

1,233,769

L. ESPENSCHIED.
 DUPLEX CIRCUIT.
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Patented July 17, 1917.

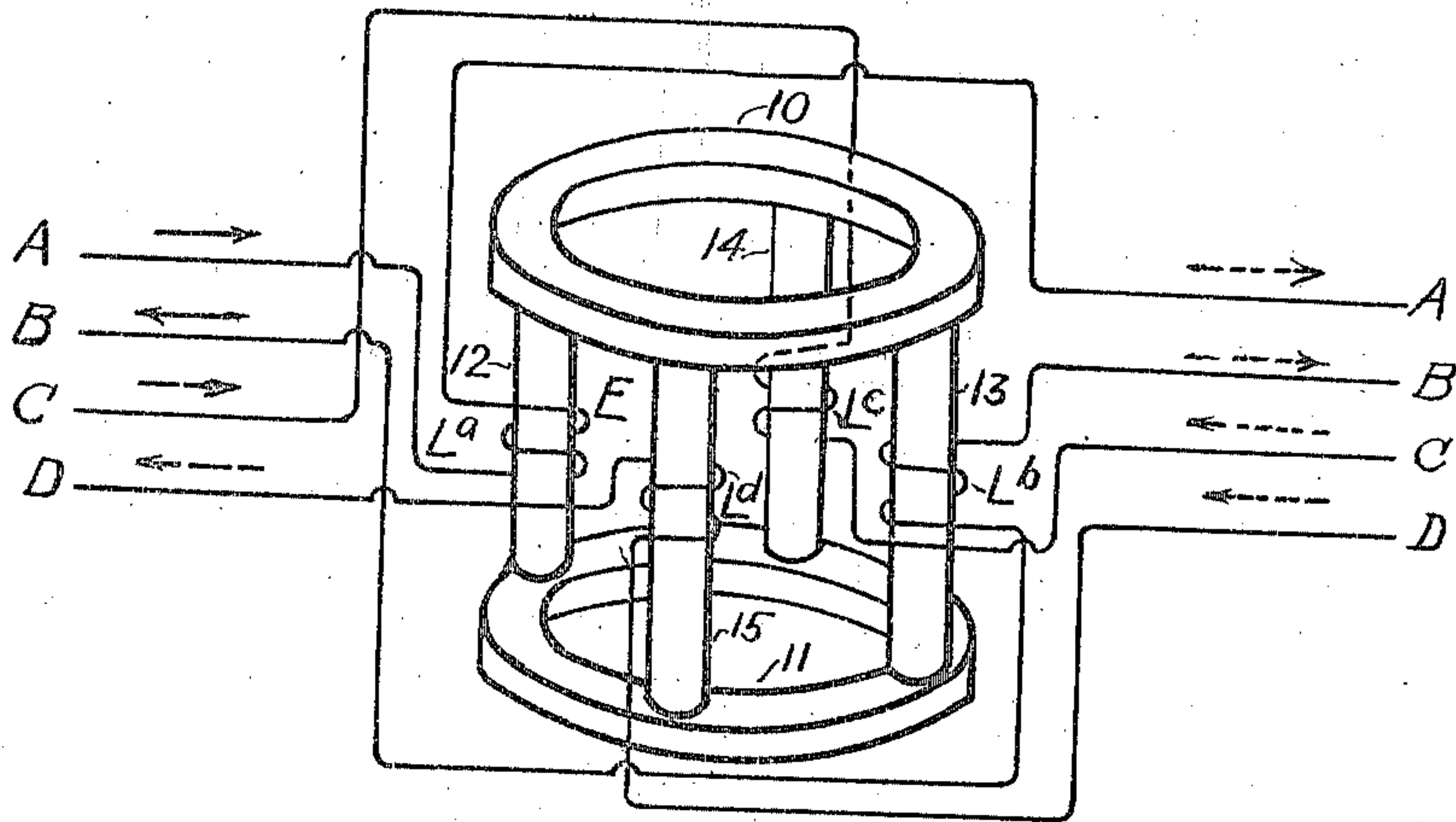


Fig. 1.

