, through the amplifier TAW and over the transmitting channel TLW to the line section MLW. The detector DE responds to interruptions of the carrier frequency over this channel, thereby interrupting the direct current flowing through the main winding of the receiving polar relay RE, so that the armature of said relay is shifted to its lower contact. Negative battery is now connected to both ends of the loop LW so that no current flows in the loop and the sounders in the loop respond to the interruptions in the carrier frequency. The polar relays PW and PW′ are not actuated, however, as the current flows through the lower windings of said relays in the direction to hold their armatures against their normal contacts. Signals may be transmitted from the loop LW by interrupting the loop, through the agency of a sending key. The interruption of the loop prevents current from flowing through the upper windings of the relays RW and RW′, and the current of the lower windings is in such direction as to shift the armatures of the relays so that the armature of the relay RW, by short-circuiting the conductors 29, interrupts the transmission of the carrier frequency to the line section MLW. The armature of the polar relay PW changes the direction of current through the auxiliary winding of the receiving relay RE, and prevents the armature of the latter relay from responding to received signals.

Signals transmitted from the line section MLW pass through the carrier channel from west to east, over the receiving channel RLW, through the amplifier RAW, over conductors 30, through the transmitting amplifier TAE in the transmitting channel TLE to the line section MLE. Interruptions of the carrier frequency transmitted over this channel cause the detector DW to interrupt the direct current flowing through the main windings of the receiving polar relay RW. The armature of said relay is thereby shifted to its lower contact so that negative battery is connected to both ends of the loop LE. No current now flows in the loop and the sounders therein respond to the interruptions of the carrier frequency. The polar relays PE and PE′ are prevented from actuation, however, due to the fact that the current flowing in the lower windings is in the direction to hold their armatures against the lower contacts.

Signals may be transmitted from the loop LE to the line section MLE by interrupting the loop in the usual manner. Since no current flows through the upper windings of the polar relays PE and PE′, when the loop is interrupted and the current flow through the lower windings of said relays is in the positive direction, the armatures of the polar relays PE and PE′ are shifted to the lower contacts. The armature of the relay PE short-circuits conductor 30, thereby interrupting the transmission of the carrier frequency to the main line section MLE. The armature of the polar relay PE′ changes the direction of the current flow through the auxiliary winding of the receiving polar relay RW, thereby preventing response of the receiving relay to received signals.

In all of the figures above described, but one set of channels is illustrated. It will be understood, however, that in practice, the system will be multiplexed so that more than one channel in each direction will be provided, as is indicated in all of the figures by the parallel connections extending from the transmitting and receiving channels adjacent to the transmitting and receiving amplifiers. When the system is multiplexed, it will be understood, of course, that each of the receiving and transmitting amplifiers schematically indicated will include two circuits for insuring selectivity between the channels, each channel for transmitting in a given direction having assigned to it a different carrier frequency.

It will be obvious that the general principles herein discussed 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 transmitting carrier channel, a receiving carrier channel, a receiving relay associated with said receiv-

ing channel, a local telegraph circuit controlled by said receiving relay, a balancing circuit for balancing said local telegraph circuit, a polar relay arrangement associated with said telegraph circuit and balancing circuit for controlling said transmitting channel, and an auxiliary winding associated with said receiving relay for preventing said receiving relay from controlling said telegraph circuit when a signal is being transmitted over said circuit to actuate said transmitting relay.

2. In a signaling system a carrier transmitting channel, a carrier receiving channel, a polar receiving relay associated with said receiving channel, a local telegraph circuit controlled by said receiving relay, a balancing circuit for said telegraph circuit, a polar relay arrangement associated with said telegraph circuit and balancing circuit for controlling said transmitting channel, and an auxiliary winding arrangement associated with said polar receiving relay for preventing the latter from controlling the telegraph circuit when a signal is transmitted over said circuit to said transmitting relay arrangement.

