May 29, 1923. 1,456,549

B. P. HAMILTON

COMPOSITE SIGNALING CIRCUITS

Filed Aug. 29, 1919 3 Sheets-Sheet 1

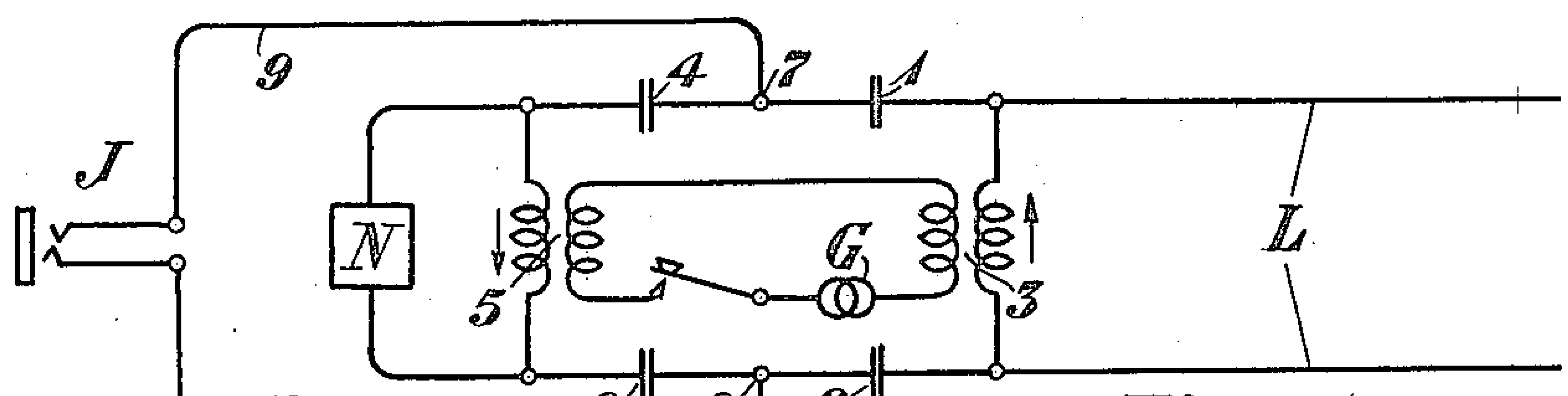

Fig. 1

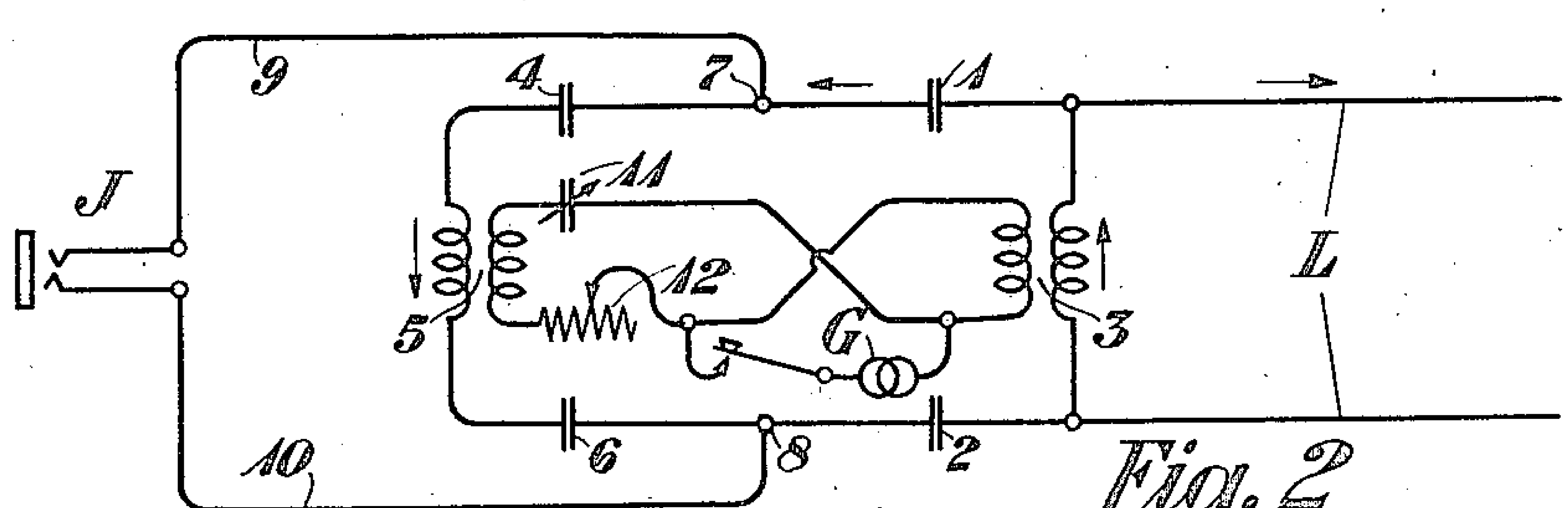

Fig. 2

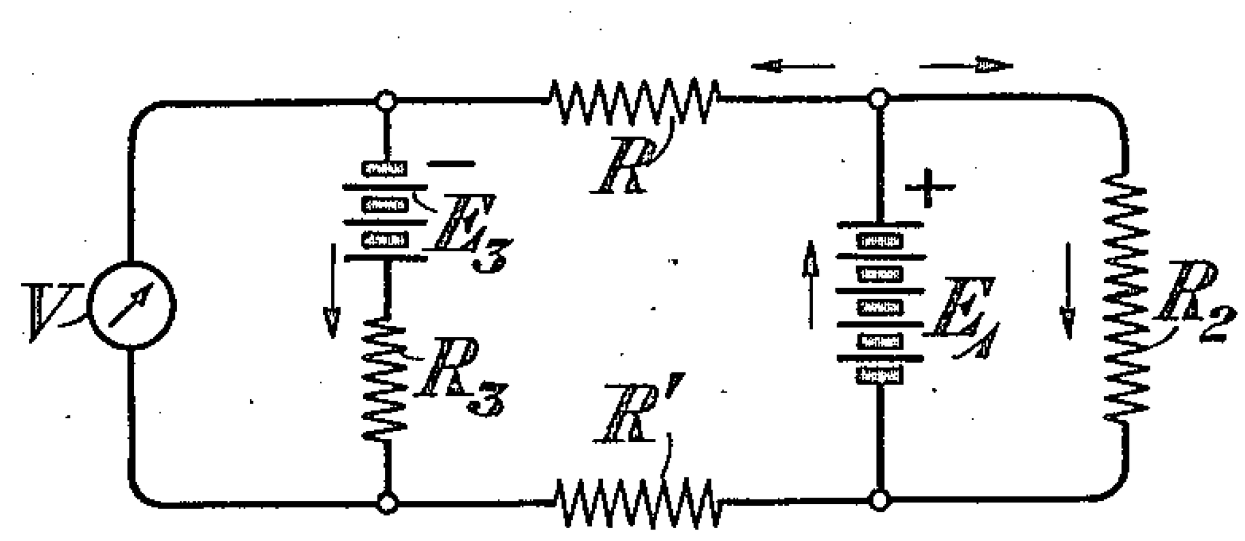

Fig. 3

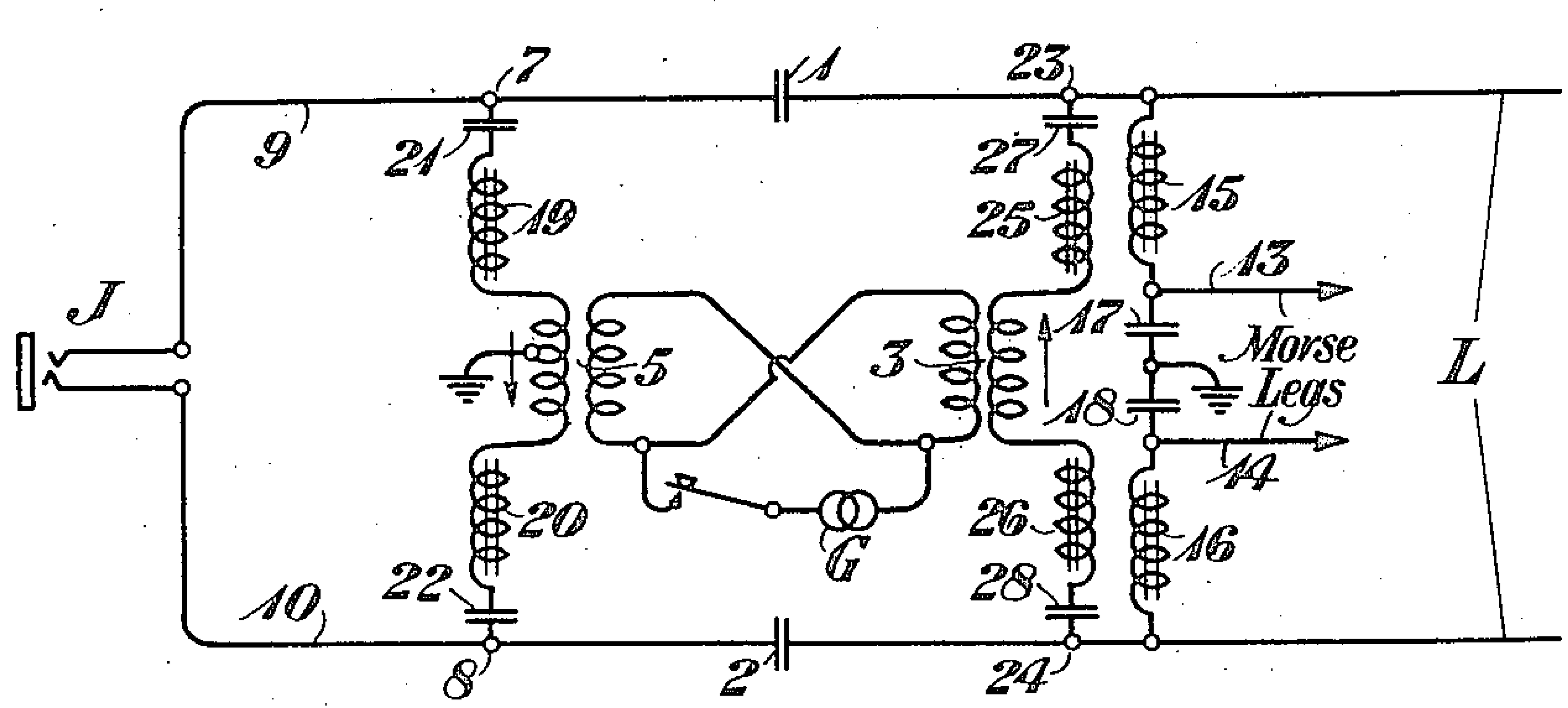

Fig. 4

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COMPOSITE SIGNALING CIRCUITS

