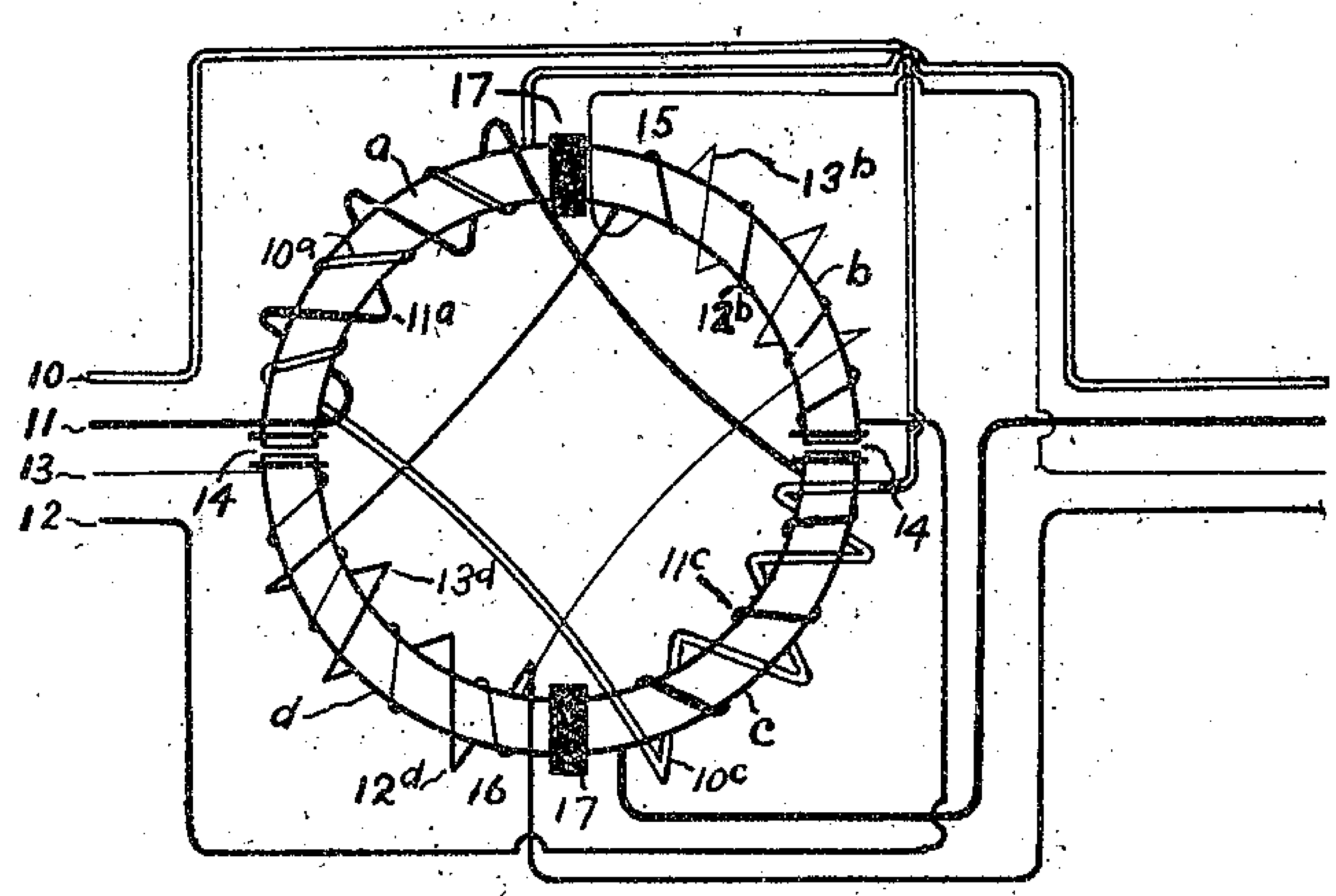
T. SHAW.
LOADING COIL.
APPLICATION FILED NOV. 5, 1914.

1,174,187.

Patented Mar. 7, 1916.
2 SHEETS—SHEET 1.