3. In a signaling system a carrier transmitting channel, a carrier receiving channel, a polar receiving relay associated with said receiving channel, a local telegraph circuit controlled by said receiving relay, a balancing circuit for said telegraph circuit, a polar relay arrangement associated with said telegraph circuit and balancing circuit for controlling said transmitting channel, an auxiliary winding arrangement associated with said polar receiving relay and a circuit arrangement whereby said winding arrangement is normally energized to bias the armature of the polar relay in the direction opposite to that in which it is held by its main winding when carrier oscillations are received in said receving channel, the biasing effect being less than the pull due to the main windings, and means whereby when said polar transmitting relay arrangement is actuated in response to a signal transmitted over the telegraph circuit said auxiliary winding arrangement of the polar receiving relay will be energized to prevent said relay from controlling said telegraph circuit.

4. In a signaling system a carrier transmitting channel, a carrier receiving channel, a polar receiving relay associated with said receiving channel, a local telegraph circuit controlled by said receiving relay, a balancing circuit for said telegraph circuit, a polar relay arrangement associated with said telegraph circuit and balancing circuit for controlling said transmitting channel, a biasing winding associated with said polar receiving relay and so arranged that with the polar transmitting relay in normal condition current will flow through said auxiliary winding in such a direction as to bias the armature in a direction opposite to the pull of the main winding of said polar relay when carrier oscillations are being received in said receiving channel, and means whereby, when said polar transmitting relay is actuated in response to the transmission of a signal over said telegraph circuit current will flow through said auxiliary winding in the opposite direction to prevent said receiving relay from controlling said telegraph circuit.

5. In a signaling system a carrier transmitting channel, a carrier receiving channel, a receiving relay associated with said receiving channel, a local telegraph circuit controlled by said receiving relay, a balancing circuit for said telegraph circuit, a pair of polar relays each having windings in said telegroph circuit and balancing circuit, means whereby one of said polar relays will control said transmission channel and means whereby the other polar relay prevents said receiving relay from controlling the telegraph circuit when the transmitting polar relay is actuated in response to a signal transmitted over said telegraph circuit.

6. In a signaling system a carrier transmitting channel, a carrier receiving channel, a receiving relay associated with said receiving channel, a local telegraph circuit controlled by said receiving relay, a balancing circuit for said telegraph circuit, a pair of polar relays each having windings in said telegraph circuit and balancing circuit, means whereby one of said polar relays controls said transmission channel, and an auxiliary winding associated with said receiving relay, said winding being controlled by the other polar relay to prevent said receiving relay controlling said telegraph circuit when said transmitting relay is actuated by a signal transmitted over said telegraph circuit.

7. In a signaling system a pair of transmission line sections comprising transmitting and receiving channels associated with each section, a local telegraph loop, means to balance said loop at each end thereof, a polar relay arrangement at each end of said loop having windings in said loop and said balancing means, said polar relays controlling said transmitting channels, a receiving relay associated with each receiving channel, connections extending from the junction points of the windings of said polar transmitting relays over the contacts of said receiving relays, sources of current associated with the normal contacts of said receiving relays, said sources being so poled as to be in series aiding relation with respect to the loop circuit whereby, with the circuit in normal condition, a greater current flows through the windings of the polar transmitting relays which are included in the loop than the current which flows through the

balancing circuit, thereby maintaining the contacts of the transmitting relays in a non-signaling condition, means to open and close the loop circuit so that current flow through the windings of the transmitting relays included in the loop when the loop is interrupted and the windings in the balancing circuits are energized to transmit signals to said transmitting channels.