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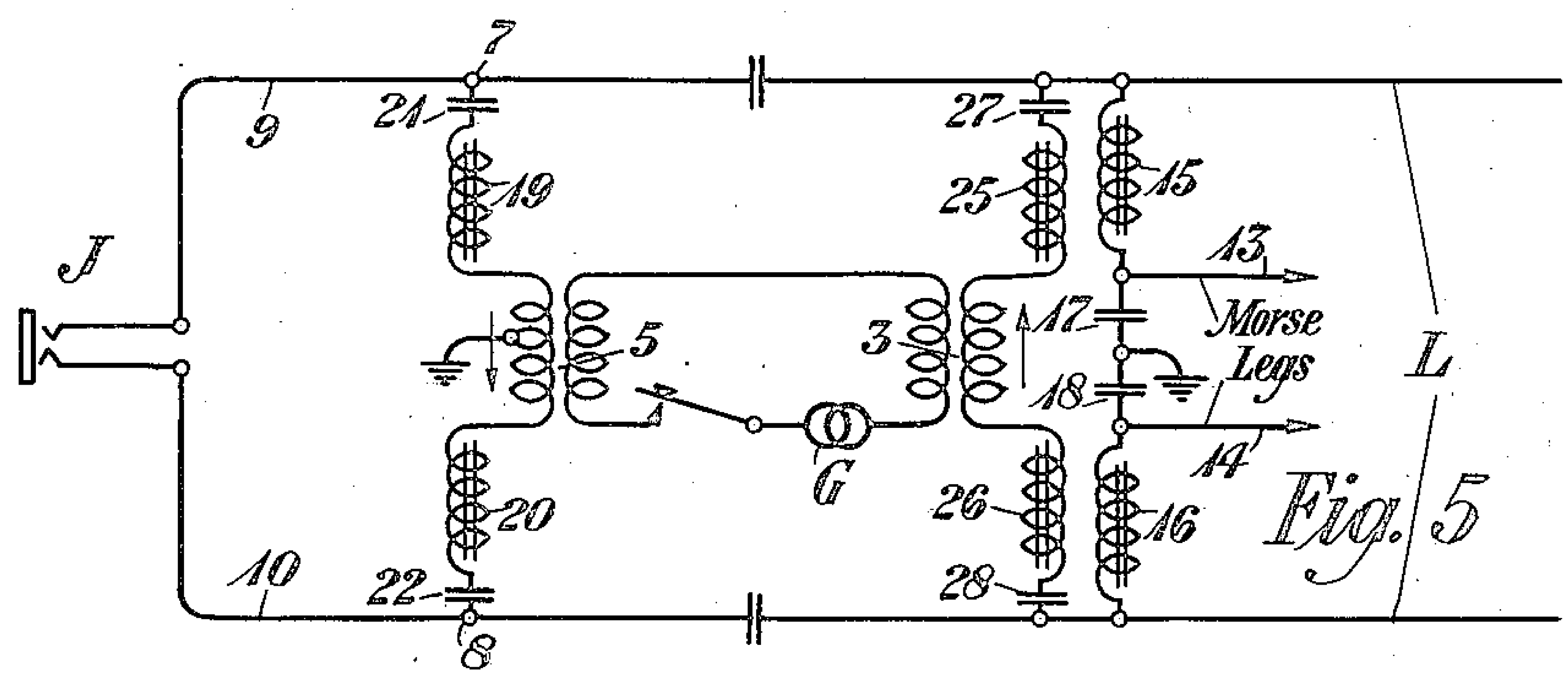