Fig. 1.



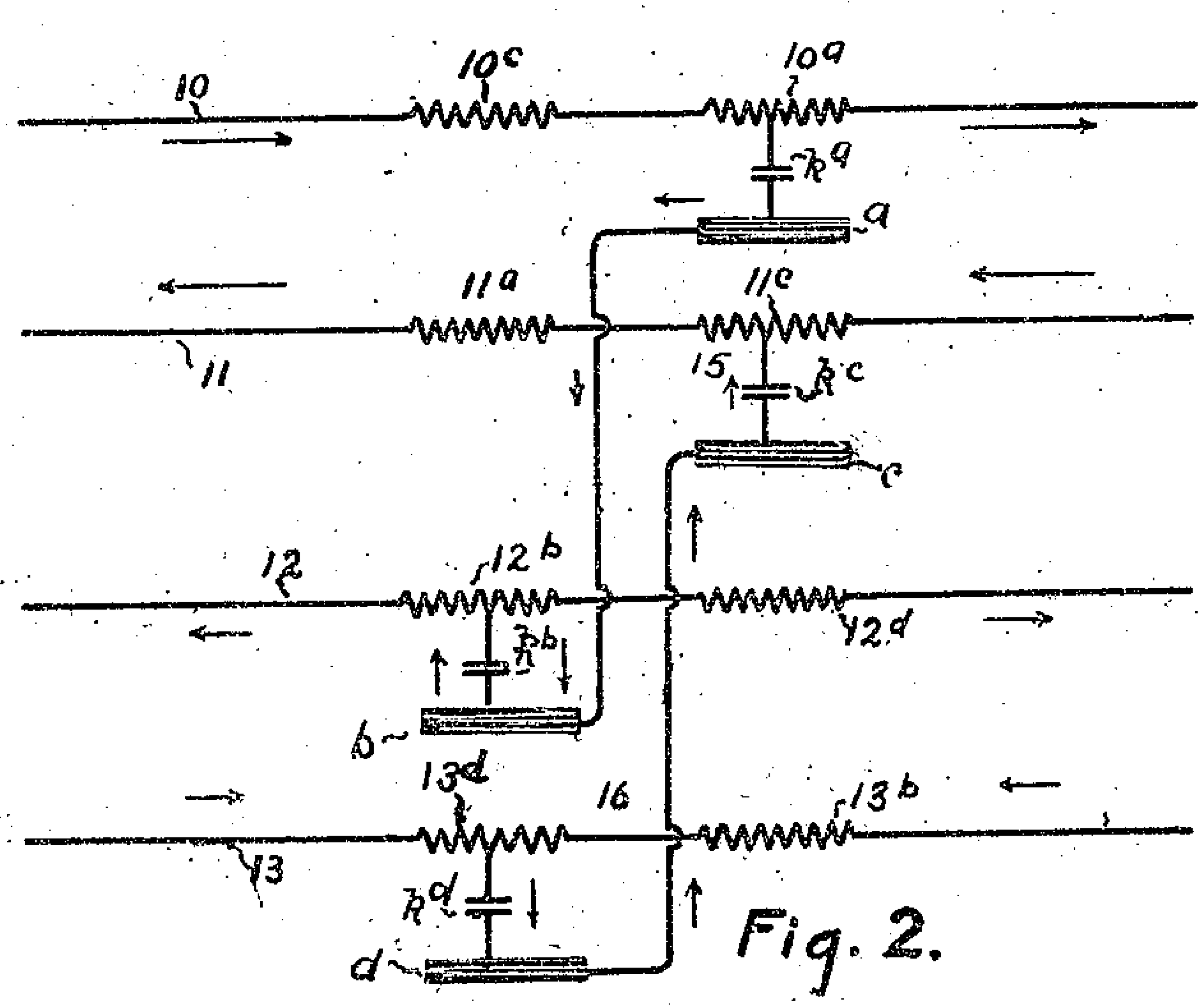


Fig. 2.

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2 SHEETS—SHEET 2.

