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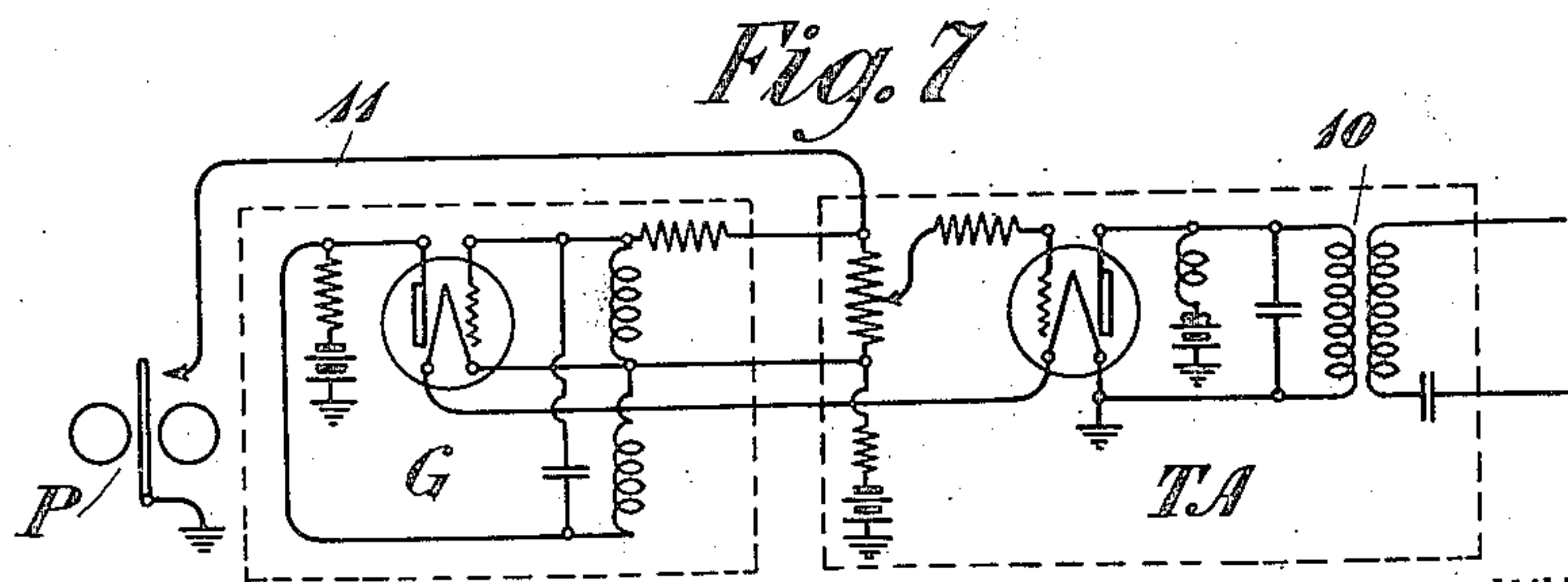
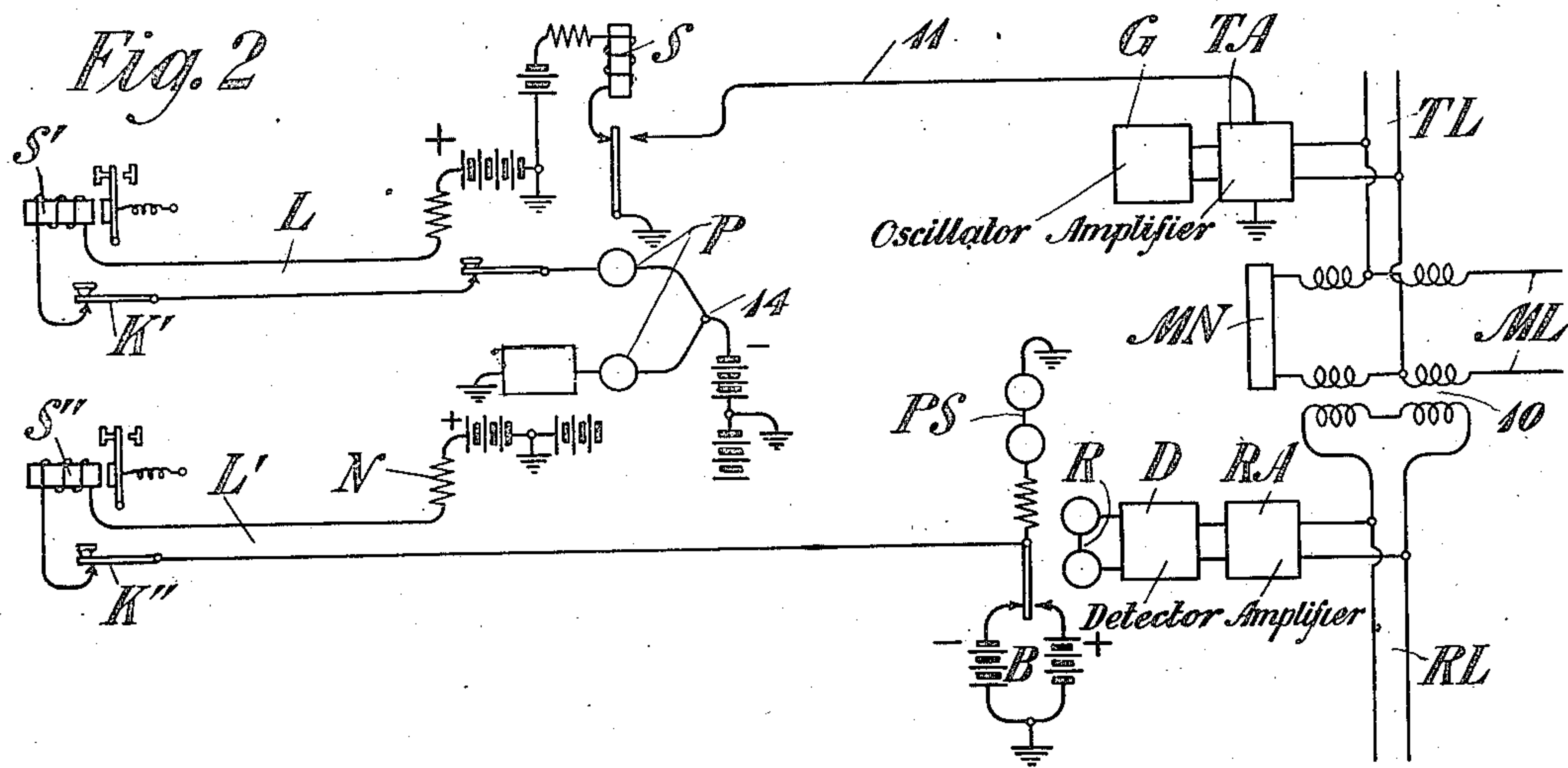
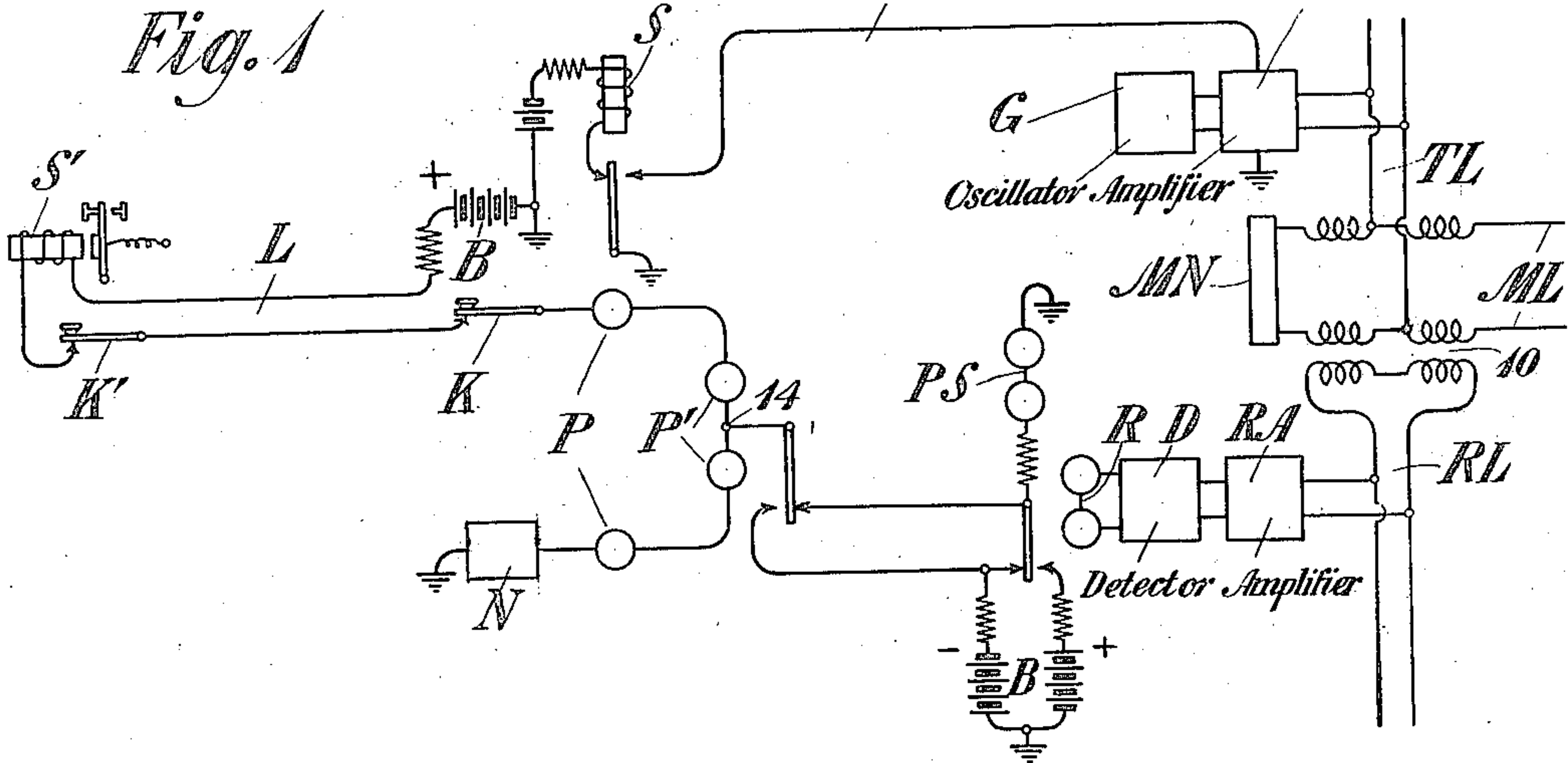
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B. P. HAMILTON

