

L. ESPENSCHIED.
INDUCTANCE DEVICE.

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Patented July 17, 1917.

1,233,768.

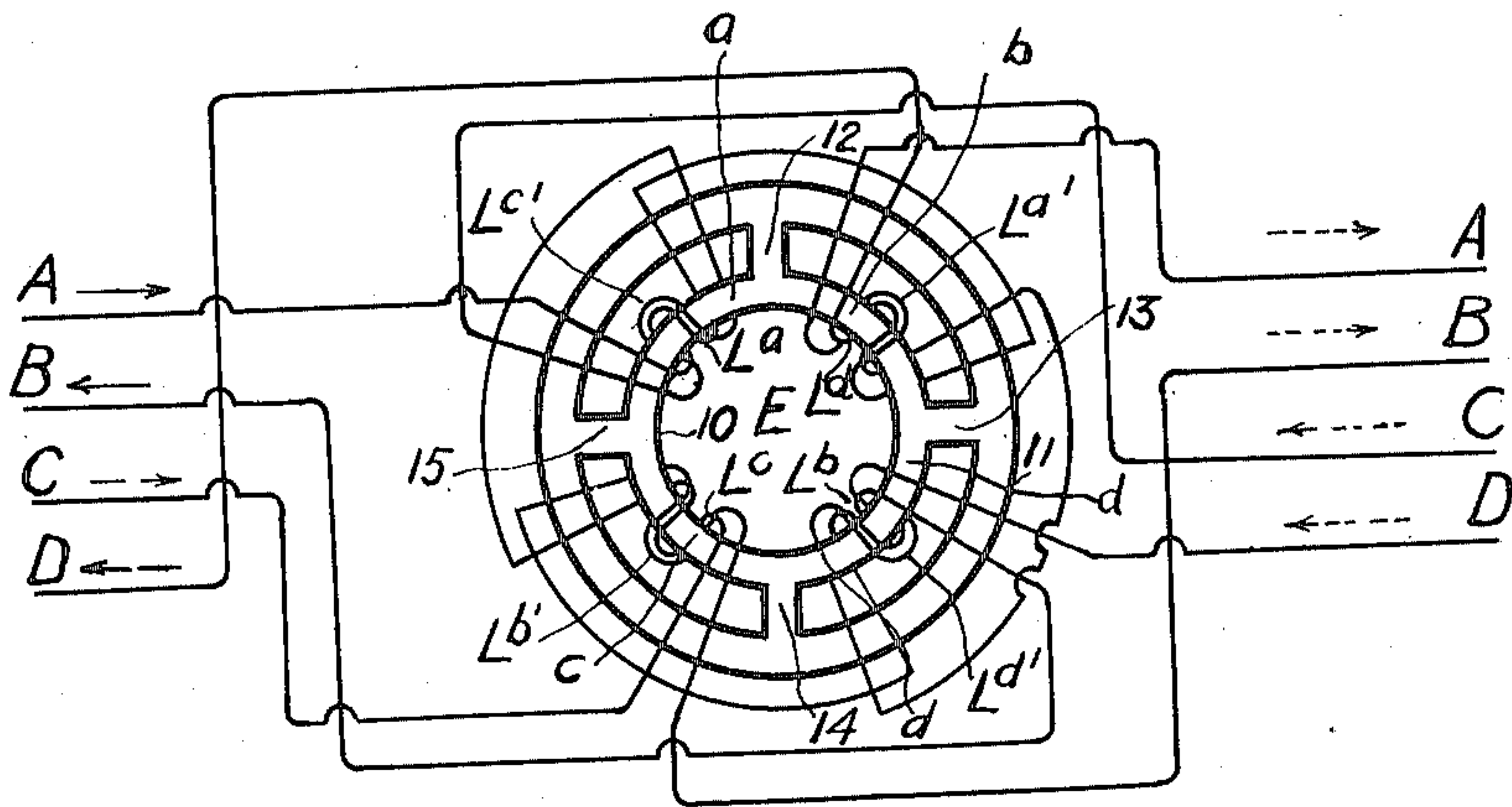


Fig. 1.