Fig. 5

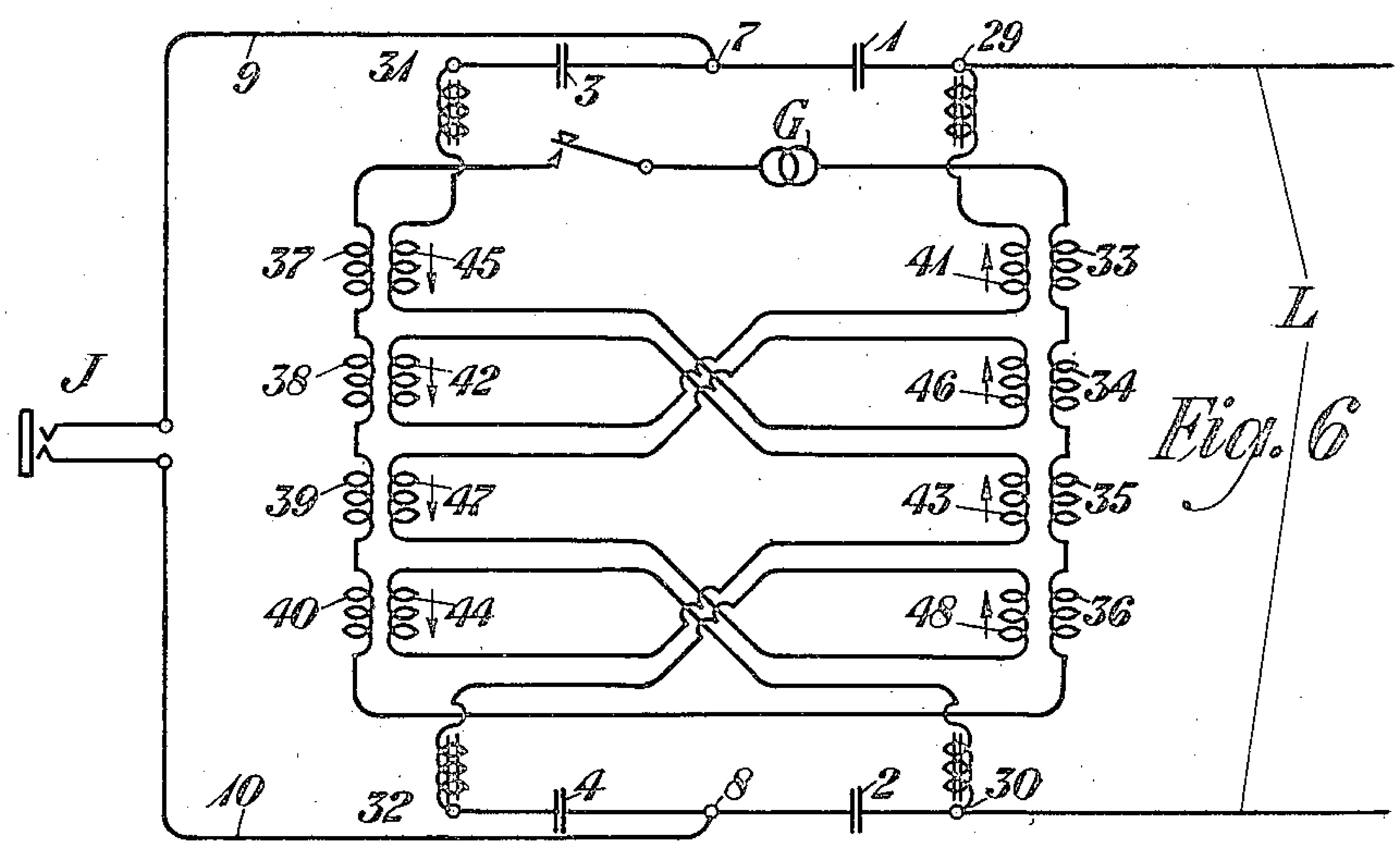

Fig. 6

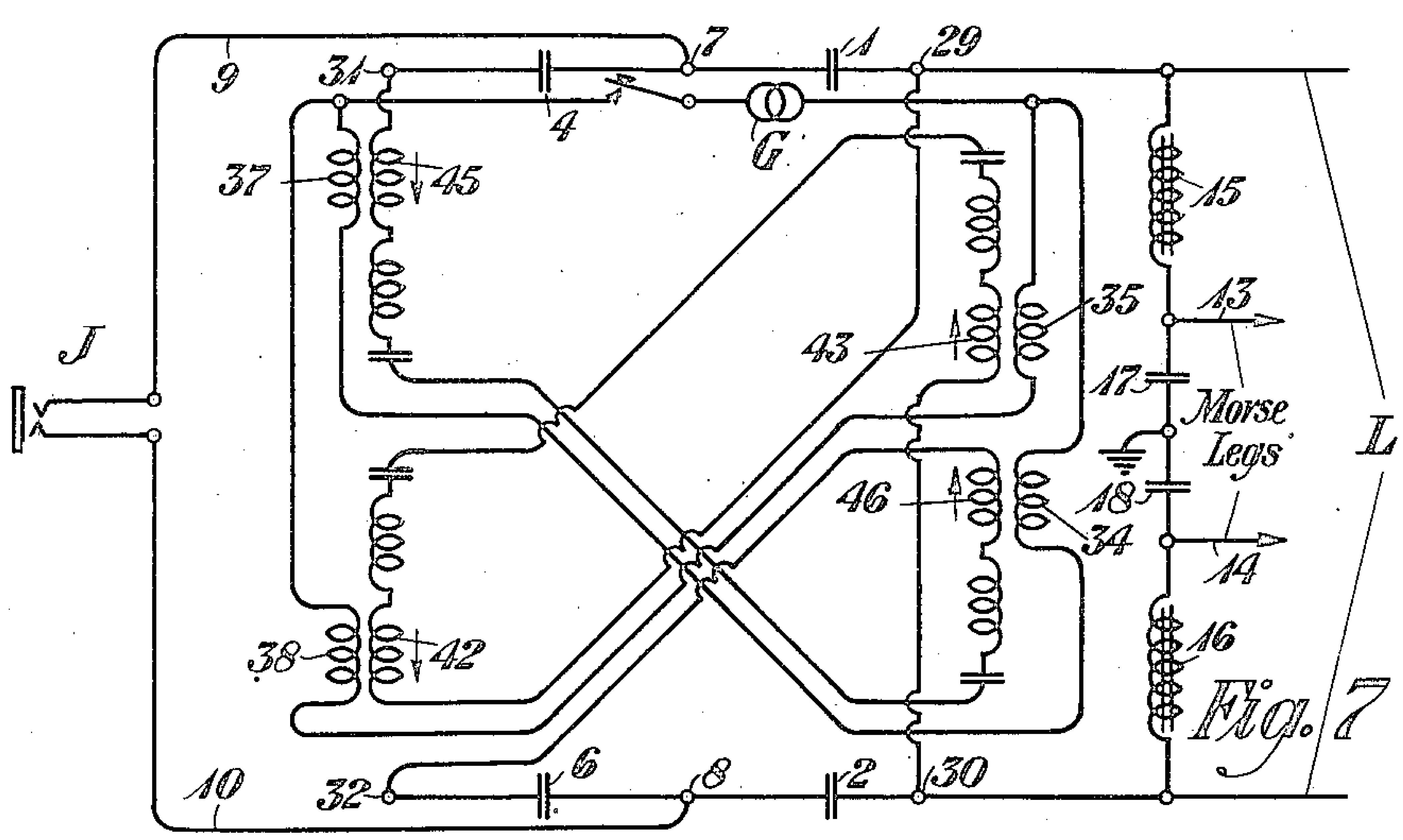

Fig. 7

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