CARRIER TELEGRAPH CIRCUITS

Filed Oct. 21, 1920

3 Sheets-Sheet 1



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Oct. 2, 1923.

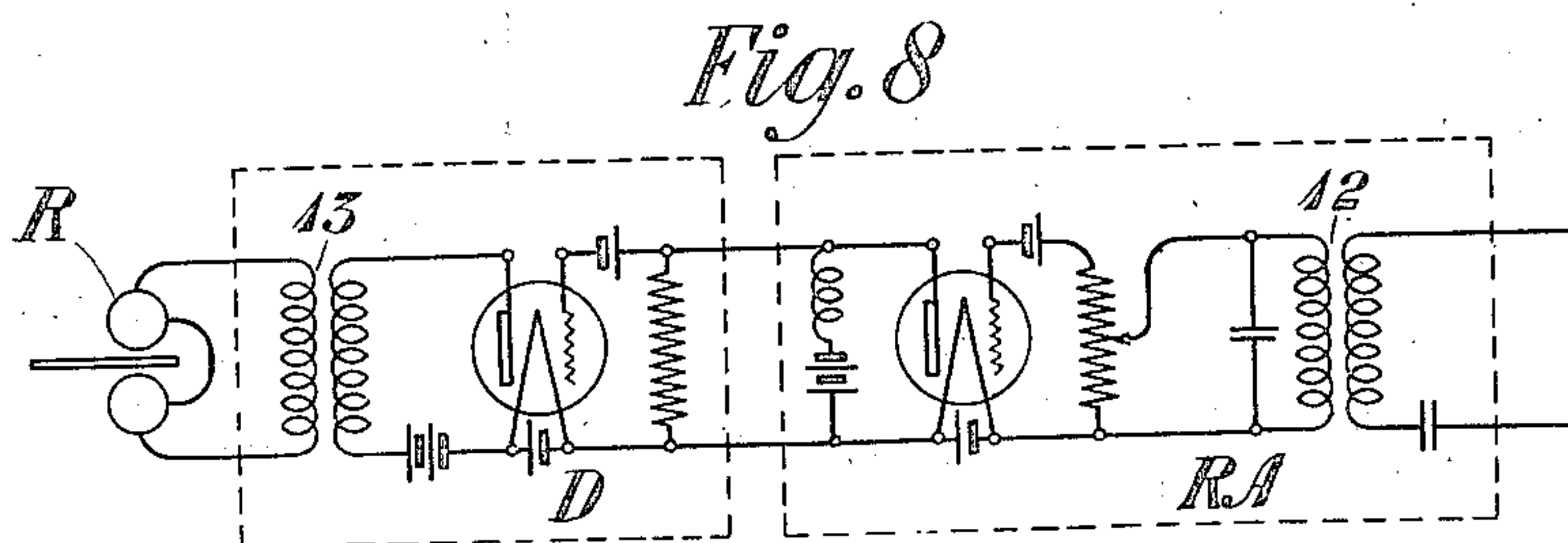
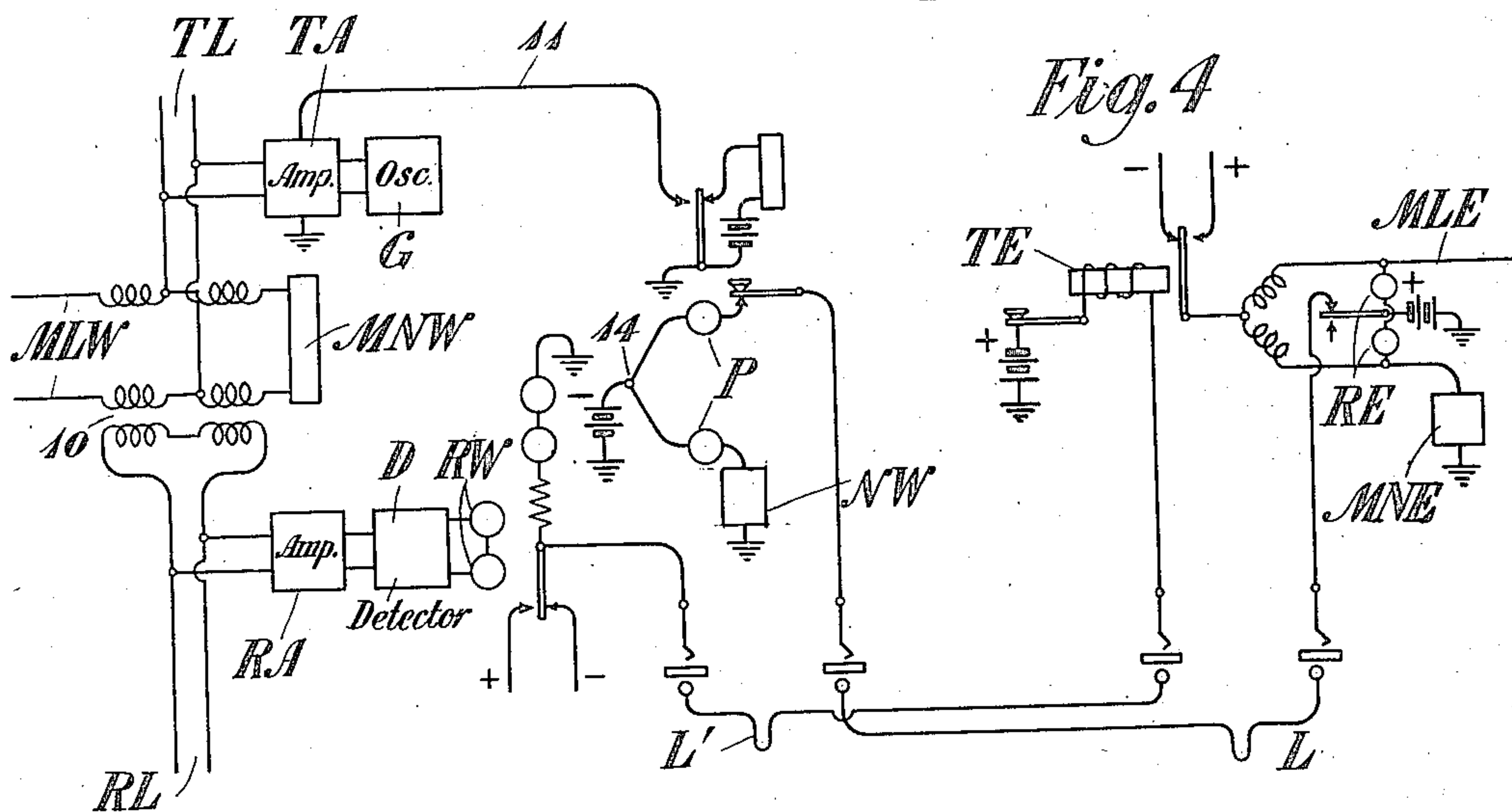
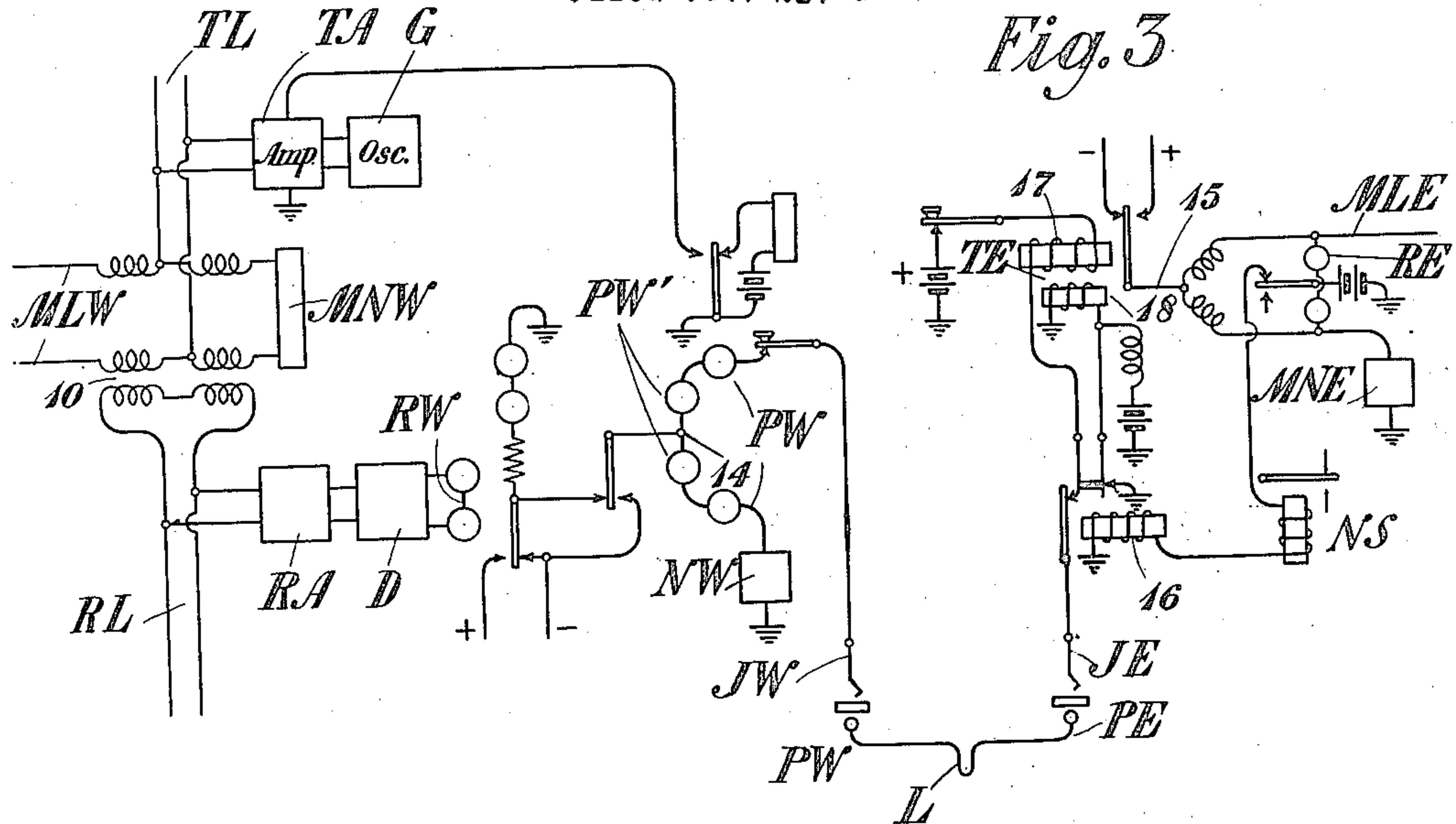
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B. P. HAMILTON