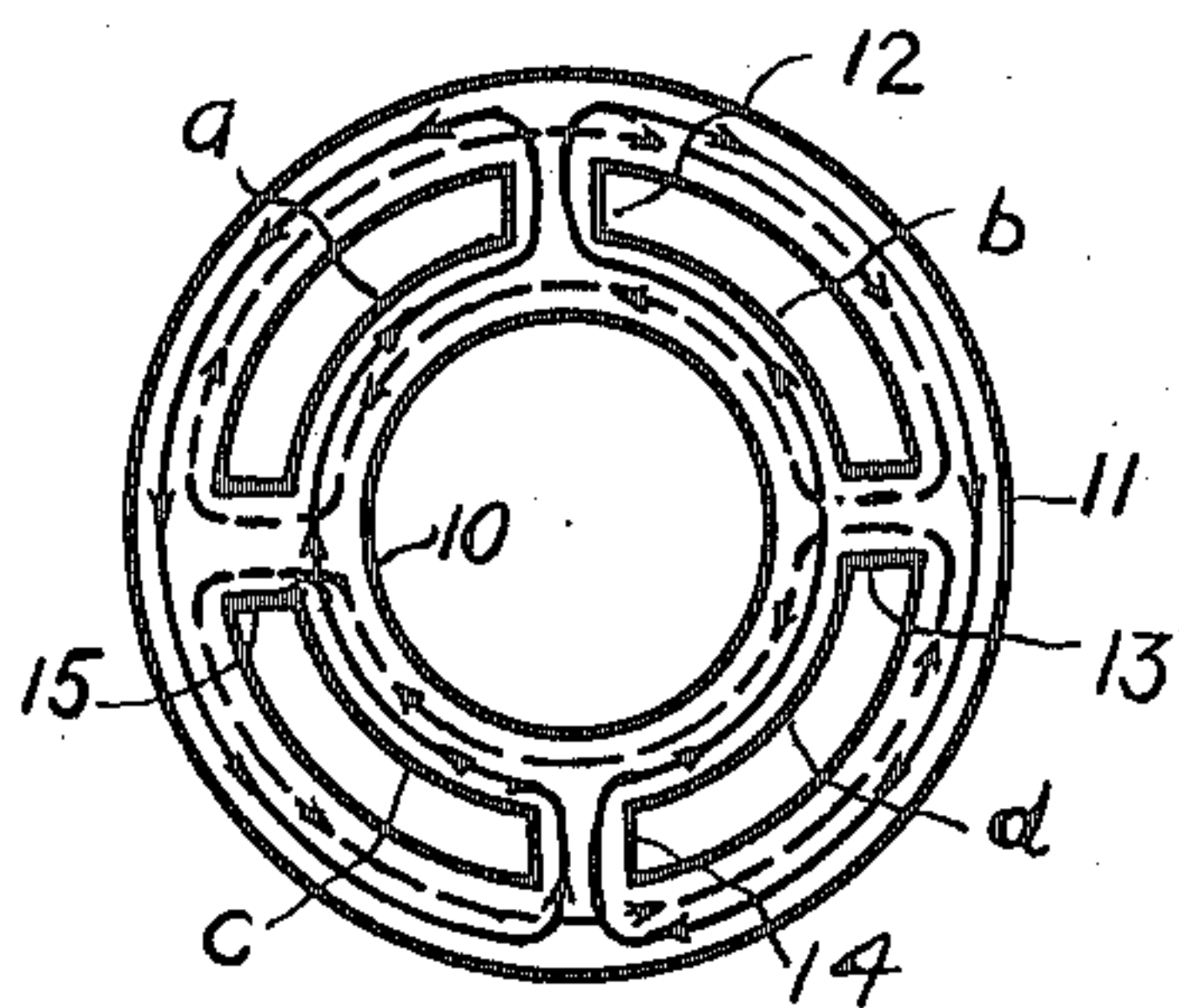


Fig. 2.