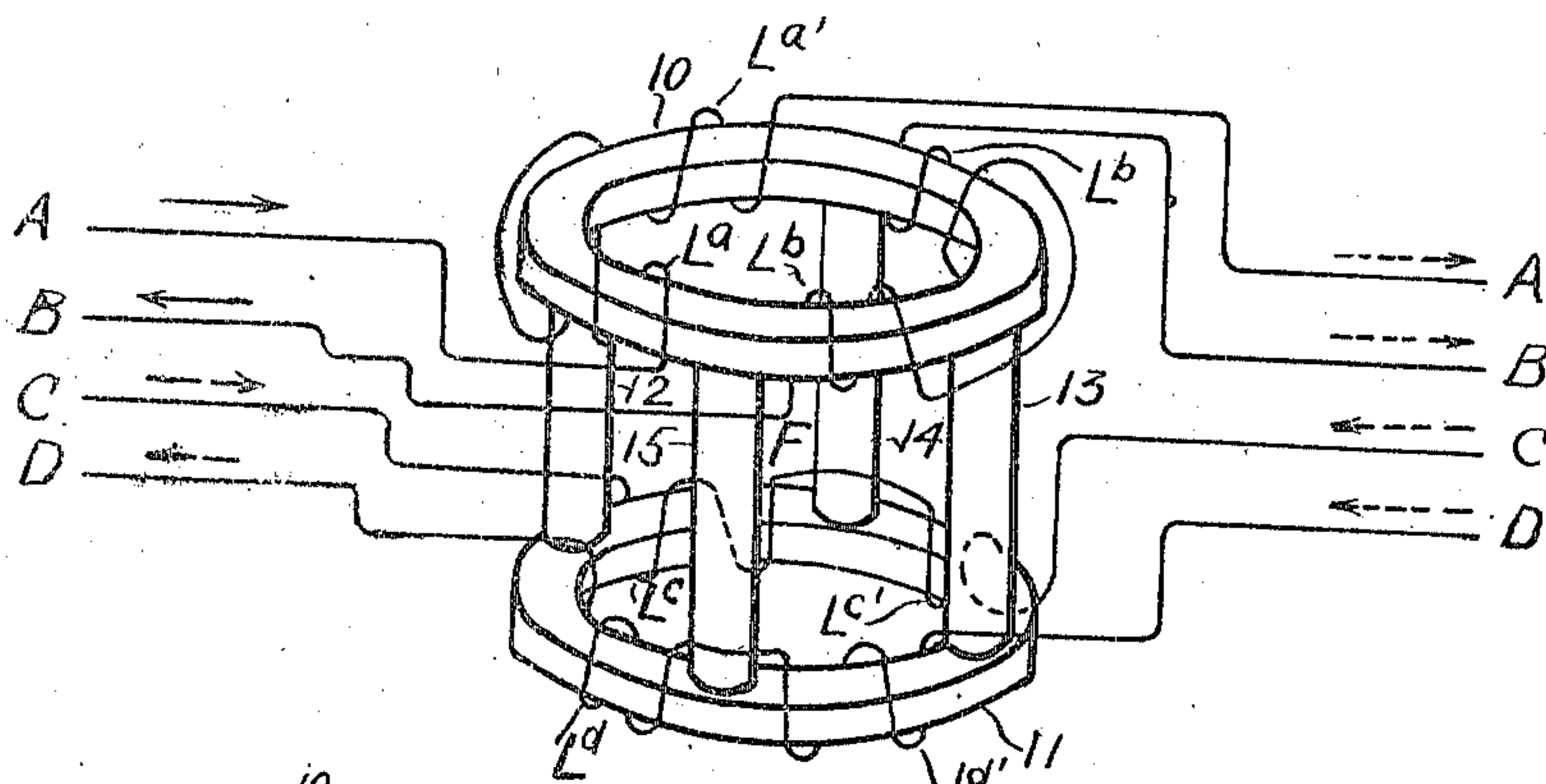


Fig. 2.

Fig. 3.