CARRIER TELEGRAPH CIRCUITS

Filed Oct. 21, 1920

3 Sheets-Sheet 2



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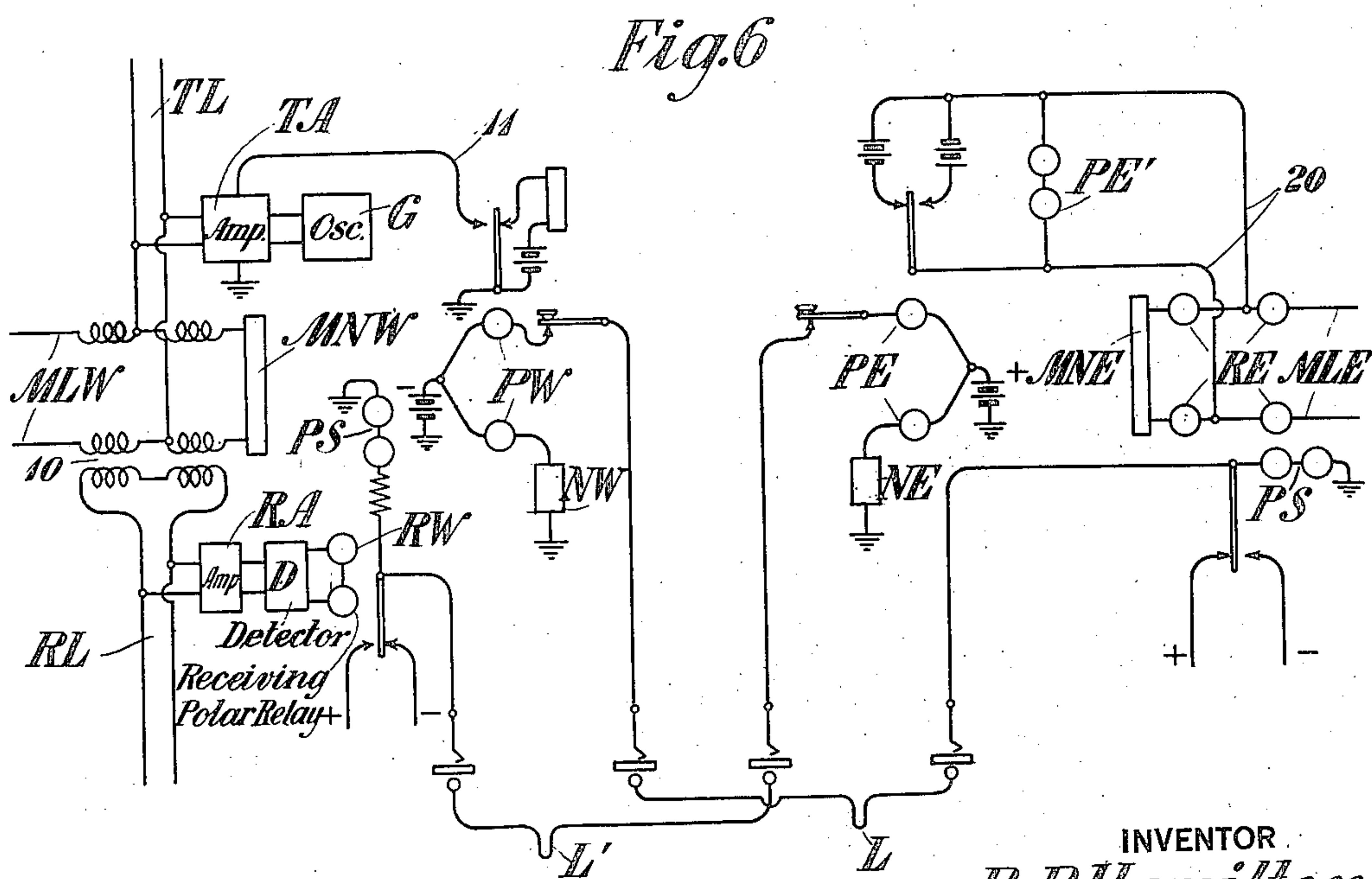
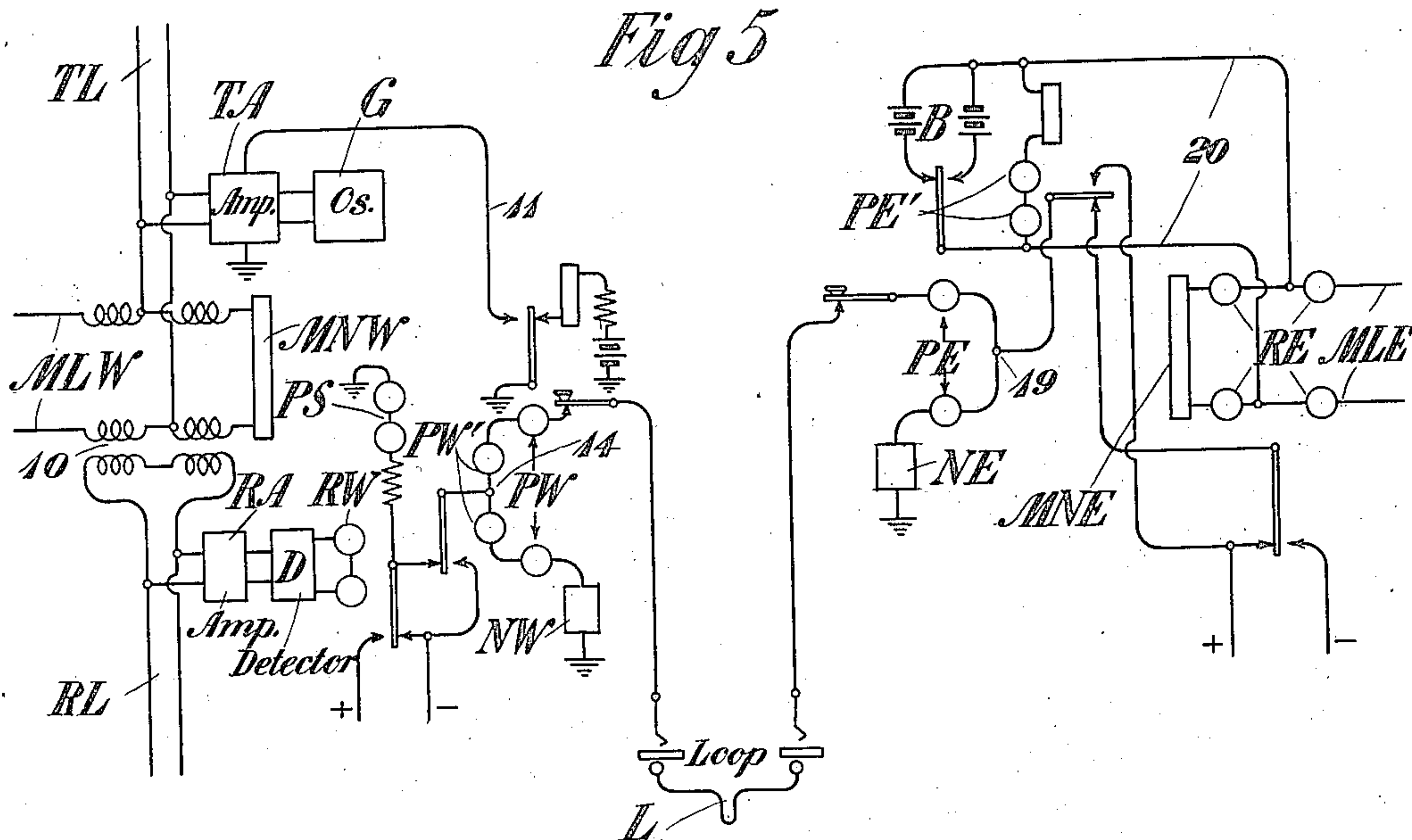
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CARRIER TELEGRAPH CIRCUITS