COMPOSITE SIGNALING CIRCUITS

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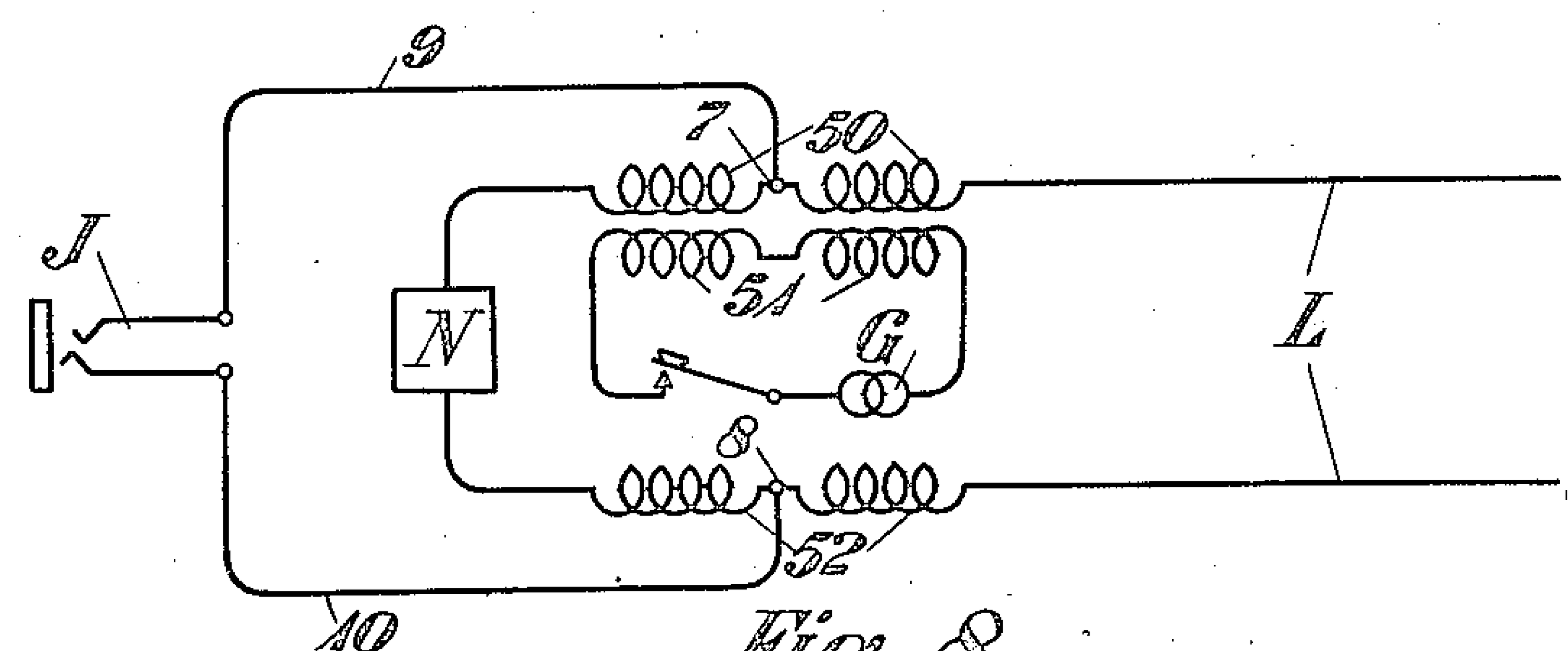