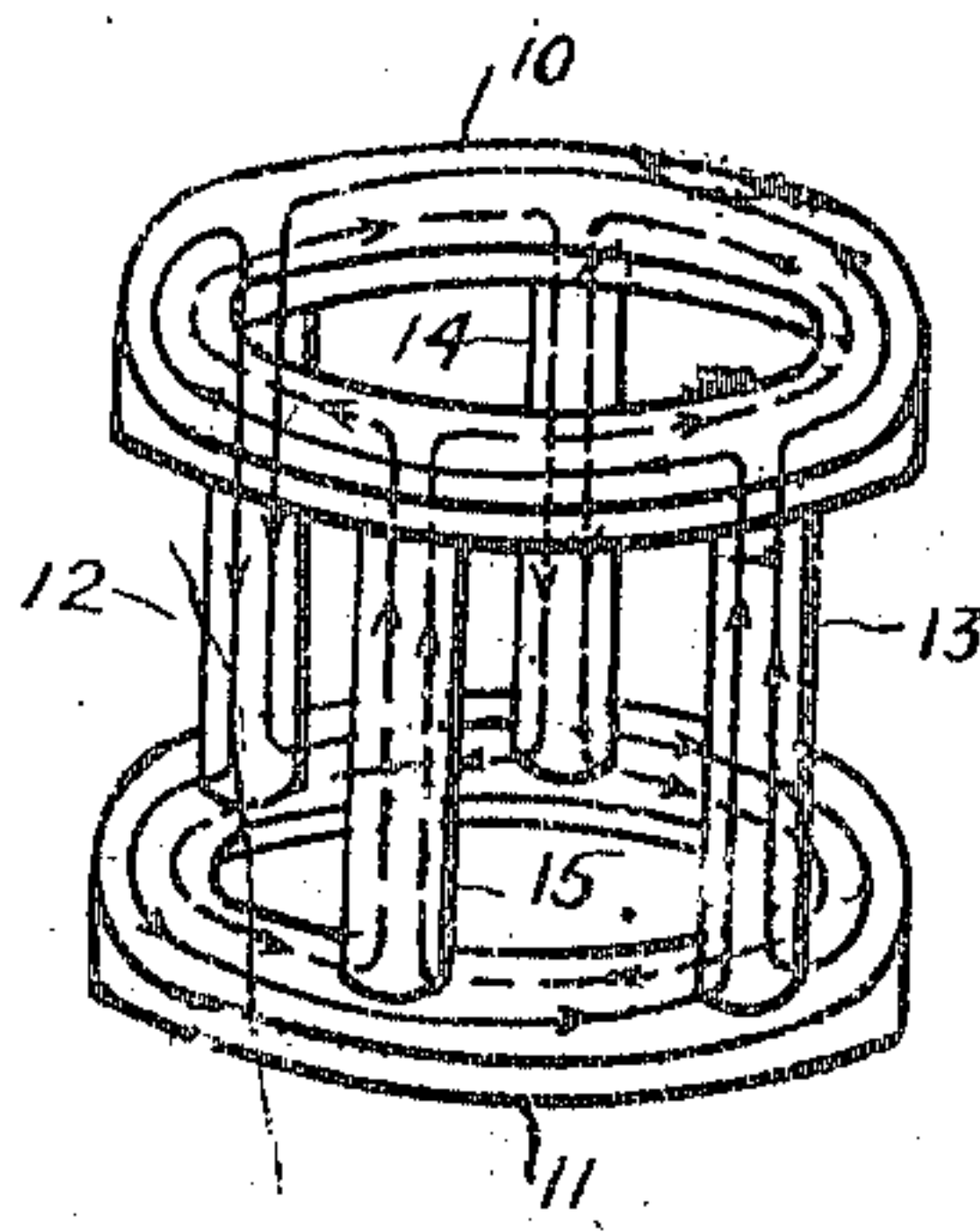