Filed Oct. 21, 1920

3 Sheets-Sheet 3



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Patented Oct. 2, 1923.

1,469,259

UNITED STATES PATENT OFFICE.

BAXTER P. HAMILTON, 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. 418,485.

To all whom it may concern:

Be it known that I, BAXTER P. HAMILTON, 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 signal systems, and more particularly to systems in which telegraph signals may be transmitted by means of carrier currents.

One of the objects of this invention is to provide an arrangement whereby a low frequency telegraph circuit or loop may be associated with the channels of a carrier system so that telegraph signals may be transmitted from the loop to the carrier circuit, and vice versa.

Another object of the invention is to provide arrangements whereby an ordinary telegraph line may be associated with a carrier transmission circuit, so that telegraph signals may be transmitted from the low frequency line to the carrier transmission circuit, and vice versa.

Another object of the invention is to provide means whereby a low frequency telegraph circuit or loop may be associated with a low frequency telegraph line, and a carrier transmission line in such a manner that telegraph signals may be transmitted from the loop to the low frequency line or the carrier transmission line, and vice versa, or, if desired, telegraph signals may be transmitted between the low frequency line and the carrier transmission line through the loop.

A still further object of the invention is to provide a loop telegraph circuit for association with the channels of the carrier circuit, the loop being so arranged that a change from current to no current condition in the loop may be produced by means of current sources, which may be arranged so as to be either mutually aiding or mutually opposing.

Further objects of the invention will be clear from the following description when read in connection with the accompanying drawings. Figure 1 of which shows a loop associated with the transmitting and receiving channels of the carrier system so as to operate on a half duplex basis, Fig. 2 of which illustrates a similar arrangement operated on a full duplex basis, Fig. 3 of

which illustrates a grounded telegraph line associated through a loop with the channels of the carrier system, and arranged to operate on a half duplex basis, Fig. 4 of which shows a similar arrangement operating full duplex, Fig. 5 of which illustrates an arrangement similar to Fig. 3, but employing a full metallic telegraph line instead of a grounded line, Fig. 6 of which illustrates an arrangement similar to Fig. 4, but employing a full metallic telegraph line, Fig. 7 of which illustrates the detailed circuit arrangements of the oscillator and transmitting amplifier in the transmitting carrier channels of Fig. 1 to 6 inclusive, and Fig. 8 of which illustrates the circuit arrangements of the receiving amplifier and detector to be used in the receiving channels.

Referring to Fig. 1, ML designates a main transmission line over which carrier currents may be transmitted, said main line being associated with a carrier transmitting circuit TL and a carrier receiving circuit RL, with which individual carrier transmitting and receiving channels may be associated. The circuits TL and RL may be rendered substantially conjugate by employing a balanced transformer 10 of well-known construction, the main line ML being balanced by an artificial line and network MN.

An individual carrier transmitting channel is illustrated, including oscillator G and transmitting amplifier TA. While the oscillator G may be any well-known source of alternating current and the transmitting amplifier TA may be any amplifier of well-known construction, it is preferable to use a vacuum tube oscillator and vacuum tube amplifier as illustrated in Fig. 7. As shown in said figure, a tuned circuit 10 is associated with the output circuit of the amplifier to render the channel circuit selective to the frequency assigned thereto, it being understood that each carrier transmitting channel will have assigned to it a different carrier frequency. The oscillator G, by means of its feed-back coupling, generates oscillations of the carrier frequency which will be transmitted to the carrier line through the amplifier TA. In order to transmit telegraph signals by means of the carrier frequency, a short circuit connection 11 is provided, said connection being made to the grid circuit of the amplifier, so that when

the short circuit connection is closed, the carrier frequency is diverted through the short circuit, and is not impressed upon the grid circuit of the amplifier. By means of this arrangement interruptions of the carrier frequency may be produced.

An individual carrier receiving channel is shown associated with the receiving circuit RL, said channel including a receiving amplifier RA, a detector D, and a receiving relay R. The amplifier RA and detector D may be of any well-known construction, but are preferably of the vacuum tube construction substantially as illustrated in Fig. 8. A tuned circuit 12 is associated with the input of the vacuum tube amplifier RA for the purpose of rendering the channel circuit selective to the carrier frequently assigned thereto. The receiving relay R associated with the out-put circuit of the detector may be of any known type, but as herein illustrated is a polarized relay. Since the out-put circuit of the detector is a direct current circuit, a transformer 13 is provided between the out-put circuit of the detector and the circuit of the polar receiving relay R, in order that the direct current component of the detected signals may be suppressed, and only the alternating component transmitted to operate the polar relay. The detector D has its grid circuit adjusted in a well-known manner, so that when the carrier frequency is not being received no current flows in the out-put circuit of the detector, but when the carrier frequency is transmitted to the detector through the amplifier RA a pulse of direct current flows in the out-put circuit of the detector during the continuance of the train of carrier oscillations. At the beginning of the pulse of current, due to a train of carrier oscillations, an alternation passes through the transformer 13 to the polar relay R in a direction to shift the armature of said relay in one direction, and at the end of the pulse an alternation passes through the transformer in such a direction as to shift the armature of the polar relay in the opposite direction.

