R. E. PIERCE.

ELECTROMAGNETIC DEVICE.

APPLICATION FILED DEC. 13, 1918.

1,368,288. Patented Feb. 15, 1921.

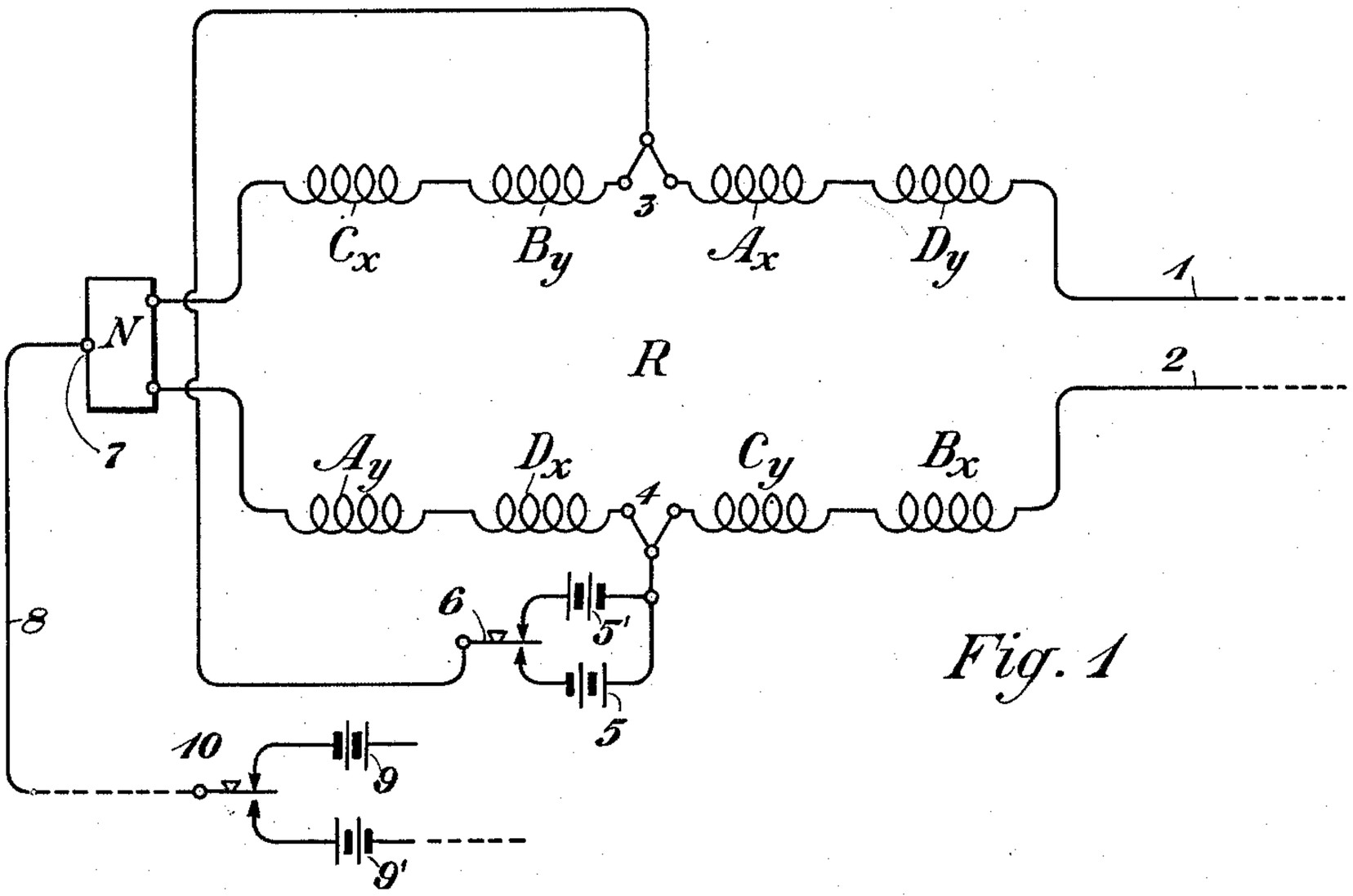