Fig. 8

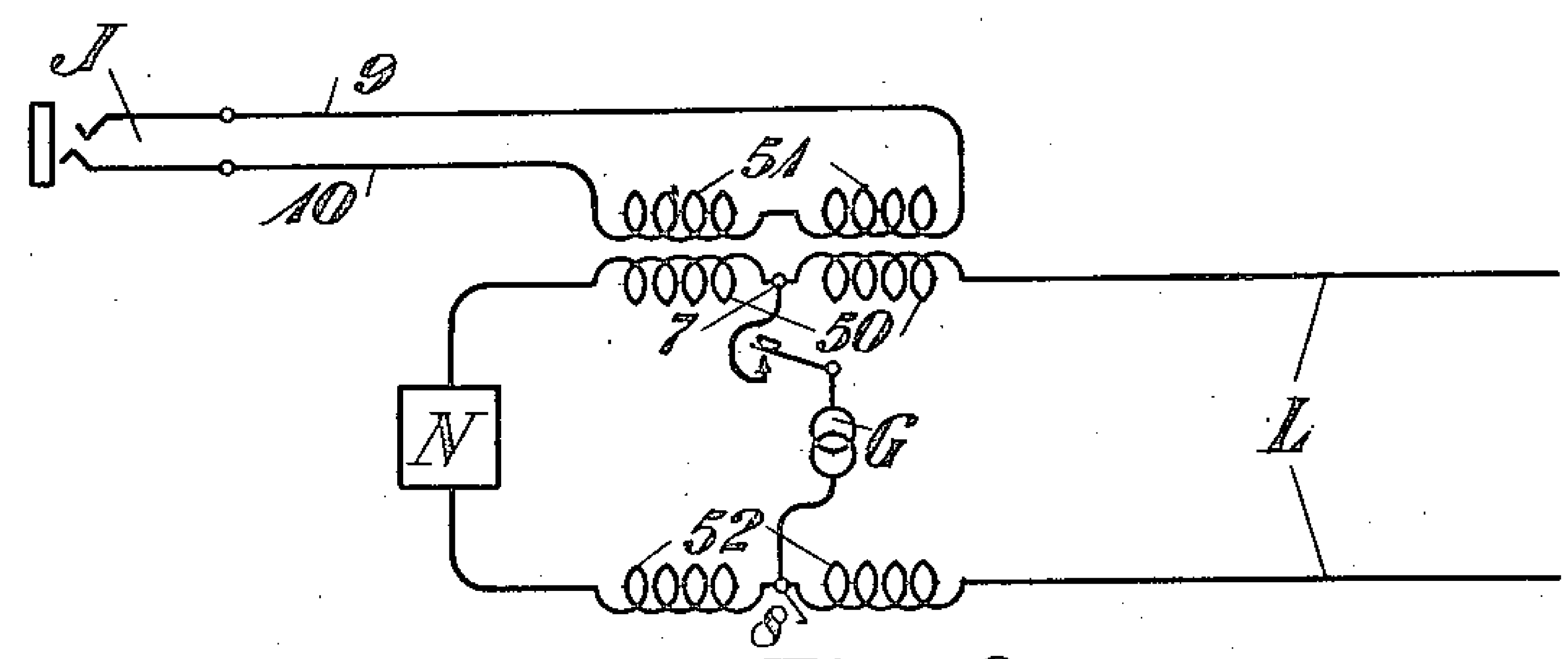

Fig. 9

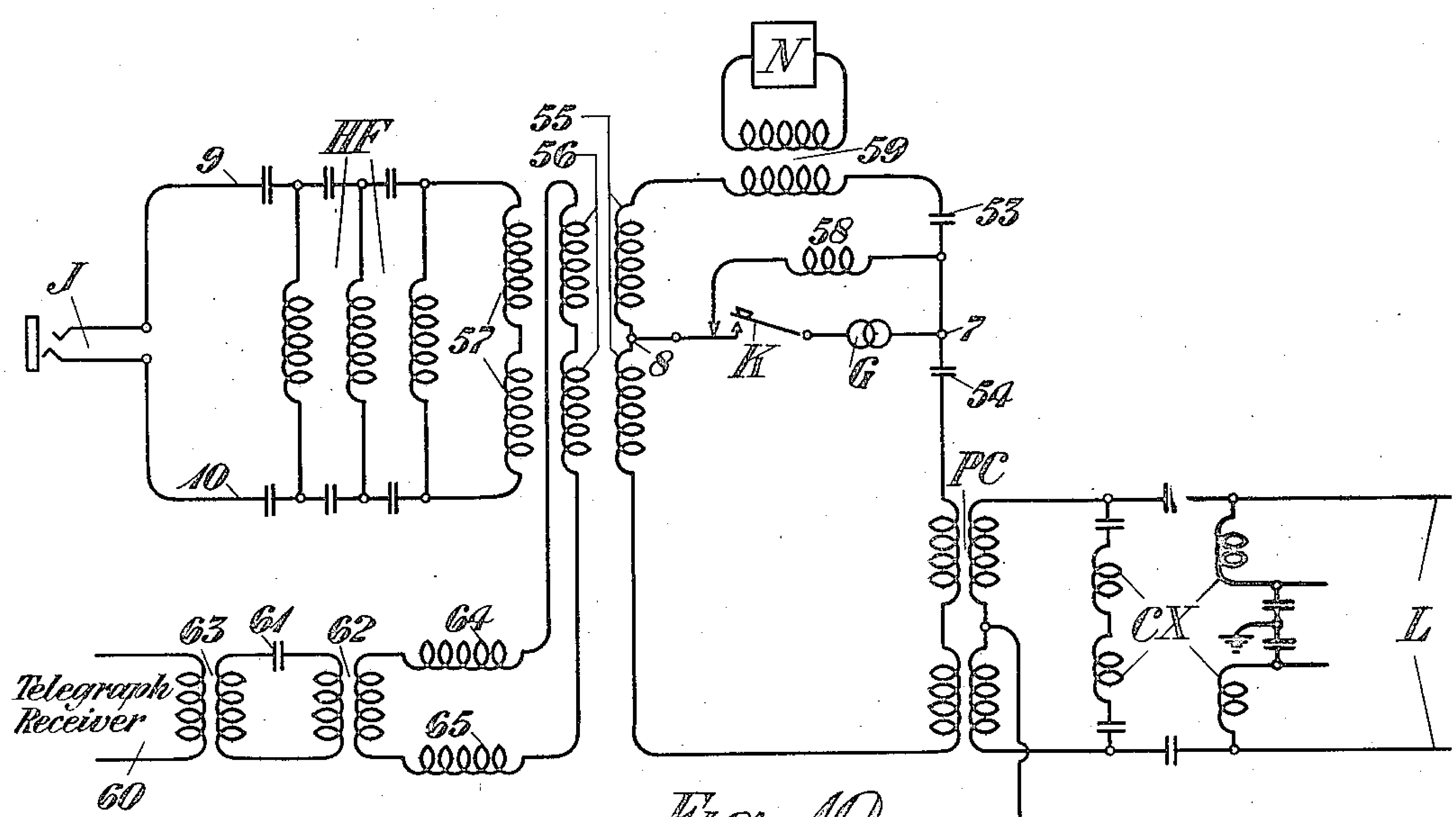

Fig. 10

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Patented May 29, 1923. 1,456,549

UNITED STATES PATENT OFFICE.

BAXTER P. HAMILTON, OF BROOKLYN, NEW YORK, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

COMPOSITE SIGNALING CIRCUITS.

Application filed August 29, 1919. Serial No. 320,705.

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 Composite Signaling Circuits, of which the following is a specification.

This invention relates to transmission circuits and more particularly to transmission circuits of the type in which a plurality of signaling channels are imposed upon the same circuit.

It has been proposed in connection with a telephone transmission circuit (which may, if desired, be composited to provide the usual direct current telegraph channels) to superimpose upon such circuit an additional signaling channel in which alternating currents of fairly low frequency are employed for transmitting the signals.

It is one of the objects of the present invention to provide a circuit arrangement by which the above results may be obtained, and which is so arranged that the alternating signaling current shall not interfere with the terminal telephone apparatus. This object, as well as others more fully appearing hereinafter, are accomplished in accordance with the present invention by providing a local balanced circuit with one side of which the transmission line is connected and upon both sides of which the alternating signaling currents are applied, so that between the two sides of the balanced circuit points may be found which are neutral with regard to the signaling currents. The terminal telephone apparatus is connected to these neutral points so that the signaling currents do not flow to the terminal circuit.

The invention may now be more fully understood by reference to the following description when read in connection with the accompanying drawings, Figures 1, 2, 4, 5, 6, 7, 8, 9 and 10 of which constitute diagrams of different modifications of the invention, and Fig. 3 of which is a schematic diagram illustrating the principle of certain of the circuits.