L is an ordinary low frequency telegraph circuit or loop leading from the terminal station to a subscriber's station, at which it is provided with a key K' and a sounder S'. One end of the loop is connected at the terminal office to one pole, say the positive pole, of a divided battery B. The other end of the loop is balanced by means of an artificial line or network illustrated at N, and polar relays P and P' are associated with the loop in such a manner that a winding of each relay is included in the loop, and a balancing winding of each relay is included in the balancing circuit, the windings of the two relays being in series with each other. The polar relay P, through its armature, controls the connection 11 for short-circuit-

ing the transmitting amplifier TA; said armature also controls the local circuit of a sounder S at the central office. If desired, a key K may also be provided at the central office for interrupting the loop. A connection extends from the junction point 14 of the windings of the polar relays in the loop over the contacts of the polar relay P' and the polar receiving relay R to the poles of the divided battery B. The circuit arrangement is such that the connection extending from the point 14 leads to the opposite terminal of the divided battery B from that connected to the opposite end of the loop, so that the two halves of the battery are series aiding with respect to the loop. By shifting the armature of the receiving relay R the connection from the point 14 will be shifted to the same pole of the battery as that to which the opposite end of the loop is connected, so that the battery connections at the opposite end of the loop are mutually opposed. The armature of the polar relay P' is so arranged that when the armature is shifted from its normal position the circuit from the point 14 to the poles of the divided battery B over the armature of the receiving relay R is open, and an independent connection is established from the point 14 to the pole of the battery to which the point 14 is normally connected, so that under these conditions the polar receiving relay R is ineffective to produce any change in the current conditions of the loop. If desired, a polar sounder PS may be arranged to be controlled by the armature of the polar receiving relay R.

The operation is as follows: Under normal conditions the circuit of the loop L is closed, and the battery connections at the opposite ends of the loop are series aiding. Consequently a current due to the full voltage of the divided battery flows through the upper windings of the polar relays P and P'. Since the balancing circuit N is connected to ground, however, a current due to the voltage of one-half of the divided battery flows through the lower windings of said polar relay. Under these conditions the upper windings of the polar relays are the controlling windings and the armatures of said relays assume the positions indicated in the drawing. The armature of the polar relay P, therefore, maintains the circuit of the sounder S closed and holds open the short circuit connection 11 of the transmitting amplifier TA, so that the carrier frequency from the oscillator G is transmitted to the main line ML through the amplifier TA. Under normal conditions also the receiving carrier frequency incoming from the main line ML operates upon the detector D, and an alternation due to the beginning of the received train of oscillations occurs of such direction as to shift the armature of the

polar receiver R to the position indicated in the drawing, in which position it remains during the continuance of the received carrier frequency.

5 Signals may be transmitted from the loop L to the carrier circuit ML by opening and closing the loop by means of the keys K or K'. When the loop is open no current flows through the upper windings of the polar relay P and P', but a current from the negative pole of the battery B flows through the lower windings, thereby shifting the armatures of said relays to the alternate contacts. The shifting of the armature of the relay P opens the circuit of the sounder S, and closes the short circuit 11, thereby interrupting the transmission of the carrier frequency to the main line, whereby the signal apparatus associated with the line will respond. The armature of the polar relay P', upon being shifted, opens the connection over the armature of the receiving relay R to the negative pole of the battery B and closes an alternative connection to the negative pole of the battery B, independent of the receiving relay, thereby preventing the receiving relay from affecting the condition of the loop circuit.

10 In receiving, the telegraph signals are transmitted from the distant station by interrupting the carrier frequency. Each time the carrier frequency impressed through the receiving circuit RL and amplifier RA upon the detector D is interrupted, the polar relay R shifts its armature to its alternate contact, thereby connecting the positive pole of the battery B to the point 14, so that the battery connections to the opposite end of the loop are mutually opposed. As a consequence, no current flows in the loop circuit and the sounder S' responds to the cessation of current flow. At the central office the polar sounder PS also responds to the shifting of the armature of the receiving relay R. Although no current flows in the loop as a result of the shifting of the armature of the polar relay R, current flows through the lower windings of the polar relays P and P', but, as the battery connections have been changed, this current flow is in a direction opposite to that normally flowing, and tends to maintain the armatures of said polar relays in their normal positions as indicated in the drawing. Consequently the received signals cannot operate through the polar transmitting relays to repeat the signal back to the main line ML.

Should it be desired, while signals are being received in the loop L from the main line ML, to interrupt or break in for the purpose of sending in the opposite direction, one of the keys K or K' may be operated to hold open the loop L for an interval. As a consequence, the armatures of the polar relays P and P' will be shifted to their

alternate contacts as already described, the armature of the polar relay P causing the interruption of the carrier frequency normally transmitted from oscillator G to the main line ML, while the armature of the relay P' opens the connection controlled by the receiving relay R and closes an alternative connection to the negative pole of the battery B, to insure that during the continuance of the break the current from the negative pole of the battery B will flow through the lower windings of the relays P and P' regardless of the action of the receiving relay R in response to the signals being received. The effect of the break signal at the distant station may be understood from a consideration of the effect produced by the transmission of a break signal from the distant station to the receiving apparatus at the station illustrated. The break signal at the distant station produces an interruption in the carrier frequency received by the amplifier RA, which interruption continues during the continuance of the break. As soon as the received carrier frequency is interrupted by the break, the polar relay R shifts its armature to the contact connected with the positive pole of the divided battery B. If at this moment the loop L is open, no result will be produced, since the armature of the polar relay P' will be shifted to the left, thereby defeating the circuit controlled by the armature of the receiving relay R. As soon as the loop is again closed, in transmitting a dash or a dot, however, positive battery will be connected to both ends of the loop, and thereafter interruptions of the loop will be ineffective to transmit signals, since the current flow through the lower windings of the polar relays P and P' will be in such a direction when the loop is open as to hold the relays against their normal contacts. The transmitting operator will be informed that a break signal is being received by the fact that the sounders S and S' do not respond to making and breaking the loop.

Fig. 2 illustrates an arrangement similar to that of Fig. 1, but operating on a full duplex basis. Similar apparatus is indicated in this figure by the same reference characters as are used in Fig. 1. Since, in a full duplex system, the operation of transmitting and receiving may take place simultaneously, two loops L and L' are provided, the loop L being used for transmitting telegraph signals through the transmitting carrier channel associated with the main line ML, and the loop L' being used for receiving telegraph signals through the receiving channel associated with said main line. The loop L is balanced, as in Fig. 1, and the arrangement of the windings of the polar relay P is the same. The polar relay P' is omitted in this instance, however, since it is

only used in connection with the break signal and in connection with the prevention of interference between the operations of transmitting and receiving. There is no
 5 necessity for a break signal in the full duplex system, and the transmitting and receiving operations take place in separate circuits. The balanced end of the loop L is permanently connected to one pole, say the
 10 negative pole of a divided battery, and the opposite end is connected to the opposite pole of the battery. The loop L' includes a receiving sounder S'' and, if desired, may include key K'' for actuating other sounders
 15 (not shown), which may be included in the loop. At one end of the loop L' is connected to a positive battery, and at the other end of the loop is connected to the armature of the polar receiving relay R, which nor-
 20 mally rests against a contact connected to negative battery. Positive battery is connected to the alternate contact so that the battery connections at the two ends of the loop will be mutually opposed, when the
 25 armature of the relay R is shifted and no current will flow in the loop. In this manner the sounder S'' will respond to the polar receiving relay R.

Signals may be transmitted from the loop
 30 to the main line ML by interrupting the loop by means of the keys K and K'. Each time the loop is interrupted the current of double strength, which normally flows through the upper windings of the polar
 35 relay P to hold its armature against its normal contact, ceases to flow, and the current flowing through the lower windings of the polar relay P shifts the armature to its right hand contact, thereby short-circuiting the
 40 grid circuit of the amplifier TA to interrupt the transmission of the carrier frequency to the main line. Signals may be received from the main line at the same time, the interrup-
 45 tions in the received frequency causing the armature of the relay R to be shifted from the negative battery to the positive battery, thereby changing the current conditions in the loop L' from a condition of current flow to a condition of no current flow. The
 50 sounder S'' responds to these changes and records the signals.