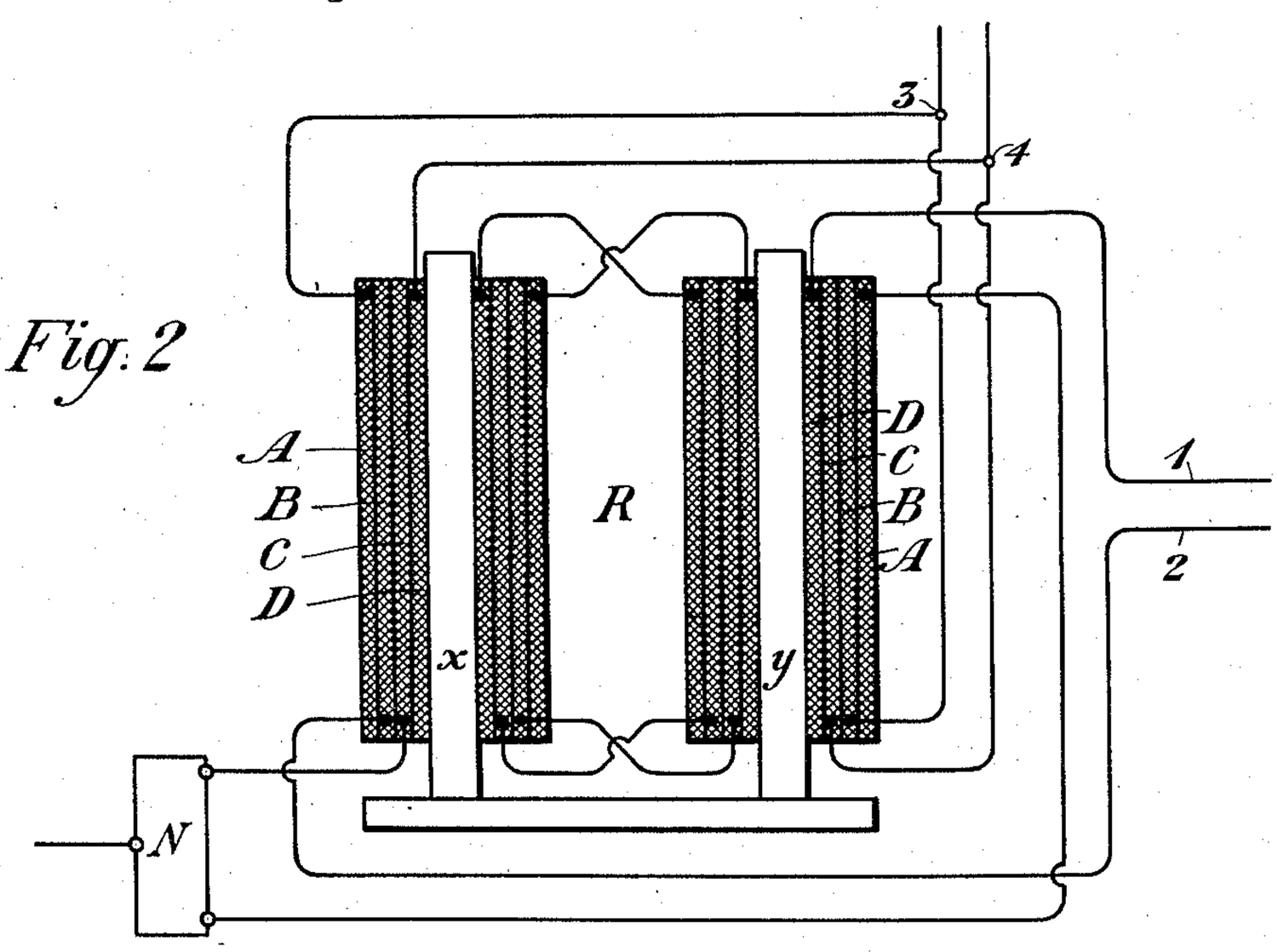


Fig. 1

Fig. 2



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ELECTROMAGNETIC DEVICE.