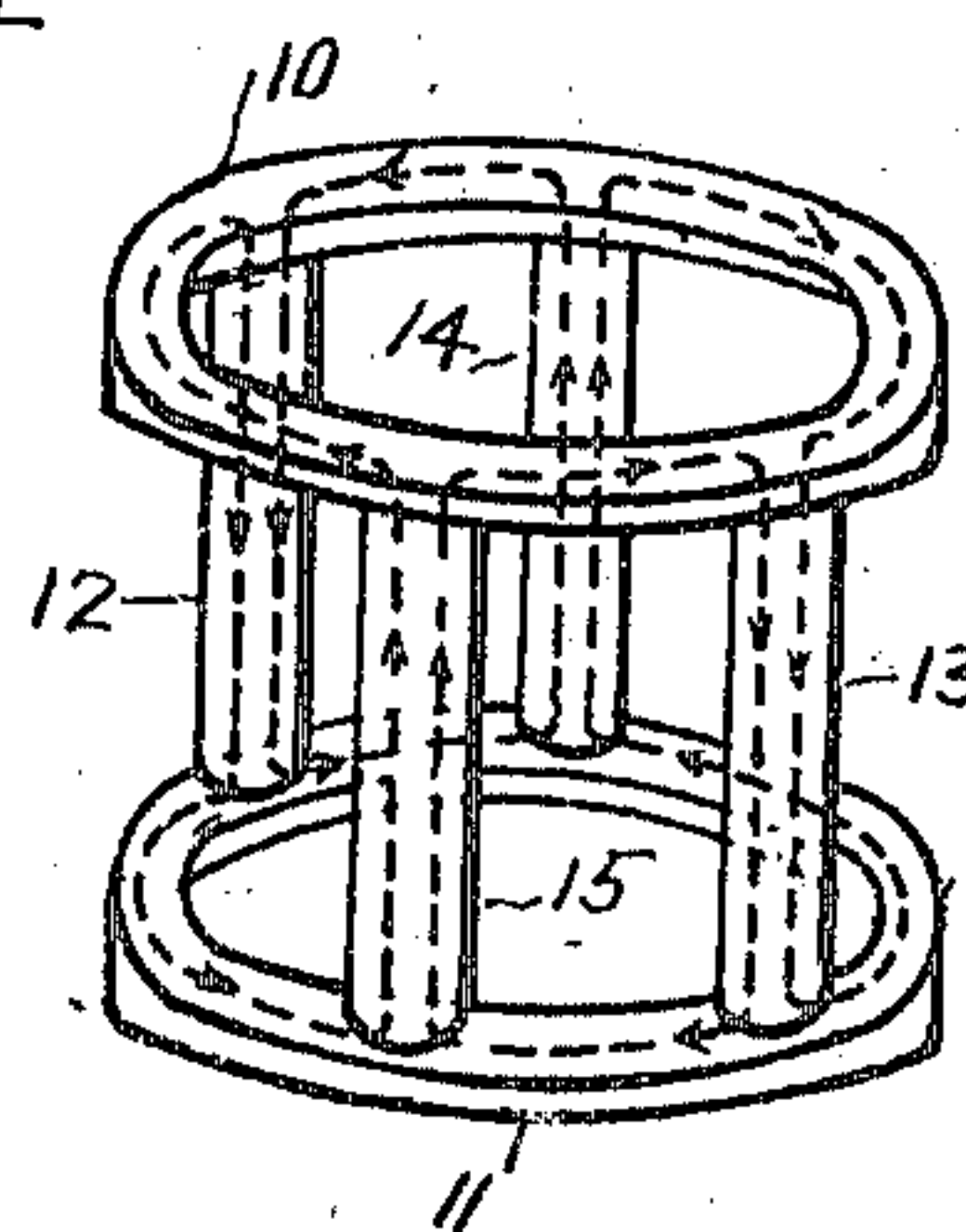