Fig. 3 illustrates an arrangement for inter-connecting the channels of the carrier telegraph system with a grounded low fre-
 55 quency telegraph line through a local subscriber's loop. The association of the loop with the carrier channels is similar to that illustrated in Fig. 1. The subscriber's loop, however, is shown as being connected to the
 60 terminal apparatus of the loop at the central office through plugs and jack PW and JW at the end associated with the carrier apparatus, and PE and JE at the end dis-
 65 sociated with the telegraph line. The telegraph line MLE terminates in the

usual form of balanced bridge arrangement, including a balancing network MNE and a polar receiving relay RE connected across equi-potential points of line and artificial
 70 line circuits with respect to the transmitting connection 15. The polar receiving relay RE controls the circuit of the control relay 16 adapted to open and close the loop circuit in response to signals transmitted from the
 75 line MLE. The loop circuit includes a main coil 17 of a pole changer PC for controlling the transmitting connection 15. The pole changer is provided with an auxiliary or locking coil 18, for preventing interference
 80 between the operations of transmitting and receiving as will be described later. The loop L is merely schematically indicated in the drawing, but will be understood to include transmitting keys and sounders similar to those illustrated in Fig. 1.

Signals transmitted over the grounded telegraph line MLE operate the polar re-
 85 ceiving relay RE to open and close the circuit of the control relay 16. Each time the control relay is deenergized the circuit of the loop L is opened, and the short circuit about the coil 18 of the pole changer is also
 90 opened. The coil 18 of the pole changer is therefore energized, so that the deenergization of the coil 17, resulting from the opening of the loop, is ineffective to transmit
 95 the received signal back to the line MLE, from which it originated. Each interruption of the loop circuit causes a cessation of the current flow through the upper wind-
 100 ings of the polar relays PW and PW'. The current flowing over normal contact of the receiving relay RW, and the normal contact of the relay PW' is in such a direc-
 105 tion that the lower windings are energized to shift the armatures of said relays to their alternate contacts. The shifting of the armature of the relay PW' opens the cir-
 110 cuit controlled by the receiving relay RW, and connects negative battery to the junction point 14, independently of the relay RW, thereby preventing the receiving re-
 115 lay from interfering with the condition of the loop. The polar relay PW, through its armature short circuits the grid circuit of the amplifier TA, thereby interrupting the
 120 transmission of the carrier frequency to the main line MNW.

Signals coming from a distant station as-
 125 sociated with the carrier line MLW are transmitted by interrupting the carrier frequency. Interruptions of the received carrier frequency operate the polar receiving relay RW to shift its armature to its alter-
 130 nate contact, so that positive battery is connected to the point 14. The battery connections at the opposite ends of the loop are now mutually opposed, and no current flows in the loop, the current flow through the lower windings of the polar relays PW

and PW', however, being in such a direction as to prevent their armatures from shifting. The interruption of the current flow through the loop L causes the sounders in the loop to respond, and deenergizes the coil 17 of the transmitting relay or pole changer TE. The coil 18 of said pole changer is at this time deenergized by reason of the short circuit controlled by the relay 16. Consequently, the pole changer shifts its armature to change the polarity of the current transmitted over the main line MLE.

It will be obvious that signals may be simultaneously transmitted from the loop to both the low frequency line MLE and the carrier line MLW by opening and closing the loop, the opening and closing of the loop affecting the carrier apparatus in exactly the same way as in Fig. 1. The opening and closing of the loop controls the pole changer TE in a manner similar to that just described in connection with signals received from the carrier line MLW, the only difference being that in the present instance the deenergization of the coil 17 of the pole changer is due to the interruption of the loop rather than to a cessation of current flow because of mutually opposed battery connections at the opposite ends of the loop.

When the line MLE is transmitting to the line MLW, a break signal may be transmitted from the line MLW by interrupting the carrier frequency, so that the polar relay RW shifts its armature to connect positive battery of the loop. No current now flows through the loop, and the pole changer 17 shifts its armature to connect positive battery to the line MLE. The effect of the break signal at the distant station of the line MLE will be identical with that now produced in commercial low frequency telegraph systems, and need not be herein described. A similar break signal may be transmitted to the line MLE by interrupting the loop L. A break signal may be transmitted from the line MLE to the line MLW when signals are being transmitted from west to east by connecting positive battery to the distant end of the line MLE during the continuance of the break. This causes the polar receiving relay RE to hold open the circuit of the relay 16 during the continuance of the break, which in turn opens the loop L without, however, affecting the pole changer TE. If at the moment the loop L is interrupted the armature of the receiving relay RW is connected to positive battery by the transmission of an interruption of the carrier frequency, no effect is produced by the interruption of the loop upon the polar relays PW and PW'. As soon as the carrier frequency is again transmitted through the receiving channel

to send a dot or dash, the armature of the receiving relay RW is again connected to the negative battery, and the lower windings of the polar relay PW and PW' will again shift the armatures of the polar relays, the one to interrupt the transmission of carrier frequency, and the other to render the loop independent of the polar receiving relay RW. The effect of the break signal at a distant station will be similar to that described in Fig. 1. A similar break signal may be transmitted to the carrier line MLW by the operator at the subscriber's station of the loop, who may interrupt the loop by means of the sending key.

Fig. 4 illustrates an arrangement similar to that of Fig. 3, but arranged for operation upon a full duplex basis. In this instance one end of the loop L is connected to positive battery directly over the contact of the polar receiving relay RE of the metallic line MLE, the other end of the loop being balanced as in Fig. 2 and connected to negative battery. The polar transmitting relay P of the loop has a winding in the loop circuit and a balancing winding in the balancing circuit NW, and said polar relay controls the short circuit connection 11 of the amplifier. An additional loop L' is provided having one end connected through the winding of the pole changer TE to positive battery, the other end of the loop being connected over the contact of the receiving relay RW to negative battery. The alternate contact of the armature of the receiving relay RW is connected to positive battery, so that when the armature of the receiving relay is shifted the battery connections at the opposite ends of the loop are mutually opposed.

The operation is as follows: Telegraph signals incoming from the grounded line MLE operate the polar receiving relay RE to open the circuit of the loop L. The polar transmitting relay P, each time the loop is interrupted acts through its lower winding to shift the armature of said relay to close the short circuit 11, thereby interrupting the transmission of the carrier frequency to the main line MLW. The interruptions of the loop also actuate the sounders (not shown) therein. Carrier signals incoming from the line MLW operate the polar receiving relay RW, so that each time the carrier frequency is interrupted the armature of said relay is shifted from the contact connected with the negative battery to the contact connected with positive battery. Under the latter condition both ends of the loop L' are connected with the same pole of the battery. No current, therefore, flows in the loop, and the sounders (not shown) in the loop respond thereto. The transmitting relay or pole changer PE is also deenergized to connect positive instead of negative battery to

the line MLE, thereby transmitting signals over the line.

Fig. 5 illustrates an arrangement for interconnecting a low frequency metallic telegraph circuit with a carrier telegraph circuit through a local subscriber's loop the system being arranged for full duplex operation. In this arrangement the loop L is associated with the carrier apparatus in the same manner as illustrated in Fig. 3. The end of the loop associated with the metallic telegraph circuit, however, is balanced by means of a balancing circuit NE, and a polar transmitting relay PE is associated with the loop in such a manner that one winding is included in the loop circuit and another winding in the balancing circuit. From the junction point 9 of the two windings of the polar relay PE a connection extends over the normal contact of a polar relay PE' and over a normal contact of a polar receiving relay RE to positive battery. The polar relay PE' corresponds in its function to the polar relay PW' at the opposite end of the loop, but is included in the transmitting circuit 20 which is bridged across equal potential points of the four windings of the polar receiving relay RE in the metallic telegraph circuit. Two windings of the polar receiving relay RE are included in the balancing circuit, including the network, MNE, balancing the metallic telegraph line MLE. Consequently the positive and negative impulses transmitted from the divided battery B under the control of the armature of the polar transmitting relay PE are transmitted to the metallic telegraph line MLE without actuating the receiving relay. The polar relay PE', however, being bridged across the circuit 20, is actuated by the transmitting relay PE and, for all practical purposes moves its armature in unison with the armature of transmitting relay PE'. The polar receiving relay RE of the metallic telegraph circuit has its alternate contact connected with negative battery, so that if the armature of said relay is shifted and the armature of the receiving relay RW remains in its normal position, mutually opposed battery connections are associated with each end of the loop L. Upon the other hand, if the armature of the receiving relay RW is shifted and the armature of the receiving relay RE is not shifted, mutually opposed battery connections will again be associated with the opposite ends of the loop L, although in this instance the battery connections will be opposite to those just described. In either case, no current flows over the loop, and the sounders in the loop respond. The armature of the polar relay PE' is arranged so that when shifted to its alternate contact the battery connections controlled by the polar relay RE are dis-

connected and a direct connection is provided to positive battery independently of the receiving relay RE.