A simple form of the invention is illustrated in Fig. 1, in which the transmission line L is shown connected to one side of a local balanced circuit comprising capacities 1 and 2 balanced against capacities 4 and 6. Alternating signaling current from a source G is applied to the two sides of the local balanced circuit through similar transformers 3 and 5, so that at a given instant currents will tend to flow in the local circuit in the direction shown by the arrows. If the local circuit be considered alone independent of the line L and other associated equipment, it will be seen that neutral points exist at 7 and 8 with respect to the oscillations applied through transformers 5 and 6. An artificial line N is connected to the left-hand side of the local balanced circuit to balance the line L. If a proper balance is maintained between the artificial line and the real line, the neutral points will still exist at 7 and 8, and consequently no current from the source G will flow through the conductors 9 and 10 connected to said points. If the conductors 9 and 10 be led to terminal telephone equipment as indicated at the jack J, the telephone equipment will be unaffected by the signaling current from the source G.

A modified arrangement by which the artificial line may be omitted is shown in Fig. 2. In this figure the local balanced circuit is arranged as before, but the artificial line N is omitted, and instead a capacity 11 and a resistance 12 are provided in the primary circuit of the transformer 5, these elements being adjustable so that the proper phase relations and amplitudes of the potentials impressed upon the two halves of the balanced circuit may be maintained.

The principle upon which this arrangement operates may be understood from Fig. 3 in which R_2 is a resistance corresponding to the line L, while R and R′ are impedances corresponding to the capacities 1 and 2 of Fig. 2. Assuming a source of voltage E_1 connected as shown, it will be seen that current from the source E_1 will tend to flow, part through the resistance R_2 in the direction indicated by the arrow, and part through the resistance R, indicating instrument V and resistance R′. Current may be prevented from flowing through the instrument V if an electromotive source E_3 be connected across the circuit as shown in series with a resistance R_3, the electromotive force E_3 tending to cause current to flow through the battery B_3 and resistance R_3 in the direction indicated by the arrow, and said source being so proportioned as to develop an electromotive force across the terminals of the indicating means V equal to and opposite in sign to that existing across the terminals by reason of the voltage E_1 applied through resistance R and R′.