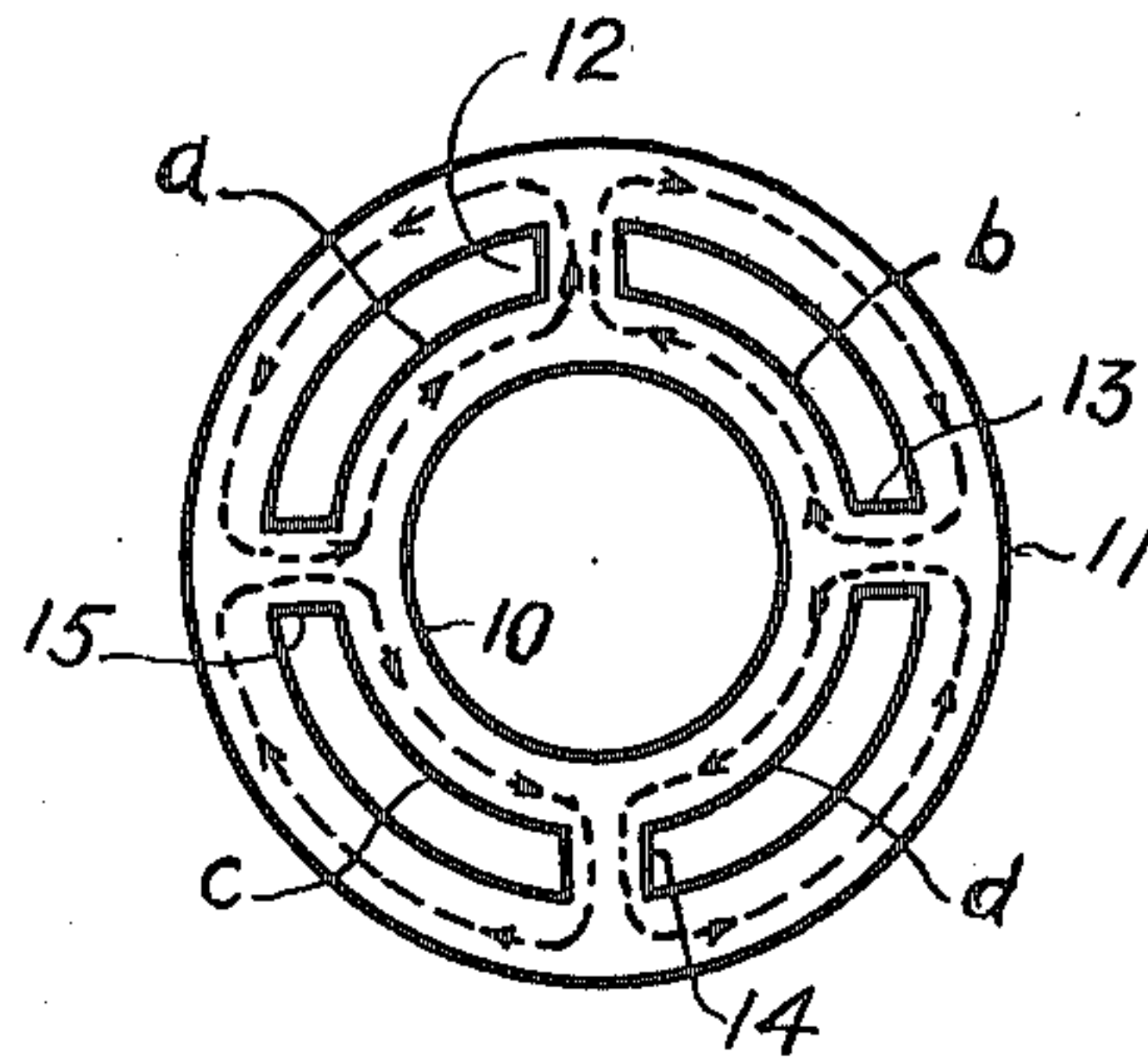


Fig. 3.