1,368,288. Specification of Letters Patent. Patented Feb. 15, 1921.

Application filed December 13, 1918. Serial No. 266,631.

To all whom it may concern:

Be it known that I, RALPH E. PIERCE, residing at Larchmont, in the county of Westchester and State of New York, have invented certain Improvements in Electromagnetic Devices, of which the following is a specification.

This invention relates to electromagnetic devices and particularly to balanced relays, magnetic switches and the like. It is especially useful in composite telephone and telegraph systems where complete metallic circuits are provided for both kinds of messages, over the same line conductors as described in the copending application of Osborne and Parker Serial No. 266,326, filed December 11, 1918, assigned to the same assignee as this application, but is obviously applicable to a variety of apparatus as will appear hereinafter.

It is very desirable in a system of the kind mentioned for instance to have the relay winding equally divided between the two telegraph leads in order to avoid unbalancing the telephone system. Where the telegraph circuit is arranged for duplex working it is further necessary that the relay windings be in two sections having equal and opposite magnetic effects with respect to currents from the local transmitter, but cumulative with respect to currents from the distant transmitter. Where the telegraph circuits are arranged to provide a phantom circuit it is also necessary to have the relay windings produce equal and opposite magnetic effects with respect to the phantom current which necessarily enters the relay windings at a point different from that at which the local transmitter current enters. It is the object of the present invention to provide an electromagnetic device so constructed, wound and connected that the electrical and magnetic effects will be balanced when subjected to condition such as above indicated.

I have illustrated the invention as embodied in a telegraph relay provided with eight windings, so disposed that their magnetic effects will be balanced for both side circuit and phantom circuit transmission when connected into a circuit of the character heretofore mentioned, and so arranged that the resistance in each branch of the circuit is substantially the same for current coming either from the side circuit transmitter or the phantom circuit transmitter. As will appear hereinafter, the invention is especially adapted for a circuit of the character shown in the copending application of H. S. Osborne, Serial No. 276,485, filed Feb. 12, 1919, assigned to the same assignee as this application, though it is obviously not limited to this use.

The invention will be more fully described in connection with the accompanying drawings in which Figure 1 is a diagram of the electrical connections of a relay embodying the invention and Fig. 2 is a schematic showing of the relay indicating the arrangement of the windings on the magnet cores.

Leads 1 and 2 represent the opposite sides of a telegraph circuit which may be connected to a metallic telephone circuit in accordance with the disclosure of the above mentioned copending applications. The receiving relay R is provided with eight windings, four being connected serially in each of the leads 1 and 2. To provide for duplex working, the other ends of the two sets of relay windings are connected to an artificial line N and the sending apparatus is bridged across the center points of the two sets of relay windings as shown at 3 and 4. This apparatus is indicated herein by batteries 5, 5′ and key 6, though it is to be understood that any suitable sending apparatus may be used, such for instance as is indicated in the above mentioned applications.

To provide for phantoming the telephone or the telegraph circuit, the elements of the artificial line N are arranged to provide a neutral point 7 to which is connected a conductor 8 constituting one of the two phantom leads. The other lead will connect with a similar neutral point in another telegraph circuit which may be a duplicate of that here illustrated and which it is therefore unnecessary to show or describe in detail or to a ground return. It will be understood that this phantom circuit may likewise be arranged for duplex transmission if desired but for the purposes of this invention it is sufficient to indicate merely the sources of sending current 9, 9′ and the key 10.

With a circuit arranged as above described, it will be apparent that the current of outgoing signals may flow through the relay windings from either the source 5—5′, or the source 9—9′. Current from the

source 5—5′ will divide at 4, traversing the two pairs of windings in lead 2 in parallel, one portion of the current flowing out over the line to the receiving station and the other through the artificial line N, and will return through the two pairs of windings in the lead 1, reuniting at 3 and thus back to the source. Current from 9—9′ will divide at 7 between the two halves of the artificial line and pass in parallel through the four windings in the leads 1 and 2 respectively, and return to the source 9—9′ over the other half of the phantom circuit not shown.