Fig. 4.



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UNITED STATES PATENT OFFICE.

LLOYD ESPENSCHIED, OF BROOKLYN, NEW YORK, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

DUPLEX CIRCUIT.

1,233,769.

Specification of Letters Patent.

Patented July 17, 1917.

Application filed October 13, 1915. Serial No. 55,717.

To all whom it may concern:

Be it known that I, LLOYD ESPENSCHIED, residing at Brooklyn, in the county of Kings and State of New York, have invented certain Improvements in Duplex Circuits, of which the following is a specification.

My invention relates to such duplex circuits as are used in telephonic transmission and in which two physical circuits are combined to furnish a third or phantom circuit. It has particularly to do with a unitary means for producing inductance effects in a plurality of the circuits, as loading the sides and phantom.

This invention has for its chief purpose the provision of a device in which the flux resulting from current in all the duplex circuits will pass through common members of the core.

Figure 1 of the accompanying drawings shows the invention diagrammatically in its application to the loading of a duplex telephone circuit; Fig. 2 shows another embodiment of the invention; and Figs. 3 and 4 illustrate respectively the paths followed by the flux due to the side circuit and phantom circuit currents in the cores of the devices shown in Figs. 1 and 2.

The characters A, B and C, D designate the line conductors of two physical telephone circuits in which the talking current flows in series through both pairs of conductors, as indicated by full and dashed arrows, respectively. By any suitable means these physical circuits are made to serve also as a phantom circuit through which talking current passes in series by way of the pairs of conductors which are joined in parallel, as the dotted arrows indicate. Included in the duplex circuit is an inductance device E adapted to affect all the three component circuits, in the present instance to give a loading effect therein. This compound loading device or coil may comprise a core consisting of end or head portions 10 and 11 of magnetic material, these being shown as toroidal, though they may be in the form of any closed figure and the central openings may be decreased in diameter to any desired extent. The toroids lie in parallel planes with their axes in alinement. Connecting the heads are intermediate core portions, which in this embodiment of the invention may be considered as primary members. Four of these intermediate portions

are illustrated, 12, 13, 14 and 15, there being one for each line conductor of the duplex circuit. They are symmetrically arranged 90° apart about the toroids and at right angles thereto.

Each of the primary core portions carries a winding included in one of the line conductors of the duplex circuit. For conductors A, B of one side circuit windings L^a and L^b are mounted upon the opposite intermediate portions 12 and 13, while the core portions 14 and 15 bear windings L^c and L^d for the conductors C, D of the other side circuit. Each pair of windings L^a , L^b and L^c , L^d are connected with their inductances mutually aiding for current peculiar to the side circuit and therefore mutually opposing for phantom circuit current. The windings of different side circuits are connected with their inductances mutually aiding for phantom circuit current. In loading coils as now usually constructed, the windings belonging to either side circuit are so closely coupled inductively that they practically neutralize one another's inductances in the circuit in which they are joined mutually opposing, in the present case the phantom circuit. In my invention, however, the windings are loosely coupled by being on separate portions 12, 13, 14 and 15 of the core and the quadrants of the toroids furnish branches of the core through which the phantom flux is diverted to the windings of the companion side circuit. Therefore, the phantom, as well as the sides, is loaded. This may be clearly seen in the flux diagrams of Figs. 3 and 4. The first shows that the resultant flux for an instantaneous value of current in the side circuit A, B through the primary core portion 12 flows into toroid 11, where it divides and passes in opposite directions to the portion 13, which it traverses to reach the toroid 10 and again divides to return to the portion 12. A similar distribution exists for the side circuit C, D with respect to the other pair of primary core portions 14 and 15. The flux of neither side circuit will link with the windings of the other side circuit so that there is no interference. For phantom current the flux produced by each line pair links with the windings of the other pair, without affecting the associated windings of the same pair, dividing in opposite directions through the toroid quadrants in leaving and returning to intermediate portions,

as will be clear from Fig. 4. As all the flux due to any winding for either side or phantom current flows through the core portions 12, 13, 14 and 15 upon which the windings are placed, a minimum number of turns may be used to obtain the desired inductance effects. In addition to this advantage, the placing of the windings upon straight portions of the core facilitates the manufacture of the device. This unit gives a ratio of phantom to side circuit inductance of approximately 0.5.

The flux distribution just described may also be obtained by the application of the windings to the toroids. Their quadrants, using the terms previously applied to the core members, carrying inductance windings become the primary portions, while the members intermediate the toroids are the branch portions. But in this arrangement, due to the division of the flux through the toroids, it is necessary to employ double the number of turns of winding to produce the same degree of inductance. As appears in the device F of Fig. 2, the windings of each side circuit are confined to one toroid, those for the conductors A, B being upon the toroid 10 and those for conductors C, D being applied to 11. Each line winding is preferably divided into two sections L^a , $L^{a'}$; L^b , $L^{b'}$; L^c , $L^{c'}$; and L^d , $L^{d'}$ situated upon adjacent toroid quadrants, and the windings of each line pair upon one toroid lie at an angle of 90° with respect to those of the pair upon the other toroid. The two sections for each conductor, as L^a , $L^{a'}$, are connected with their inductances mutually opposing, and the adjacent sections of the different windings of the same side circuit, as L^a , L^b , mutually aiding for side circuit current. Thus the two complete line windings of each side circuit are connected in groups mutually opposing, with the halves of each group mutually aiding. The two side circuit windings are made mutually aiding for phantom circuit current by connecting sections upon corresponding quadrants of the two toroids mutually aiding. The ratio of phantom to side circuit inductance is as in the preceding form.