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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.

INDUCTANCE DEVICE.

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Specification of Letters Patent.

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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 Inductance Devices, of which the following is a specification.

This invention relates to devices for producing various inductance effects, it being especially applicable to a unitary structure or coil employed for loading all the components of a duplex circuit in which two physical circuits are associated to furnish a third or phantom circuit. It consists in the features and combinations hereinafter described and more particularly claimed.

Figure 1 of the accompanying drawings shows the invention diagrammatically as applied to loading a duplex telephone circuit; and Figs. 2 and 3 illustrate, respectively, the paths followed by the flux due to the side circuit and phantom circuit currents in the core of the device shown in Fig. 1.

The characters A, B and C, D designate the line conductors of two physical telephone circuits in which talking current flows in series through both pairs of conductors, as indicated by the 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 through the pairs of conductors each joined in parallel, as the dotted arrows indicate. Included in the duplex circuit is an inductance device E adapted to produce its effect, in the present instance a loading action, in each of the three component circuits. The device comprises a core of magnetic material having a primary portion 10 in the form of a closed figure, preferably a toroid, though it is to be understood that this term does not necessarily imply a body circular in cross section. Upon this primary portion is a sectional winding for each of the conductors of the duplex circuit, the sections being separately designated as L^a , $L^{a'}$, L^b , $L^{b'}$, L^c , $L^{c'}$, L^d , $L^{d'}$, with the same small letter superscript indicating the sections of the same line winding. Since it is desired to cause the windings to affect both the physical and phantom circuits, and since the close inductive coupling of the windings and consequent neutralizing action for current for

which the coil is not designed to act defeats this in the usual apparatus, the windings in accordance with this invention are loosely coupled, through their manner of distribution upon the core and by the provision of branch core portions which divert the flux resulting from the windings of one side circuit through those of the other side circuit. These branches, in the embodiment of the invention now under consideration, are furnished by a second closed core portion 11, which is shown as toroidal and situated outside and concentric to the portion 10, though it may also consist of a continuous inclosing body or shell. To reduce the reluctance of the flux paths from the inner, or primary, portion of the core to the outer portion, intermediate connecting portions 12, 13, 14 and 15 are preferably provided, these extending radially at points 90° apart about the peripheries of the inner and outer portions. The sections of the line windings occupy the quadrants of the portion 10 marked by the connecting portions, passing between this portion 10 and the portion 11. The sections L^a and $L^{a'}$ belonging to the conductor A are upon adjacent quadrants a and b , while the sections of the companion winding L^b and $L^{b'}$ for conductor B are upon the opposite quadrants c and d , they thus being on distinct divisions of the portion 10 at opposite sides of a horizontal line. The sections belonging to the conductors of the other physical circuit C, D are similarly situated upon opposite sides of a vertical line, the two sets of line windings thus lying at 90° with respect to one another. Thus the sections of the different physical circuits overlie one another, L^c being upon the quadrant c with section $L^{b'}$ of conductor B, while $L^{c'}$ is on quadrant a with section L^a . Sections L^d and $L^{d'}$ are associated with $L^{a'}$ and L^b on quadrants b and d , respectively. To aid in balancing the windings, the sections for the same line conductor are at different distances from the core, being one within and the other without the winding section of the other circuit which shares the quadrants with them. The two sections of each line winding, as L^a and $L^{a'}$, are connected with their inductances mutually opposing, and adjacent sections of different line windings of the same side circuit, as L^a and L^b , are connected with their inductances mutu-

ally aiding for side circuit current. The sections of each side circuit pair of line windings are thus joined in symmetrical groups, the two sections of each group having their inductances mutually aiding and the two groups as units having their inductances mutually opposing for side circuit current. For phantom circuit current, the superposed sections on each quadrant, as L^a and $L^{c'}$, are connected mutually aiding.