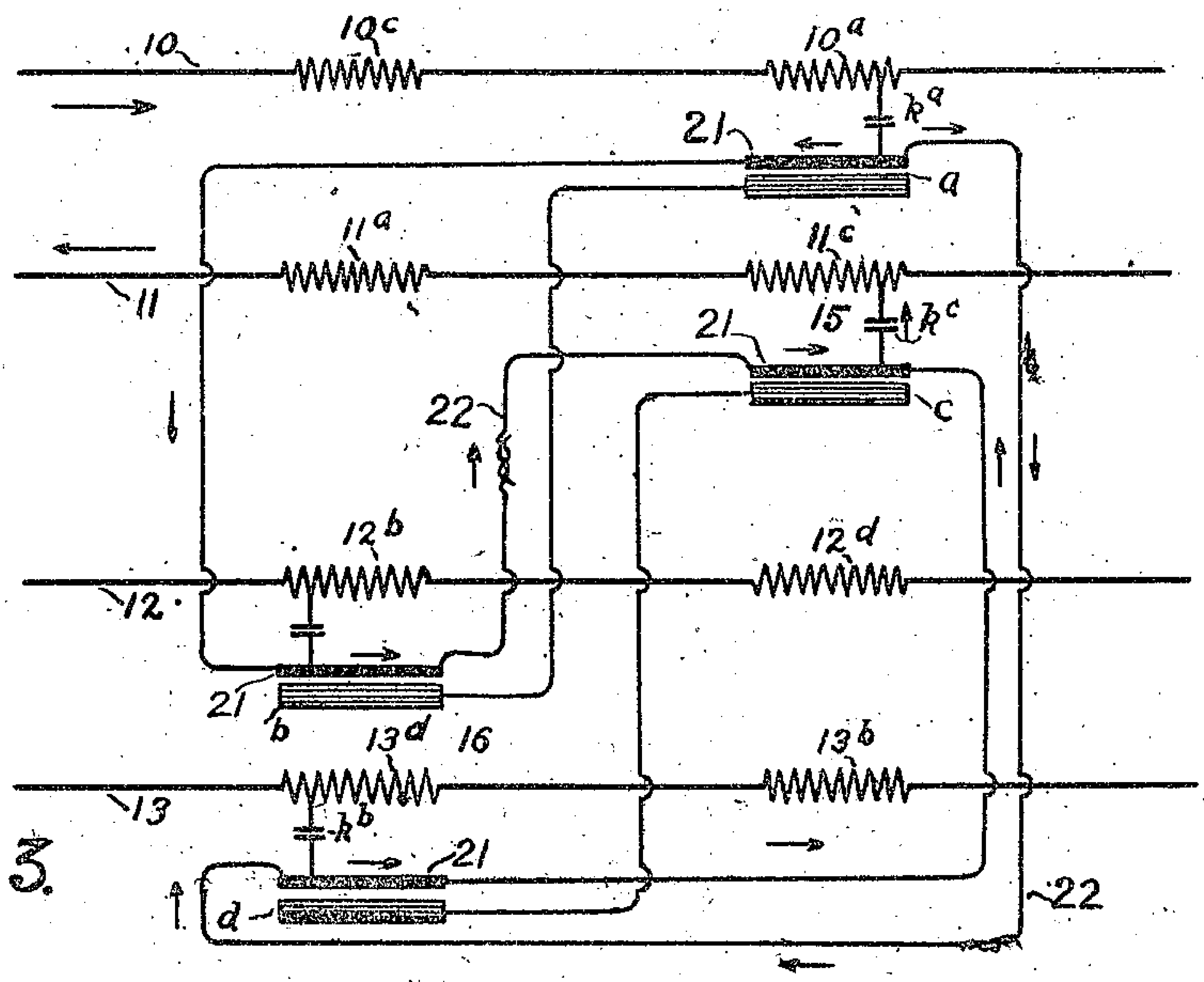

Fig. 3.