Inasmuch as the relay is not intended to respond to currents from either source 5—5′ or source 9—9′, it will be obvious that the windings of the relay must be so disposed as to be balanced for current entering them from either of these sources. The current which is intended to operate the relay comes from a distant station over the line 1, passes through the upper set of relay windings, the sending branch connecting 3 and 4 and the artificial line in parallel, the lower set of relay windings, line 2, and back to the source. It will also be clear that the windings in either branch of the circuit, whether we consider the current flowing from 5—5′ or from 9—9′, must have substantially equal impedances for without this the currents and therefore the magnetic effects of the two branches will not be the same notwithstanding the fact that they may have a like number of turns similarly disposed upon the magnet core.

The arrangement of windings to produce the necessary balance for sending-current from either source 5—5′ or 9—9′ is indicated in Fig. 2. The magnet is provided with two cores *x* and *y* and on each core are four windings A, B, C, and D arranged concentrically as shown on the drawing. The outer winding A on core *x* is connected to the inner winding D on core *y*, and the inner winding D on core *x* is connected to the outer winding A on core *y*. The next to the outer winding B on core *x* is connected to the next to the inner winding C on core *y* and the next to the inner winding C on core *x* is connected to the next to the outer winding B on core *y*. These connections are indicated in Fig. 2 but more clearly in Fig. 1 where the eight windings are designated by the appropriate letter A, B, C, or D, with the character *x* or *y* suffixed to indicate the core on which the particular winding is located.

It will be observed that the windings D, being immediately next to the cores, will have a less resistance than the windings C, and so on outward, the windings A having the greatest resistance, assuming that they have substantially the same number of turns, which is necessary in order that they may be balanced magnetically. With windings arranged in this manner to give substantially equal magnetic effects, the impedance of winding A plus the impedance of winding D is substantially equal to the impedance of winding B plus the impedance of winding C. With the windings disposed on the cores and connected as above described it will be observed that, whether the current be flowing from the source 5—5′ or from the source 9—9′ there is an "A," a "B," a "C" and a "D" winding in each branch of the circuit and that each branch, in either instance, has two windings on each of the two magnetic cores. Furthermore, by connecting the "A" windings to the "D" windings and the "C" windings to the "B" windings, as above indicated, the halves of the branch circuits are likewise balanced. Thus for current dividing at the point 7 and proceeding over the upper and lower windings, as shown in Fig. 1, the potential drops to the points 3 and 4, respectively, will be the same. If it were not for this there would be a current flow across the sending bridge between 3 and 4, whenever this bridge was closed, as it frequently would be. Any current from source 9—9′ taking such a course would obviously unbalance the whole relay. Similarly it is necessary that current from source 5—5′ have no tendency to traverse the bridge formed by the phantom leads at each end of the line, and it will be noticed that the arrangement shown likewise avoids any such tendency.

In a magnetic device subject to circuit conditions such as here described, it is not sufficient that the ordinary requirement of balance in a Wheatstone bridge be satisfied *i. e.* that $\frac{a}{b}=\frac{c}{d}$ where *a*, *b*, *c*, and *d*, represent the four arms, but it is further necessary that the actual impedances in either branch of the circuit be the same whether the branching be considered as from the point 3 or the point 7.

By arranging the relay windings to be balanced for all currents, as above indicated, it will be obvious that any tendency to unbalance the telephone circuit is also avoided since the relative admittances on the two sides of the line will remain the same as if no relay were connected thereto.

The specific arrangement of windings hereon shown is illustrative only as it will be obvious that other specific arrangements may be made without departing from the spirit of the invention.

What is claimed is:

1. In a magnetic device, a plurality of windings having substantially equal magnetic effects but unequal impedances, a plurality of sources of current so associated with said windings that the windings provide two parallel paths for current from

either source, and different for the two sources, the windings being so connected together and to said sources of current that the total impedance in each parallel branch for current from either source is equal to the total impedance in the other parallel branch for current from the same source.