The resultant flux distribution may be seen in Figs. 2 and 3. For current peculiar to the side circuit, the flux generated by each entire pair of line windings (Fig. 2) is through the pairs of adjacent quadrants of core portion 10 which are surrounded by winding sections of different conductors, as L^a , $L^{b'}$ and $L^{a'}$, L^b , joined with their inductances aiding, then together through the connecting portions between the quadrants upon which are the winding sections of one conductor, as L^a , $L^{a'}$, there dividing and passing through opposite halves of the outer toroid and returning to the inner by way of the opposite connecting portion between the winding sections of the other conductor of the same side circuit, as L^b , $L^{b'}$. The phantom current flux (Fig. 3) traverses four paths furnished by adjacent connecting portions of the core and the intercepted quadrants of both toroids. The ratio of the phantom to side circuit inductance produced by this arrangement is approximately 0.5.

The mutual inductances which affect the electromagnetic balance between the circuits are those between line windings of different 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 arrangement described, the windings 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). Moreover, the complete line winding of one side circuit is arranged symmetrically upon the core with respect to each of the line windings of the other side circuit. For example, the sections L^a , $L^{a'}$ of conductor A have the same relation to the sections L^c , $L^{c'}$ of conductor C that they have to sections L^d , $L^{d'}$ of conductor D. Each winding section presents an angular relation to the sections of the other side circuit as follows—one of zero

degrees, as L^a to $L^{c'}$; two of 90° , as $L^{a'}$ to L^c and L^d ; and one of 180° , as L^a to $L^{d'}$. This gives a resultant relation of 90° for all the sections. The device is therefore theoretically balanced as to mutual inductances. By symmetry of design, it is 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 claims hereof are directed to branch magnetic circuit loading coils having inner and outer core portions with cooperating line windings and to the division of the windings into separate sections for such branch magnetic circuits. Other specific embodiments of the invention herein claimed are disclosed in Fig. 4 of my copending application Serial No. 55,714, filed October 13, 1915, and in Fig. 2 of my copending application Serial No. 55,717, filed October 13, 1915.

The structure herein illustrated and described constitutes another embodiment of the generic invention claimed in my said copending application Serial No. 55,714, and also constitutes another embodiment of the invention claimed in my said copending application Serial No. 55,717.

I claim:

1. A loading coil for use in duplex circuits including two metallic telephone lines, said coil comprising inner and outer core portions each in the form of a closed figure, and pairs of line windings cooperating with said core portions, each pair being upon different parts of the core portions.

2. A loading coil for use in duplex circuits including two metallic telephone lines, said coil comprising inner and outer core portions each in the form of a closed figure, pairs of line windings cooperating with said core portions, the pairs of windings being differently disposed in respect to said core portions, and the windings of different pairs being upon the same parts of the core portions.

3. A loading coil for use in duplex circuits including two metallic telephone lines, said coil comprising inner and outer core portions each in the form of a closed figure, and pairs of line windings mounted on the inner core portion, said pairs being differently disposed in respect to said core portions.

4. A loading coil for use in duplex circuits including two metallic telephone lines, said coil comprising inner and outer core portions each in the form of a closed figure, pairs of line windings on the inner core portion, said pairs being differently disposed in respect to said core portions, and the windings of different pairs being upon the same core portions.

5. A loading coil for use in duplex circuits including two metallic telephone lines, 130-

said coil comprising inner and outer core portions each in the form of a closed figure, other core portions connecting said core portions, and a plurality of pairs of line windings surrounding the inner core portions, said pairs of windings being differently disposed in respect to said core portions.

6. A loading coil for duplex circuits including two metallic telephone lines, said coil comprising inner and outer core portions each in the form of a closed figure, other core portions connecting said closed core portions, and a plurality of pairs of line windings surrounding the inner core portions between the connecting portions, the windings of different pairs being upon the same parts of the inner core portions.