Comparing this arrangement with that shown in Fig. 2, the operation of the latter circuit will at once be clear. At a given instant the voltage applied to the transformer 3 tends to cause current to flow over line L in the direction of the arrow and also through condensers 1 and 2 in the direction indicated. At this same instant voltage may be applied through the transformer 5 of such value and direction as to equalize the potential drop between points 7 and 8 due to the voltage applied through capacities 1 and 2. Consequently, if the phase relation is properly adjusted by capacity 11 and the amplitude is properly determined by the impedance 12, points 7 and 8 will be neutral with respect to source G and no current will flow over the conductors 9 and 10 to the telephone apparatus.

Fig. 4 illustrates a slightly modified arrangement of the invention as applied to a telephone circuit composited for direct current Morse operation. In this figure the Morse legs 13 and 14 are connected to the telephone circuit L through impedances 15 and 16 adapted to prevent high frequency telephone currents from flowing through the Morse legs, condensers 17 and 18 being provided to shunt to ground the higher frequencies in the telegraph impulses transmitted from the Morse legs 13 and 14. Capacities 1 and 2 readily permit of the passage of telephone current but tend to prevent the transmission of Morse currents. Impedance elements 19 and 20 and capacities 21 and 22 shunted to ground from points 7 and 8 provide paths to ground for any telegraph currents which pass through the condensers 1 and 2, thereby preventing the telephone apparatus connected to conductors 9 and 10 from reaction of Morse currents. Alternating signaling currents from the source G may be applied through transformers 3 and 5 to the bridge circuits connected between points 7 and 8, and 23 and 24 respectively. The latter bridge circuit includes inductances 25 and 26 and capacities 27 and 28 whereby the bridge is tuned to the frequencies of the currents from the source G. The transformers 3 and 5 are so proportioned with reference to each other that the voltage impressed across points 7 and 8 through the transformer 5 will be equal to and opposite in sign to that impressed across said points through the transformer 3 and the capacities 1 and 2. Points 7 and 8 are therefore neutral with respect to the generator G, and the alternating signaling currents will not affect the telephone apparatus connected to the jack J.

Instead of applying the alternating currents to the transformer 3 and 5 through parallel circuits as shown in Fig. 4 a series connection of the transformers may be used as shown in Fig. 5. The operation of the circuit of Fig. 5 is, however, in all respects similar to that of Fig. 4 and need not be further described.

The arrangements shown in Figs. 4 and 5, while not causing as severe loss in telephonic energy as the circuit shown in Fig. 1, have the disadvantage that the phase relation and amplitude of the currents applied through the two transformers in the local balanced circuit will have to be adjusted with variations in the impedance of the external transmission circuit L. This will be clear from Fig. 3 since, assuming the circuit to be balanced so that no current flows through the indicating means V, if the resistance R_2 be increased or decreased, it will at once be necessary to vary the voltage of the source E_3 in order to maintain the balance.

An arrangement is illustrated in Fig. 6 which tends to obviate this difficulty and has the advantage that the local circuit will be at all times more nearly balanced regardless of the external impedance of the transmission line. The telephone loss due to the balanced circuit will be comparatively small due to the inductances 29, 30, 31 and 32. In this arrangement, the transformers, by means of which the source G is associated with the two sides of the balanced circuit, are each provided with a plurality of primary and secondary windings. The two sets of primary windings in the circuit of the generator G are designated as 33, 34, 35, 36 and 37, 38, 39 and 40 respectively. The bridge circuit between the points 29 and 30 includes four secondary windings of which 41 and 43 are associated with the righthand primary windings, and 42 and 44 are associated with the lefthand primary windings. Similarly a bridge circuit between points 31 and 32 includes four secondary windings of which 45 and 47 are inductively related to the lefthand primary windings and 46 and 48 are inductively associated with the righthand primary windings. Considering now the local balanced circuit as being disconnected from the line L and from the terminal conductors 9 and 10, it will be seen that voltages are applied through the several windings of the two transformers, so that neutral points occur at 7 and 8. If now the line L is connected to points 29 and 30 as shown, the energy supplied from the source G to the line L through the bridge connection between points 29 and 30 will be derived one-half from the righthand transformer arrangement and the other half from the lefthand transformer arrangement. Similarly the energy supplied to the line L through the bridge connected to points 31 and 32 is obtained one-half from the righthand transformer arrangement and the other half from the lefthand transformer arrangement. It follows, therefore, that the line L, regardless of its external impedance, receives its energy equally from both sides of the local balanced circuit, and does not, therefore, disturb the neutral condition of the points 7 and 8. The telephone apparatus associated with conductors 9 and 10, therefore, will not be affected by the signaling current supplied from the source G.

A slightly modified arrangement for securing even better balance as applied to a composited telephone circuit is shown in Fig. 7. In this arrangement the Morse legs 13 and 14 are associated with the line L in the same manner as illustrated in Figs. 4 and 5. The bridge connection between points 29 and 30 includes secondary windings 42 and 43 associated with the lefthand and righthand primary windings 38 and 35 respectively. Inductances and capacities are also included in the bridge connection to tune the same to the frequency of the source G. In a similar manner the bridge between points 31 and 32 in addition to inductances and capacities for the purpose of tuning, includes secondary windings 45 and 46 associated with the lefthand and righthand primary windings 37 and 34 respectively. It will be seen that this arrangement is balanced in a manner similar to that of Fig. 6 and consequently the points 7 and 8 will be neutral, so that the terminal telephone apparatus connected to conductors 9 and 10 will not be affected by currents from the source G. The fact that the composite apparatus associated with the Morse legs 13 and 14 is bridged across the line L does not affect the operation of the circuit as the local balanced circuit including capacities 1, 2, 4 and 6 remains balanced by reason of the peculiar transformer arrangement, regardless of the character of the circuit connected to the righthand side of the balanced arrangement at points 29 and 30.

A modified embodiment of the invention, somewhat analogous to that illustrated in Fig. 1, is shown in Fig. 8. In this case the telephone line L includes a three-winding transformer arrangement comprising windings 50, 51 and 52 and is balanced by an artificial line or network N. The terminal leads 9 and 10 of the telephone apparatus are then connected to midpoints 7 and 8 of the windings 50 and 52 in the telephone line. The source of signaling or telegraphic current G, together with the controlling key, is connected in series with the winding 51, so that when signaling current is applied to the telephone line through the transformer 50, 51, 52, points 7 and 8 are at substantially the same potential and a minimum reaction of the signaling current upon the terminal telephone apparatus results.