The operation is as follows: Telegraph signals are transmitted over the metallic telegraph line MLE as positive and negative currents, and in response to changes in polarity of the current flowing over the line MLE the receiving relay RE shifts its armature from the positive battery connection to the negative battery connection. As negative battery is now connected with both ends of the loop L, no current flows therein, and the sounders in the loop respond. Owing to the cessation of current flow through the loop, the upper winding of the polar relay PE is deenergized. The current flow through the lower winding, however, is now in such a direction that that armature of said relay is held against its normal contact, and is therefore unable to transmit received signals back to the line MLE. Current also ceases to flow in the upper windings of the polar relays PW and PW', so that the lower windings operate to shift the armatures to their alternate contacts. The armature of the relay PW closes a short circuit connection 11 to interrupt the carrier frequency transmitted to the main line MLW. The armature of polar relay PW', on the other hand, opens the battery connections to the point 14, extending over the armature of receiving relay RW, and connects negative battery to the point 14 independently of the receiving relay RW, thereby preventing the current condition of the loop from being disturbed by the receiving relay.

Telegraph signals transmitted over the main line MLW as interruptions in the carrier frequency normally transmitted operate upon the detector D to shift the armature of the polar relay RW from the negative battery connection to the positive battery connection. The positive battery being now connected to both ends of the loop, the sounders therein respond and the upper windings of the relay PW and PW' are deenergized, the lower windings, however, having current flowing through them as to hold their armatures against their normal contacts. The cessation of the flow of current in the loop also deenergizes the upper winding of the transmitting relay PE, so that the lower winding becomes operated to shift the armature of said relay from connection with one pole of the battery to the opposite pole of the battery, thereby transmitting currents of opposite sign over the metallic telegraph line MLE. The polarized relay PE' is also operated by reversals of current, and each time the armature is shifted the battery connections to point 19 over the armature of the receiving relay RE are disconnected and positive battery is connected directly with the point 19 and in-

dependently of the receiving relay, so that the loop circuit can not be affected by the receiving relay while signals are being transmitted. Signals may obviously be transmitted from the loop to the metallic line MLE and to the carrier circuit MLW by interrupting the loop.

A break signal may be transmitted from the metallic line MLE to the carrier circuit MLW by sending a continuous spacing current over the metallic line, as a result of which the armature of the receiving relay R is shifted to its alternate contact to connect negative battery to the point 19. As negative battery is now connected with both ends of the loop, no current flows in the loop, and the upper windings of the relays PW and PW' are deenergized, permitting the lower windings to shift the armatures of said relays to their alternate contacts. The armature of the relay PW thereby closes the short circuit connection 11, so that the transmission of the carrier frequency from the generator G to the line MLW is interrupted during the continuance of the break. The armature of the relay PW' opens the circuit controlled by the receiving relay RW and independently connects negative battery to the point 14, so that the loop no longer responds to the signals then being received. The break signal acts upon the loop circuit associated with the carrier transmitting station, so that current no longer flows in said loop and the sounders do not respond to the sending key, thereby apprising the sending operator that a break signal is being transmitted. Similarly, if signals were being transmitted from the loop L at the time the break signal occurred, the sounders in the loop L would not respond to the sending key, and the operator would thus become aware of the break signal.

Should a break signal be transmitted from a distant station associated with the carrier transmission line MLW while signals are being transmitted from east to west, the break signal would be evidenced at the station illustrated in Fig. 5 by a continued interruption of the carrier frequency received by the receiving channel, so that the direct current flowing through the primary windings of the transformer associated with the polar relay RW would cease, and the armature of said relay would be shifted to its normal contact, thereby connecting positive battery to the point 14. Positive battery would now be connected to both ends of the loop L, so that no current flows in the loop, and the sounders therein cease to respond to the signals transmitted over the metallic line MLE. The upper winding of the polar relay PE is deenergized, and the lower winding becomes effective to shift armature of said relay to its alternate contact, thereby

transmitting a continuous space current to the metallic line MLE, so that the distant signaling operator receives the break signal. Here again, if the signals were being transmitted from the loop L at the time the break signal was received, instead of being transmitted from the metallic line MLE, the sending operator at the loop L would become aware of the break signal by reason of the fact that the sounders in the loop no longer respond to the transmitting key.

Fig. 6 illustrates an arrangement similar to that of Fig. 5, except that the circuit is arranged to operate on a full duplex basis. In this case the battery connection at one end of the loop L is controlled by the receiving relay RE, and the other end of the loop is balanced by the balancing circuit NW, the windings of the polar transmitting relay PW being included in the loop and balancing circuit as before. Negative battery is connected to the junction point of the loop and balancing circuit. The loop L functions to receive signals from the metallic circuit MLE, to transmit signals to the carrier circuit MLW, and to repeat signals received from the line MLE to the carrier circuit MLW. In a similar manner the loop L' is arranged to receive signals from the carrier circuit MLW, transmit signals to the metallic line MLE, and repeat signals from the carrier circuit to the metallic line. The battery connection to one end of the loop L' is controlled by the receiving relay RW of the receiving carrier channel. The other end of the loop is balanced, the windings of the transmitting relay PE being arranged in the loop circuit and the balancing circuit; positive battery is connected to the junction point of the loop L' and the balancing circuit NE.

The operation is as follows: Signals incoming from the metallic line MLE being transmitted as direct current impulses of opposite sign operate the polar receiving relay RE to shift its armature from its normal contact to its alternate contact. When the armature of the receiving relay is shifted to its alternate contact, negative battery is connected with both ends of the loop L, so that no current flows in the loop and the sounders therein respond to the interruptions in the current flow. Each time the current flow ceases in the manner described, the upper winding of the transmitting polar relay PW is deenergized and the lower winding becomes effective to shift the armature of the relay, thereby closing the short circuit connection 11 to the grid of the amplifier TA, thus interrupting the transmission of the carrier frequency from the generator G to the metallic line MLW. Signals from the carrier circuit MLW are transmitted as interruptions of the carrier frequency. Each time the carrier frequency is interrupted the

polar receiving relay RW associated with the carrier receiving channel shifts its armature to the connection leading to positive battery, so that the positive battery is connected to both ends of the loop L', thereby causing the sounders in the loop L' to fall off. The cessation of current flow in the loop L' results in the deenergization of the upper winding of the polar relay PE, so that the lower winding becomes effective to shift the armature of said relay, thereby reversing the direction of current flow over the metallic line MLE so that the signals are transmitted over said line. If desired, a polar sounder PE' may be bridged across the transmitting circuit 20 of the metallic line, said sounder responding to the signals transmitted by the polar relay PE to the metallic line.

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

What is claimed is:

1. In a signaling system, a carrier transmitting channel, a telegraph circuit, a balancing circuit therefor, a polar transmitting relay having windings in the telegraph circuit and balancing circuit, said relay controlling said carrier transmitting channel, a source of current connected to the junction point of the windings of the polar relay and a source of current associated with the opposite end of said telegraph circuit in such a manner as to be series-aiding with respect to said first mentioned source.

2. In a signaling system, a carrier transmitting channel, a telegraph loop circuit, a balancing circuit for said loop, a polar transmitting relay having windings in said loop and said balancing circuit, said polar relay controlling said carrier transmitting channel, a source of current connected to the junction point of the windings of said polar relay, a second source connected to the opposite end of said loop, said second source being so poled as to be series-aiding with respect to said first mentioned source, a low frequency telegraph line, receiving apparatus associated therewith, and means controlled by said receiving apparatus for connecting and disconnecting said second mentioned source from said loop.

3. In a signaling system, a carrier receiving channel, a receiving relay associated therewith, a telegraph circuit, a source of current connected to said telegraph circuit over one contact of said receiving relay, a second source of current associated with the opposite end of said telegraph circuit, said source being so poled as to be series-aiding with respect to said first mentioned source, and a third source of current connected to

a contact of said receiving relay opposite to said first mentioned contact, whereby, when the armature of the relay is shifted, two sources of current which are mutually opposing are connected to the opposite ends of the telegraph circuit.