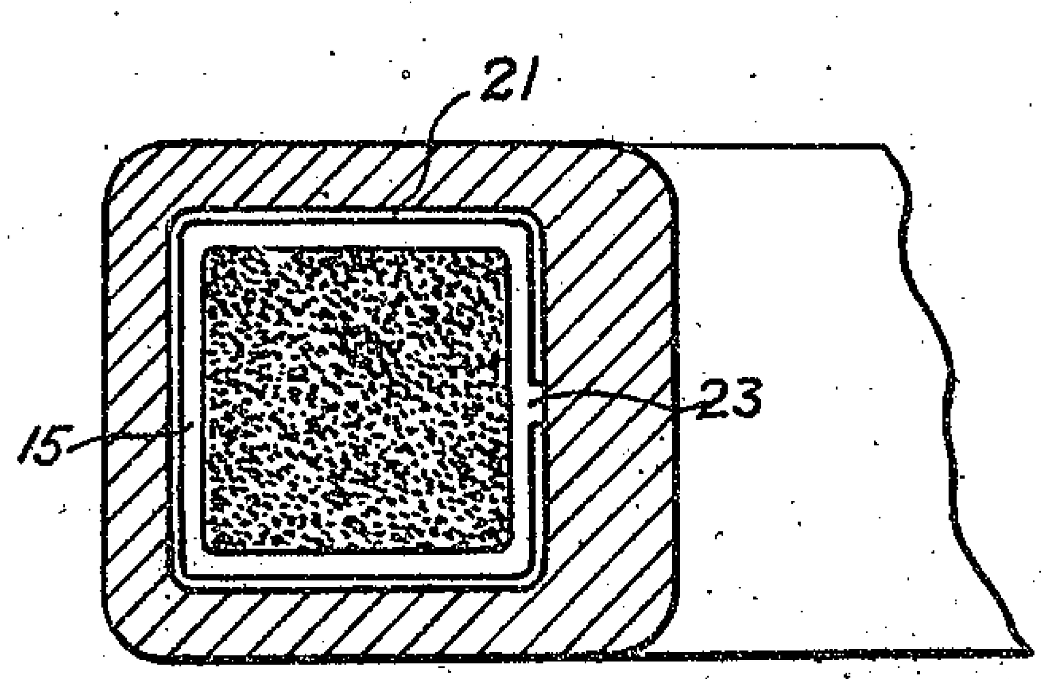

Fig. 4.