8. In a signaling system a pair of transmission line sections comprising transmitting and receiving channels associated with each section, a local telegraph loop, means to balance said loop at each end thereof, a polar relay arrangement at each end of said loop having windings in said loop and said balancing means, said polar relays controlling said transmitting channels, a receiving relay associated with each receiving channel, connections extending from the junction points of the windings of said polar transmitting relays over the contacts of said receiving relays, sources of current associated with the normal contacts of said receiving relays, said sources being so poled as to be in series aiding relation with respect to the loop circuit whereby, with the circuit in normal condition, a greater current flows through the windings of the polar transmitting relays which are included in the loop than the current which flows through the balancing circuit, thereby maintaining the contacts of the transmitting relays in a non-signaling condition, means to open and close the loop circuit so that current flow through the windings of the transmitting relays included in the loop is interrupted and the windings in the balancing circuits are energized to transmit signals to said transmitting channels, and means responsive to the actuation of one of said receiving relays to connect a source of potential to the junction point of the windings of the corresponding transmitting relay, said source having a potential opposite to that connected to said junction point from the normal contact of a receiving relay whereby current ceases to flow through the loop and the windings of the polar relay at the opposite end of the loop are energized to transmit a signal from the corresponding transmitting channel while the current flow through the balancing winding of the other transmitting relay is in such a direction as to hold its contacts in normal condition and therefore prevent the transmission of the received signal back to the line section from which it was received.

9. In a signaling system a pair of transmission line sections comprising transmitting and receiving channels associated with each section, a local telegraph loop, means to balance said loop at each end thereof, a polar relay arrangement at each end of said loop having windings in said loop and said balancing means, said polar relays controlling said transmitting channels, a receiving relay associated with each receiving channel, connections extending from the junction points of the windings of said polar transmitting relays over the contacts of said receiving relays, sources of current associated with the normal contacts of said receiving relays, said sources being so poled as to be in series aiding relation with respect to the loop circuit whereby, with the circuit in normal condition, a greater current flows through the windings of the polar transmitting relays which are included in the loop than the current which flows through the balancing circuit, thereby maintaining the contacts of the transmitting relays in a non-signaling condition, and means responsive to the actuation of one of said receiving relays to connect a source of potential to the junction point of the windings of the corresponding transmitting relay, said source having a potential opposite to that connected to said junction point from the normal contact of a receiving relay whereby current ceases to flow through the loop and the windings of the polar relay at the opposite end of the loop are energized to transmit a signal from the corresponding transmitting channel while the current flow through the balancing winding of the other transmitting relay is in such a direction as to hold its contacts in normal condition and therefore prevent the transmission of the received signal back to the line section from which it was received.

10. In a signaling system two transmission line sections at least one of which is used for the transmission of carrier currents, transmission channels associated with each line section, a telegraph loop, a balancing circuit at each end thereof, polar transmitting relays at each end of the loop having windings in the loop and corresponding balancing circuit, sources of opposite potential connected to the junction points of the windings of the transmitting relays at each end of the loop whereby a greater current flows through the windings of the polar relays in the loop circuit than flows through the windings in the balancing circuit thereby maintaining the transmitting relays in non-signaling condition, and means to open and close the loop, thereby interrupting the current flowing through the loop windings in the transmitting relays and permitting the balancing windings to be energized to shift the armatures of the relays.

11. In a signaling system a pair of transmission line sections for transmitting carrier current, transmission channels associated with each line section, a telegraph loop, a balancing circuit at each end thereof, polar transmitting relays at each end of the loop

having windings in the loop and corresponding balancing circuit, sources of opposite potential connected to the junction points of the windings of the transmitting relays at each end of the loop whereby a greater current flows through the windings of the polar relays in the loop circuit than flows through the windings in the balancing circuit thereby maintaining the transmitting relays in non-signaling condition, and means to open and close the loop, thereby interrupting the current flowing through the loop windings of the transmitting relays and permitting the balancing windings to be energzed to shift the armatures of the relays.

12. In a signaling system a pair of transmission line sections for transmitting carrier current, a repeater arrangement for interconnecting the sections comprising transmission and receiving carrier channels associated with each section, means associated with each receiving channel for translating carrier currents into low frequency signals, connections in shunt with said translating means and extending to the transmitting channel associated with the opposite transmission line section for directly associating the receiving channel of each line circuit with the transmitting channel of the opposite line circuit, a telegraph loop, balancing circuits at each end thereof, polar transmitting relays at the ends of the loop each having windings in the loop and in the balancing circuits, and sources of current of opposite polarity connected to the junction points of the windings of the polar transmitting relays.