4. In a signaling system, a carrier receiving channel, a receiving relay associated therewith, a telegraph loop, a source of current connected to said loop over one contact of said receiving relay, a second source of current connected to the opposite end of said loop, said second source being so poled as to be series-aiding with respect to said first mentioned source, and a third source of current connected to another contact of said receiving relay, said third source being so poled that when the armature of the receiving relay is shifted from its normal position, mutually opposed sources are connected to the opposite ends of the loop, a low frequency telegraph line, means associated with the end of the loop to which said second mentioned source is connected for transmitting signals over said telegraph line in response to the action of said receiving relay.

5. In a signaling system, a carrier transmitting channel, a carrier receiving channel, a telegraph circuit, a balancing circuit therefor, a polar transmitting relay having windings in said telegraph circuit and balancing circuit, said polar transmitting relay controlling said carrier transmitting channel, a receiving relay associated with said carrier receiving channel, a source of current connected to the junction point of the windings of said polar transmitting relay over one contact of said receiving relay, a source of current associated with the opposite end of said telegraph circuit, said source being so poled as to be series-aiding with respect to said first mentioned source, and a third source of current connected to a second contact of said receiving relay, said third source being so poled that when the armature of said receiving relay is shifted, sources of current which are mutually opposed will be connected to the opposite ends of said telegraph circuit.

6. In a signaling system, a carrier transmitting channel, a carrier receiving channel, a telegraph loop, a balancing circuit therefor, a polar transmitting relay having windings in said loop and balancing circuit, said polar relay controlling said carrier transmitting channel, a receiving relay associated with said carrier receiving channel, a source of current connected to the junction point of the windings of said polar transmitting relay over one contact of said receiving relay, a source of current connected with the opposite ends of said loop, said source being so poled as to be series-aiding with respect to said first mentioned source, and a third source of current con-

connected to another contact of said receiving relay, said third source being so poled that when the armature of the receiving relay is shifted, mutually opposed sources will be connected to opposite ends of said loop, a telegraph line, transmitting apparatus and receiving apparatus associated therewith, means whereby said receiving apparatus controls the connection and disconnection of said second mentioned source with said loop, and means associated with said loop for controlling the transmitting apparatus of said telegraph line.

7. In a signaling system, a carrier transmitting channel, a carrier receiving channel, a telegraph circuit, a balancing circuit therefor, a polar relay arrangement having windings in said telegraph circuit and balancing circuit, said polar relay arrangement controlling said transmitting channel, a receiving relay associated with said carrier receiving channel, a source of current connected to the junction point of the windings of said polar relay arrangement over one contact of said receiving relay, a source of current associated with the opposite end of said telegraph circuit, said source being so poled as to be series-aiding with respect to said first mentioned source, a third source of current connected to another contact of said receiving relay, said source being so poled that when the contact of said receiving relay is shifted, mutually opposed sources will be connected to opposite ends of said telegraph circuit, and means controlled by said polar relay arrangement whereby, when signals are initiated in said telegraph circuit, said first mentioned source of current is connected to the junction point of the windings of said polar relay independently of said receiving relay.

8. In a signaling system, a carrier transmitting channel, a carrier receiving channel, a telegraph loop, a balancing circuit therefor, a polar relay arrangement having windings in said loop and balancing circuit, said polar relay arrangement controlling said carrier transmitting channel, a receiving relay associated with said carrier receiving channel, a source of current connected to the junction point of the windings of said polar relay arrangement over one contact of said receiving relay, a source of current associated with the opposite end of said loop, said source being so poled as to be mutually aiding with respect to said first mentioned source, a third source of current connected to another contact of said receiving relay whereby, when the armature of said relay is shifted, mutually opposed sources will be connected to opposite ends of said loop, a telegraph line, transmitting apparatus and receiving apparatus associated therewith, said receiving apparatus controlling the connection and disconnection of said

second mentioned source of current with said loop, means associated with said loop for controlling said transmitting apparatus and means controlled by said polar relay arrangement whereby, when signals are transmitted over said loop, originating in said loop or incoming from said telegraph line, said first mentioned source of current will be connected to the junction point of the windings of said polar relay arrangement independently of said receiving relay.

9. In a signaling system, a carrier transmitting channel, a low frequency telegraph line, a telegraph loop associated with said transmitting channel and said line, a balancing circuit for said loop, a polar transmitting relay having windings in said balancing circuit and said loop, said polar relay controlling said carrier transmitting channel, a source of current connected to the junction point of the windings of said polar relay, a receiving relay associated with said line, a source of current connected to said loop over one contact of said receiving relay, said source being so poled as to be mutually aiding with respect to said first mentioned source, and a third source connected to another contact of said receiving relay whereby, when the armature of the receiving relay is shifted mutually opposed sources are connected to the opposite ends of said loop.

10. In a signaling system, a carrier receiving channel, a low frequency telegraph line, a telegraph loop, a balancing circuit therefor, a polar relay having windings in said balancing circuit and said loop, transmitting apparatus associated with said telegraph circuit and controlled by said polar relay, a source of current connected to the junction point of the windings of said polar relay, a receiving relay associated with said carrier receiving channel, a second source of current connected to one contact of said receiving relay, said source being so poled as to be series-aiding with respect to said first mentioned source, and a third source connected to another contact of said receiving relay, whereby, when the armature of said relay is shifted, mutually opposed sources will be connected to opposite ends of said loop.

11. In a signaling system, a carrier transmitting channel, a carrier receiving channel, a low frequency telegraph line, a telegraph loop having its ends associated with said carrier channels and the said telegraph line, balancing circuits for said loop at each end thereof, a polar relay having windings in one end of said loop and in the corresponding balancing circuit, said polar relay controlling said carrier transmitting channel, a second polar relay having windings in the opposite end of said loop and in the corresponding balancing circuit, transmitting ap-

paratus associated with said telegraph line, said transmitting apparatus being controlled by said second polar relay, a carrier receiving relay associated with said carrier receiving channel, a source of current connected with the junction point of the windings of said first mentioned polar relay over one contact of said carrier receiving relay, a telegraph receiving relay associated with said telegraph line, a second source of current connected to the junction point of the windings of said second polar relay over one contact of said telegraph receiving relay, said second source being so poled as to be mutually aiding with respect to said first source, and a third source connected to another contact of said carrier receiving relay, said third source being so poled that when the armature of said carrier receiving relay is shifted and said second source is connected to the loop, said second and third sources will be mutually opposed, a fourth source connected to another contact of said telegraph receiving relay, said fourth source being so poled that when the armature of said telegraph receiving relay is shifted, and said first mentioned source is connected to the loop, said first and fourth sources will be mutually opposed.

12. In a signaling system, a carrier transmitting circuit, a carrier receiving circuit, a low frequency telegraph line, a telegraph loop having its ends associated with said carrier channels and said telegraph line, balancing circuits associated with each end of said loop, a polar relay arrangement having windings in the end of said loop and the corresponding balancing circuit associated with said carrier channels, said polar relay arrangement controlling said carrier transmitting channel, a second polar relay arrangement having windings in the end of said loop and the corresponding balancing circuit associated with said telegraph line, a transmitting apparatus associated with said telegraph line, said transmitting appa-

ratus being controlled by said second polar relay arrangement, a carrier receiving relay associated with said carrier receiving channel, a source of current connected to the junction point of the windings of said first mentioned polar relay arrangement over one contact of said carrier receiving relay, a telegraph receiving relay associated with said telegraph line, a source of current connected to the junction point of the windings of said second polar relay over one contact of said telegraph receiving relay, said second source being so poled as to be mutually aiding with respect to said first mentioned source, a third source connected to another contact of said carrier receiving relay, said third source being so poled that when the armature of the receiving relay is shifted and said second source is connected to the loop, said second and third sources will be mutually opposed, and a fourth source connected to another contact of said telegraph receiving relay, said source being so poled that when the armature of said receiving relay is shifted and said first source is connected to the loop, said first and fourth sources will be mutually opposed, means controlled by said first polar relay arrangement whereby, when signals are transmitted over the loop from the opposite end thereof, said first mentioned source will be connected to the junction point of the windings of said first polar relay arrangement independently of the carrier receiving relay, and means controlled by said second polar relay arrangement whereby, when signals are transmitted over the loop from the opposite end thereof, said second source will be connected to the junction point of the windings of said polar relay arrangement independently of said telegraph receiving relay.

In testimony whereof, I have signed my name to this specification this 18th day of October, 1920.

BAXTER P. HAMILTON.