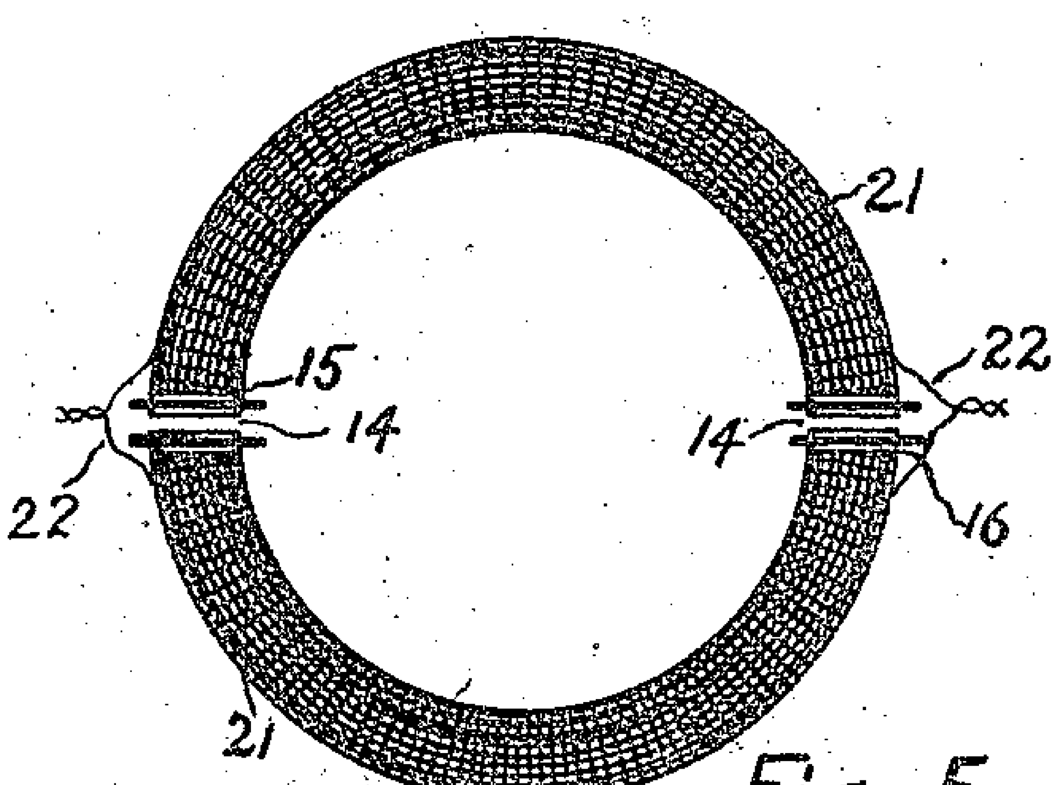

Fig. 5.