13. In a signaling system a pair of transmission line sections for transmitting carrier current, a repeater arrangement for interconnecting the sections comprising transmission and receiving carrier channels associated with each section, means associated with each receiving channel for translating carrier currents into low frequency signals, connections in shunt with said translating means and extending to the transmitting channel associated with the opposite transmission line section for directly associating the receiving channel of each line circuit with the transmitting channel of the opposite line circuit, a telegraph loop, balancing circuits at each end thereof, polar transmitting relays at the ends of the loop each having windings in the loop and in the balancing circuits, receiving relays associated with each receiving channel, sources of current of opposite polarity connected from the normal contacts of said receiving relays to the junction points of the windings of the transmitting relays, and means whereby when a receiving relay is actuated a source of current having potential equal to but polarity opposite to that of the source connected to the normal contact of the relay will be connected with the junction point of the windings of the corresponding transmitting relay.

14. In a signaling system a pair of transmission line sections for transmitting carrier currents, a repeater for interconnecting said line sections comprising transmitting and receiving channels associated with each section, means associated with the receiving channels for translating the carrier currents into low frequency signals, receiving relays associated with each receiving circuit, connections extending from each receiving circuit in shunt with its translating means to the transmitting circuit associated with the opposite transmission line section, a telegraph loop, a balancing circuit at one end thereof, a polar relay having windings in the loop and in the balancing circuit, a connection from the junction point of said windings over the normal contact of at least one of said receiving relays to a source of current, a source of current associated with the opposite end of the loop, said source being so poled as to be series aiding with respect to said first mentioned source, and means operated by said polar relay for preventing the actuation of at least one of said receiving relays when signals are transmitted by said loop.

15. In a signaling system a pair of transmission line sections for transmitting carrier currents, a repeater for interconnecting said line sections comprising transmitting and receiving channels associated with each section, means associated with the receiving channels for translating the carrier currents into low frequency signals, receiving relays associated with each receiving circuit, connections extending from each receiving circuit in shunt with its translating means to the transmitting circuit associated with the opposite transmission line section, a telegraph loop, a balancing circuit at one end thereof, a polar relay having windings in the loop and in the balancing circuit, a connection from the junction point of said windings over the normal contact of at least one of said receiving relays to a source of current, a source of current associated with the opposite end of the loop, said source being so poled as to be series aiding with respect to said first mentioned source, at least one of said receiving relays having an auxiliary winding, and means controlled by said polar relay for energizing said winding so as to prevent the actuation of said receiving relay when signals are transmitted by said loop.

16. In a signaling system a pair of transmission line sections for transmitting carrier currents, a repeater for interconnecting said line sections comprising transmitting and receiving channels associated with each section, means associated with the receiving

channels for translating the carrier currents into low frequency signals, receiving relays associated with each receiving circuit, connections extending from each receiving circuit in shunt with its translating means to the transmitting circuit associated with the opposite transmission line section, a telegraph loop, a balancing circuit at one end thereof, a polar relay having windings in the loop and in the balancing circuit, a connection from the junction point of said windings over the normal contact of at least one of said receiving relays to a source of current associated with the opposite end of the loop, said source being so poled as to be series aiding with respect to said first mentioned source, an auxiliary winding associated with at least one of said receiving relays and means whereby with said signaling relay in normal condition said auxiliary winding is energized in such a manner as to bias the armature of the receiving relay in the direction opposite from that which it assumes when carrier currents are received in the corresponding receiving channel and whereby when said transmitting relay is in abnormal condition said auxiliary winding is so energized as to hold the armature of the receiving relay from being shifted.

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

RALPH WARNER DEARDORFF.