7. A loading coil for use in duplex circuits including two metallic telephone lines, said coil comprising inner and outer core portions each in the form of a closed figure, other core portions connecting said closed core portions, and a plurality of pairs of windings cooperating with said core portions, said pairs being differently disposed in respect to said core portions.

8. A loading coil for use in duplex circuits including two metallic telephone lines, said coil comprising inner and outer core portions each in the form of a closed figure, other core portions connecting said closed core portions, a plurality of pairs of line windings cooperating with said core portions, said pairs being differently disposed in respect to said core portions, and the windings of different pairs being upon the same parts of the core portions.

9. An inductance device for use in duplex circuits comprising a magnetic core having a toroidal portion, two pairs of line windings each winding being in two sections, the sections of each winding being upon adjacent toroid quadrants with the sections of the companion line winding upon opposite toroid quadrants, and the sections of two pairs of line windings lying at 90° with respect to one another.

10. An inductance device for use in duplex circuits comprising a magnetic core having a portion forming a closed figure, and two pairs of line windings each winding being in two sections, the sections of each winding being on adjacent quadrants of the closed portion of the core with the sections of the companion line windings on opposite quadrants, and the sections of the two pairs of line windings lying at right angles to one another.

11. An inductance device for use in duplex circuits comprising a magnetic core having a toroidal portion, and two pairs of line windings each winding being in two sections, the sections of each winding being upon adjacent toroid quadrants with the sections of the companion line winding upon opposite

toroid quadrants, and the sections of the two pairs of line windings lying at 90° with respect to one another upon the same toroidal portion.

12. An inductance device for use in duplex circuits comprising a magnetic core having a plurality of toroidal portions, and two pairs of line windings each winding being in two sections, the sections of each winding being upon adjacent toroid quadrants with the sections of the companion line winding upon opposite toroid quadrants, and the sections of the two pairs of line windings lying at 90° with respect to one another upon the same toroidal portion.

13. A loading coil for use in duplex circuits comprising a magnetic core having two toroidal portions and intermediate portions connecting the toroidal portions and dividing them into quadrants, and two pairs of line windings each winding being in two sections, the sections of each winding being upon adjacent toroid quadrants with the sections of the companion line winding upon opposite toroid quadrants, and the sections of the two pairs of line windings lying at 90° with respect to one another.

14. A loading coil for use in duplex circuits including two metallic telephone lines, said coil comprising inner and outer core portions each in the form of a closed figure, and pairs of line windings cooperating with said core portions, each winding being in sections, said pairs being differently disposed in respect to said core portions, and the sections of different pairs of windings being upon the same parts of the core sections.

15. An inductance device for duplex circuits comprising a magnetic core having a primary winding portion and branch portions, and line windings divided into sections, the sections of different line windings overlying one another upon the same core portion and being situated at different distances from the core.

16. A loading coil for use in duplex circuits including two metallic telephone lines, said coil comprising inner and outer core portions each in the form of a closed figure, and pairs of line windings upon the inner core portion, said pairs being differently disposed in respect to said core portions, said windings being in sections and the sections of different pairs of windings being upon the same parts of the core sections.

17. An inductance device for duplex circuits comprising a magnetic core having inner and outer portions, and line windings divided into sections, the sections of different line windings overlying one another upon the same core portion.

18. An inductance device for use in duplex circuits consisting of two physical circuits and a phantom circuit comprising a core, and windings for each of the conduc-

tors of the physical circuits, each winding
being divided into two sections, the sections
of each line winding being connected with
their inductances mutually opposing and the
5 adjacent sections of the windings of dif-
ferent conductors of the same physical cir-
cuit being connected with their inductances
mutually aiding for side circuit current,
while winding sections of the conductors of
10 different physical circuits are connected with

their inductances mutually aiding for phan-
tom circuit current.

In testimony whereof, I have signed my
name to this specification in the presence of
two subscribing witnesses, this 27th day of 15
September 1915.

LLOYD ESPENSCHIED.

Witnesses:

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