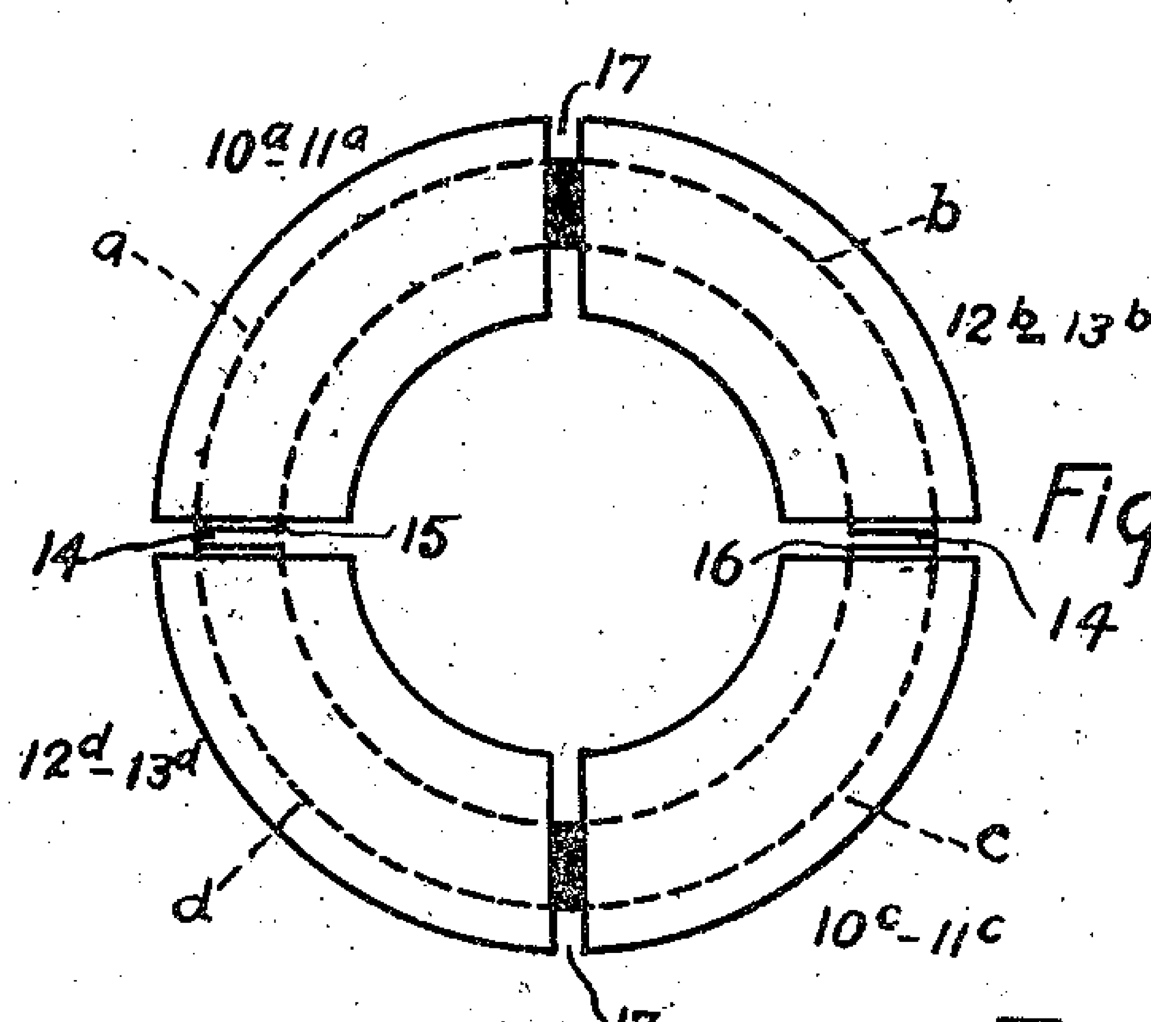

Fig. 6.

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UNITED STATES PATENT OFFICE.

THOMAS SHAW, OF HACKENSACK, NEW JERSEY, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

LOADING-COIL.

1,174,187. Specification of Letters Patent. Patented Mar. 7, 1916.

Application filed November 5, 1914. Serial No. 870,485.

To all whom it may concern:

Be it known that I, THOMAS SHAW, residing at Hackensack, in the county of Bergen and State of New Jersey, have invented certain Improvements in Loading-Coils, of which the following is a specification.

It has been found desirable in loading coils, of the continuous core or toroidal type employed in telephone lines, to form gaps in the cores, thereby effecting an increase in what is termed the "magnetic stability", or that quality by virtue of which the inductance and resistance of the coil remain constant irrespective of the variable magnetic history or experience of the core. This result is due to the fact that the magnetizing force created by the free poles at the ends of the core sections adjacent to the gaps opposes the magnetic force which creates it and also tends to neutralize the residual magnetism retained by the core after the removal of the magnetizing force.

The purpose of the present invention is to reduce the electromagnetic and electrostatic crosstalk existing in a coil thus organized.

The invention is particularly applicable to duplex phantom loading coils in which the line windings are arranged in sections upon quadrants of the core, as in my joint patent with George A. Campbell, No. 980,921, dated January 10, 1911, and in which the core itself is divided into two sections by diametric gaps.

In the accompanying drawings, Figure 1 shows diagrammatically a phantom loading coil having its core and winding-sections arranged in accordance with the present invention; Fig. 2 is a diagrammatic illustration of the distribution of capacities between the windings and core in such a coil; Fig. 3 is a similar view showing the path of crosstalk current when shields are applied to the core; Fig. 4 is an enlarged irregular transverse section through one side of the coil with the outer winding-section omitted; Fig. 5 shows in elevation the core of the coil with the electrostatic shields; and Fig. 6 shows the space relations between the ends of the groups of winding-sections in the coil of Fig. 1.

Throughout the drawings similar characters designate like elements.

Referring to Fig. 1, a phantom loading coil is shown, having pairs of windings for insertion in conductors 10, 11 and 12, 13 of each of two physical telephone circuits. The iron core of this coil is, as illustrated, of the usual toroidal form and is divided at 14, 14 by diametric gaps occupied by non-magnetic material. Upon the sections 15, 16 of the core thus formed, the line windings are arranged in sections 10^a, 10^c, 11^a, 11^c, 12^b, 12^d, 13^b, and 13^d, there being two sections for each line winding situated on opposite core quadrants *a*, *b*, *c*, and *d*, each section extending from a point in proximity to one of the gaps 14 to a point adjacent to the center of the core section. To prevent electromagnetic crosstalk in the coil between the two physical circuits, the windings included in said circuits must be electromagnetically balanced, and this requires that the mutual impedances between the winding-sections separated by the core gaps shall be equal to the mutual impedances between those on the same section. In the manufacture of loading coils having plural-section cores, it is necessary to leave an appreciable space between the windings to allow for cutting the core; and between the gaps, in the two-section core coil carrying four groups of winding-sections such as is now being described, the windings are naturally put as closely together as is consistent with the requirements of dielectric strength to economize winding space. The presence of the gaps and the separation of the windings at these points leads to considerable magnetic leakage, causing mutual impedance unbalance between the windings and consequent crosstalk. In accordance with this invention, the leakage at the extremities of the winding-sections is, as far as practicable, equalized, and approximate electromagnetic balance is therefore attained and crosstalk from this source becomes almost negligible. This is accomplished in two ways: The ends of the winding-sections at opposite sides of the gaps are brought as closely together as is possible, and yet leave space to cut through the core without injuring the windings. This minimizes the leakage at these points. In a standard loading coil this separation between the windings may be as little as one eighth of an inch. At ninety degrees from the gaps, the opposite extremities of the windings are separated at 17, by, say, from an eighth to a quarter of an inch, creating poles which have similar leakage effects to the core gaps. Just what this leakage-equalizing spacing of the windings shall be depends upon various considerations, as gap and core proportions and coil inductance.