The mutual inductances which affect the electromagnetic balance between the circuits are those between line windings of different side circuits. In order that the component circuits shall be balanced, and hence non-interfering in this respect, it is necessary that there be no resultant mutual inductance between the three circuits. That is, that the four mutual inductances between the four line windings neutralize one another. To provide that the effective mutual inductance between the circuits be zero, two of the four mutual inductances must balance the other two. In the arrangements described, the resultant disposition of the

windings of one side circuit is symmetrical with respect to the windings of the other side circuit, and are so poled that two act oppositely to the other two for either the side circuit connection in both side circuits (the condition for zero side-to-side crosstalk) or for the side circuit connection in one circuit and the phantom circuit connection in the other circuit (the condition for zero phantom-to-side crosstalk). Both are therefore theoretically balanced as to mutual inductance. By symmetry of design, they are also balanced electrostatically and with respect to effective resistance and self inductance. In consequence of this, there will be theoretically no crosstalk between the several circuits of the loading unit.

The division of line windings of a branch magnetic circuit loading coil into separate sections, and the distribution of said sections upon the associated core, as illustrated for example in Fig. 2 of the drawings, is not claimed herein, but relates to a different invention claimed in my copending application Serial No. 55,716, filed October 13, 1915, renewed June 14, 1917, Serial No. 174,778. The structure herein illustrated and described also constitutes another embodiment of another different invention claimed in my copending application Serial No. 55,714, filed October 13, 1915. Another specific embodiment of interconnected toroidal magnetic cores, such as claimed herein, is disclosed in my said copending application Serial No. 55,716 (renewal Sr. No. 174,778).

I claim:

1. The combination with two physical circuits consisting of line conductors together furnishing a phantom circuit, of an inductance device comprising a magnetic core having two separated portions each forming a closed figure and intermediate portions, and a winding for each line conductor situated upon the core, the windings being positioned to produce a magnetic flux in the core passing through both the first-named portions and intermediate portions on passage of either side circuit or phantom circuit current.

2. The combination with two physical circuits consisting of line conductors together furnishing a phantom circuit, of an inductance device comprising a magnetic core having two separated portions each forming a closed figure and intermediate portions, a winding for each line conductor situated upon the intermediate portions of the core, the windings for each physical circuit being connected with their inductances mutually aiding for side circuit current, and the windings of the two physical circuits being connected with their inductances mutually aiding for phantom circuit current.

3. The combination with two physical

circuits consisting of line conductors together furnishing a phantom circuit, of an inductance device comprising a magnetic core having two separated portions each forming a closed figure and intermediate portions, and a winding for each line conductor situated upon the intermediate portions of the core.

4. The combination with two physical circuits consisting of line conductors together furnishing a phantom circuit, of an inductance device comprising a magnetic core having two separated portions each forming a closed figure and symmetrically arranged intermediate portions, and a winding for each line conductor situated upon the intermediate portions of the core.

5. The combination with two physical circuits consisting of line conductors together furnishing a phantom circuit, of an inductance device comprising a magnetic core having two separated portions each forming a closed figure and intermediate portions symmetrically arranged in opposite pairs, and windings for each pair of line conductors situated respectively upon such opposite pairs of core portions.

6. An inductance device comprising a magnetic core having opposite end portions and intermediate portions, and inductance

windings for a plurality of talking circuits confined to the intermediate portions, said windings being adapted when a current is passed in one of said circuits to produce inductive effects individual to said circuit.

7. A loading coil comprising a magnetic core consisting of two separated toroids and portions connecting the toroids, and windings for a plurality of talking circuits confined to the connecting portions, said windings being adapted when a current is passed in one of said circuits to produce inductive effects individual to said circuit.

8. A loading coil comprising two toroids lying in parallel planes and four connecting portions equally spaced about the toroids, and line windings for a plurality of talking circuits confined to the connecting portions, said windings being adapted when a current is passed in one of said circuits to produce inductive effects individual to said circuit.

In testimony whereof, I have signed my name to this specification in the presence of two subscribing witnesses, this 27th day of September 1915.

LLOYD ESPENSCHIED.

Witnesses:

CHAS. G. HEISER, Jr.,
A. C. FRANCA.