2. In an electromagnetic device, a plurality of windings having substantially equal electromagnetic effects but unequal impedances, two line conductors in each of which half of the said windings are connected, a source of current connected to said windings at points intermediate their terminal connections to the line conductors and such that the windings provide parallel paths for said current, the windings being so connected to each other and to said line conductors and source of current, that the impedance of the windings in the two line conductors is the same and the impedance for current from said source in the two parallel branches is the same.

3. In an electromagnetic device, a plurality of windings having substantially equal electromagnetic effects but unequal impedances, two line conductors in each of which half of the said windings are connected, a source of current connected to said windings at points intermediate their terminal connections to the line conductors such that the windings provide parallel paths for said current, the windings being so connected to each other and to said line conductors and source of current that the impedance and magnetic effect of the windings in the two line conductors is the same, and the impedance and magnetic effect for current from said source in the two parallel branches is the same.

4. In an electromagnetic device, a plurality of concentric windings, each having substantially the same magnetic effect but of unequal impedances, a second set of concentric windings of like character coöperating therewith, two sources of current connected to said windings at different points and each having different parallel paths through said windings, the several parallel paths for current from either source being of substantially equal impedance and substantially equal electromagnetic effect.

5. In a relay, a core having two poles, a set of four windings located on each pole, all of the windings having substantially equal magnetic effects but unequal impedances, a pair of line conductors, each line conductor having four of said windings connected in series therein, two from each of said sets and so selected that the total impedance in series with each line conductor is the same, a source of current connected to the center point of the four windings in each line conductor, the arrangement of the windings being such that the impedance of the parallel paths through said windings for current from said source is the same.

6. In an electromagnetic relay, two sets of windings, each comprising four windings of substantially equal magnetic effect but unequal impedance, said windings being connected together serially, two sources of current, each connected to said windings so as to have parallel paths therethrough, the connection of the windings to each other and to the sources being such that the two parallel paths presented to current from either source have substantially equal impedance.

7. In an electromagnetic relay, two sets of windings, each comprising four windings of substantially equal magnetic effect but unequal impedance, said windings being connected together serially, two sources of current, each connected to said windings so as to have parallel paths therethrough, the connection of the windings to each other and to the sources being such that the two parallel paths presented to current from either source have substantially equal impedance and substantially equal magnetic effect.

8. In a composite telephone and telegraph system arranged to provide a metallic circuit for the telegraph currents over the telephone conductors, two leads connecting respectively with the two telephone conductors, a relay for said telegraph circuit having a plurality of windings, half of which are connected in series in each of said leads, a source of sending-current connected across the midpoints of the windings in each lead, the windings being proportioned and arranged to provide parallel paths for current from said source of substantially equal magnetic effect and substantially equal impedance.

9. In a composite telephone and telegraph system arranged to provide a metallic circuit for the telegraph currents over the telephone conductors, two leads connecting respectively with the two telephone conductors, a relay for said telegraph circuit having a plurality of windings, half of which are connected in series in each of said leads, and so proportioned that the windings in each lead have substantially the same magnetic effect and substantially the same impedance, a source of sending current connected across the midpoints of the windings in each lead, the windings being proportioned and arranged to provide parallel paths for current from said source of substantially equal magnetic effect and substantially equal impedance.

10. In a composite telephone and telegraph system arranged to provide a metallic circuit for the telegraph currents over the telephone conductors, two leads connecting respectively with the two telephone conductors, a relay for said telegraph circuit having a plurality of windings, half of

which are connected in series in each of said leads, and so proportioned that the windings in each lead have substantially the same magnetic effect and substantially the same impedance, a source of sending current connected across the midpoints of the windings in each lead, the windings being proportioned and arranged to provide parallel paths for current from said source of substantially equal magnetic effect and substantially equal impedance, and a second source of sending current connected to transmit impulses through said relay windings in parallel paths which include respectively the windings located in each of said leads.

In testimony whereof, I have signed my name to this specification this eleventh day of December, 1918.

RALPH E. PIERCE.