Since the terminal telephone apparatus and the circuit including the source of the signaling current G are conjugate, it is obvious that their connections may be interchanged as illustrated in Fig. 9, in which the source G is applied to the midpoints 7 and 8 of windings 50 and 52, while the terminal telephone conductors 9 and 10 are connected to the windings 53. The result in this case is the same as in Fig. 8, since the energy from the source G divides equally between the line L and the artificial line N, so that no current is induced in the winding 53 and consequently the telephone apparatus is substantially unaffected by the telegraph currents.

The arrangement shown in Fig. 10 is substantially the same as that illustrated in Fig. 9, but shows additional refinements of the circuit, including an arrangement for receiving the telegraph signals. In this case the line L is provided with the usual composite apparatus CX, for superposing Morse signals upon the telephone line and is further provided with the phantom coil PC, whereby the line may be used as one side of a phantom circuit in a well-known manner. Coupled with the line L, through the phantom coil PC, is a balanced circuit including condensers 53 and 54, together with a winding 55 of a transformer including two additional windings, 56 and 57. The generator G may be connected between points 7 and 8 of the balanced circuit, when the key K is operated. Normally, however, an impedance element 58 is connected across these points over a back contact controlled by the key K, the impedance element being so designed as to have substantially the same impedance as the generator G. An artificial line N, for balancing the line L, is associated with the balanced circuit through the transformer 59. The terminal telephone leads 9 and 10 are connected to the winding 57 of the three-winding transformer and a high pass filter HF is included in the terminal circuit. This filter is of the general type described in the U. S. patents to George A. Campbell, Nos. 1,227,113 and 1,227,114, dated May 22, 1917, and is so designed as to freely transmit frequencies above the lower limit ordinarily utilized in voice signaling, while substantially suppressing Morse frequencies and low alternating current frequencies such as are supplied from the generator G. An alternating telegraph receiving circuit 60 is connected to the transformer winding 56 of the three-winding transformer, through a filtering arrangement comprising capacity 61, transformers 62 and 63, and inductances 64 and 65.

When the key K is operated the generator G is bridged between points 7 and 8 and the energy therefrom divides between the line L and the artificial line N, so that substantially no energy is transmitted to the terminal telephone apparatus associated with the jack J. The telegraph receiving circuit 60 is also in conjugate relation with respect to the generator G and is therefore substantially unaffected by the current transmitted therefrom. Alternating signaling or telegraph current received over the line L is transmitted through the phantom coil PC to the balanced circuit, from which it is transmitted through the three-winding transformer arrangement 55, 56, 57 to the telegraph receiving circuit which is selective at this signaling frequency. The filter HF in the terminal telephone connection, offers a very high impedance to currents of this frequency, however, so that they are not transmitted to the terminal telephone apparatus with sufficient amplitude to cause material interference.

By means of the arrangements of this invention alternating signaling currents may be applied to a composite circuit without affecting the local terminal telephone apparatus associated therewith, and while the invention has been shown embodied in certain arrangements which are considered most desirable, it will be obvious that the general principles herein disclosed 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 composite signaling system, a metallic transmission line, a local balanced circuit associated therewith, means to compensate for the connection of the line to said balanced circuit whereby neutral points may be established, means to apply signaling currents to both sides of said balanced circuit for transmission over both sides of said metallic line, and terminal signaling apparatus connected to points of said balanced circuit which are neutral with respect to said signaling currents.

2. In a composite signaling system, a transmission line, a local balanced circuit associated therewith, means to compensate for the connection of the line to said balanced circuit whereby neutral points may be established, means to apply signaling currents to both sides of said balanced circuit for transmission over the line, and terminal telephone apparatus connected to points of said balanced circuit which are neutral with respect to said signaling currents.

3. In a composite signaling system, a local circuit comprising two sections, a metallic transmission line connected to one of said sections, means to compensate for the connection of the line to said section whereby neutral points may be established between the sections, means to apply signaling current to each of said sections for transmission over both sides of said metallic line, and terminal signaling apparatus connected to points between said sections which are neutral with respect to said signaling currents.

4. In a composite signaling system, a local circuit comprising two sections, a transmission line connected to one of said sections, means to compensate for the connection of the line to said section whereby neutral points may be established between the sections, means to apply signaling current to each of said sections for transmission over said line, and terminal telephone apparatus connected to points between said sections which are neutral with respect to said signaling currents.

5. In a composite signaling system, a local balanced circuit comprising two sections, a transmission line connected to one of said sections, a source of signaling current, a transformer for each section, having a secondary winding in each section, the primary windings of said transformers being connected to said source, said secondary winding being divided and arranged so that one half of each secondary is inductively related to one primary winding and the other half is inductively related to the other primary winding, whereby equal amounts of the signaling energy applied to the line is supplied over each section of said local circuit from each transformer, and terminal signaling apparatus connected to points between said sections which are neutral with respect to the signaling currents supplied to said sections.

6. In a composite signaling system, a local balanced circuit comprising two sections, a transmission line connected to one of said sections, a source of signaling current, a transformer for each section, having a secondary winding in each section, the primary windings of said transformers being connected to said source, said secondary windings being divided and arranged so that one half of each secondary is inductively related to one primary winding and the other half is inductively related to the other primary winding, whereby equal amounts of the signaling energy applied to the line is supplied over each section of said local circuit from each transformer, and terminal telephone apparatus connected to points between said sections which are neutral with respect to the signaling currents supplied to said sections.

7. In a composite signaling system, a local circuit comprising two sections, a transmission line connected to one of said sections, means to apply alternating signaling current to each of said sections for trans-

mission over said line, terminal telephone apparatus connected to points between said sections which are neutral with respect to said signaling currents, a direct current telegraph apparatus associated with said line, means to substantially prevent telephone currents or alternating signaling currents from affecting said telegraph apparatus, and means to substantially prevent direct current telegraph impulses from affecting said telephone apparatus.

In testimony whereof, I have signed my name to this specification this 27th day of August, 1919.

BAXTER P. HAMILTON.