The use of two diametric core-gaps, unless means were taken to prevent it, would lead to electrostatic crosstalk between the side circuits by way of the capacities k^a, k^b, k^c and k^d between the inner layers of the winding-sections which are next the core and core-sections. The distribution of these winding-to-core admittances appears in Fig. 2. It will be seen that k^a and k^b are associated with the core section 15 and k^c and k^d with the other section. The circuit 10, 11 is considered as the disturbing side circuit, the flow of current therein being indicated by long arrows. The path for crosstalk, shown by the short arrows, is as follows: from the conductor 10 by way of winding-section 10^a through capacity k^a, the core quadrants a and b and capacity k^b to the winding-section 12^b, where the current divides and flows in opposite directions through the conductor 12 of the disturbed side circuit, back over the other conductor 13 of this side circuit to the winding-section 13^d, through the capacity k^d, quadrants d and c and capacity k^c to the winding-section 11^c and the conductor 11 of the disturbing side circuit. Disturbing current will flow in the circuit indicated because the capacities k^a and k^c are associated with the opposite conductors of the same side circuit and will thus have its full potential acting upon it. This electrostatic crosstalk may be eliminated by applying to each core-section an electrostatic shield 21 (Figs. 4 and 5) and conductively connecting these at 22. The shields may consist of thin metallic sheets, as copper netting or tin foil, wrapped about the core-sections with the adjacent edges extending circumferentially of the core. These edges should be separated or insulated from one another at 23, so that they shall not furnish a closed electrical circuit about the core acting as a short-circuited secondary winding thereof. The connections 22 must be of non-magnetic metal to avoid short-circuiting the gaps in the core and is preferably soldered to the shields at each extremity. The low resistance connections between the shields short-circuit the high impedance crosstalk paths in the manner shown by the short arrows in Fig. 3.

I claim:

1. In a loading coil, core-sections separated by gaps, and a plurality of separate winding-sections on each core-section, one winding-section on one part of a core-section being separated by a gap from another winding-section on another part of said core-section, the extent of separation between the winding-sections tending to equalize their mutual impedances.

2. In a loading coil, core-sections separated by gaps, and a plurality of winding-sections on each core-section and separated from one another at the gaps and between said gaps, the relation between the ends of the winding-sections tending to equalize magnetic leakage.

3. A generally toroidal core provided with diametric gaps separating it into two sections, and two groups of winding-sections arranged on each section of the core, the separation between the groups of winding-sections upon the same core-section being at least as great as between the groups of winding-sections at the extremities of the core-sections.

4. A coil having a plurality of core-sections, windings thereon, conductive shields situated between the core-sections and windings, and a conductive connection between the shields.

5. A coil having a plurality of core-sections, windings thereon, non-magnetic conductive shields situated between the core-sections and windings, and a conductive connection between the shields.

6. In a coil, a toroidal core having a plurality of sections, a sheet of conductive material surrounding each section with the adjacent edges of each sheet extending circumferentially of the core and being insulated from one another, a conductive connection between the shields of different sections, and windings outside the shields.

In testimony whereof, I have signed my name to this specification in the presence of two subscribing witnesses, this twenty sixth day of October 1914.

THOMAS SHAW.

Witnesses:
LLOYD ESPENSCHIED,
WALTER J. DODGE.