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W. L. CASPER

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SHIELDED INDUCTANCE

Filed June 6, 1930

FIG. 1.

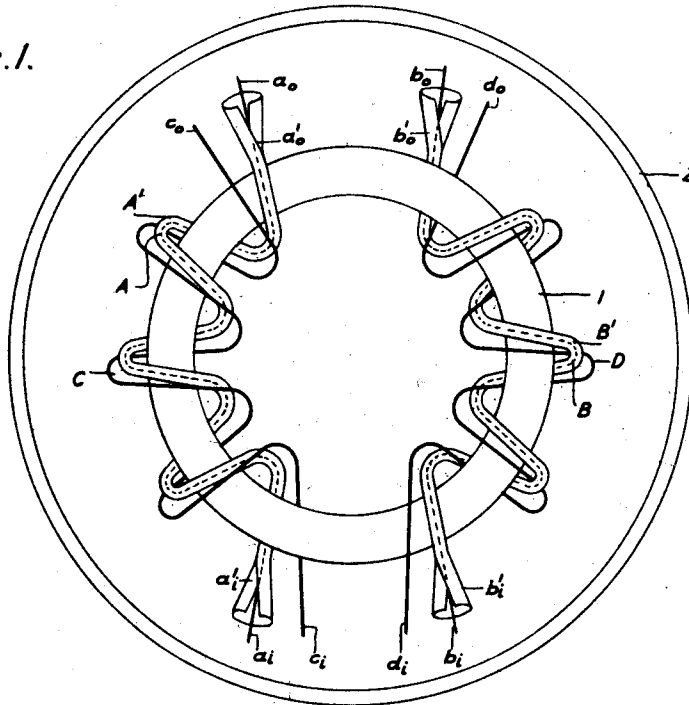
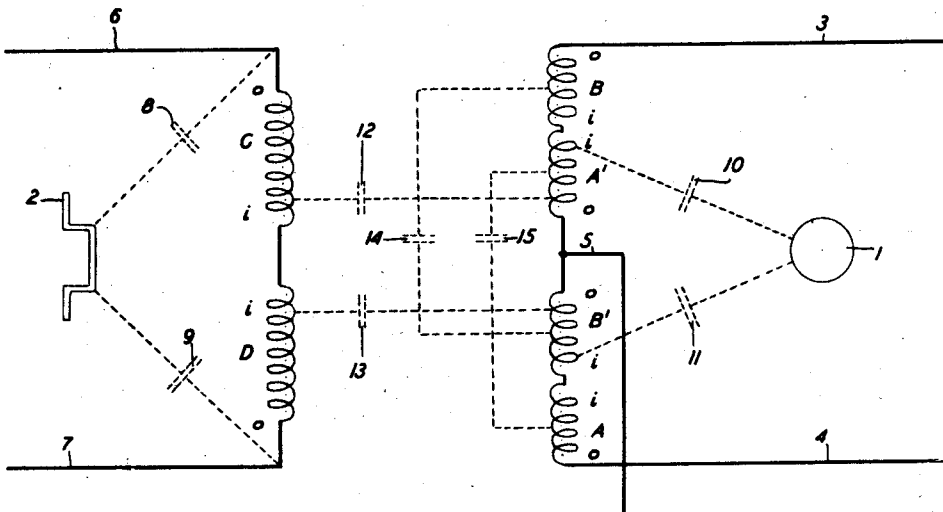


FIG. 2



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SHIELDED INDUCTANCE

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This invention relates to inductance devices and more particularly to those comprising a plurality of windings.

An object of this invention is to provide means for eliminating unbalanced impedance effects in an inductance device.

Another object of this invention is to provide means for reducing noise and cross-talk in balanced or phantom circuits.

A feature of this invention is a sectionalized winding in which the conductor of one section is made an electrostatic shield for the conductor of another section.

A particular application of this invention, to be described hereinafter in greater detail, is to repeater coils of the type used in phantom circuits such, for example, as described in U. S. Patent 981,015, issued January 10, 1911, to T. Shaw.

Heretofore, as in the present invention, such a repeater coil comprised three winding sections, two of which were connected in series across a pair of line wires comprising one side-circuit of the phantom system, the junction points of the winding sections being available as a phantom circuit tap. The third winding section was connected to a second pair of line wires. While a perfect phantom system would permit communication over the several available channels without any interference between them, it has been found in practice that a certain amount of interference or "cross-talk" is usually present. This effect may be due to inequalities in or an unsymmetrical disposition of the various capacities existing within the repeater coil itself, as those between sections of the windings, the case, the core, and any other associated elements, or it may be due to inequality of the inductance of line windings.

In accordance with applicant's invention a coil construction is provided which greatly reduces the amount of cross-talk introduced by unbalanced impedance effects within the repeater coil. A feature of this construction is a compound wire having a central conducting core surrounded by and insulated from a second, coaxial conductor which takes the form of a sheath. By this arrangement the enclosed conductor is completely insulated from

any electrostatic effects external of the outer conductor. Both sheath and core comprise coil sections, which are arranged as hereinafter described so that the shielding eliminates certain capacity effects which, if present and unbalanced, would be detrimental.

A further advantage inherent in applicant's invention is the high degree of inductive balance between line windings, which is greater than that obtained when the conductors forming these windings are wound as a twisted pair as heretofore. Because core and sheath are coaxial and the flux of one is concentric with the flux of the other, the inductances of the windings which they comprise are matched almost perfectly, and as the magnetic coupling is practically unity, very little impedance is offered to phantom currents.

The capacity balance also is an improvement over that obtainable by the twisted pair method of winding for the reason that the concentric formation of the core and sheath provides a greater uniformity in the capacity between these two conductors. By using equal lengths of the compound wire then, there is a greater assurance that the capacity effects in the two wires will be equal and therefore capable of being balanced in the coil.

The invention will be more fully understood by a consideration of the following detailed description of a specific embodiment, reference being made to the drawings, of which

Fig. 1 shows in diagrammatic form the disposition of the various windings on the core; and

Fig. 2 shows the electrical connections of these windings and the capacity effects existing within the coil.

In both drawings, 1 represents a transformer core of any desired construction, a toroidal form being shown. On one half of the core coils A and A' are wound with the compound wire above described, the conductor of coil A' comprising a sheath for that of coil A. Similarly, on the other half of the core are placed windings B and B', the latter acting as a sheath for the former. Any suitable material, such as cotton covering, may

be used to electrically insulate sheath from central conductor. For the particular method of connection shown, the coils are wound in the same sense with respect to the magnetic circuit. These four winding sections are connected in series as shown in Fig. 2 and together form what will be termed the secondary winding.

The "primary" winding, electrically separate from the secondary winding, comprises two winding sections C and D placed on opposite sides of the core, with C, as shown, covering sections A and A' and D covering B and B'. Surrounding core and windings is the protective case 2.

Although each winding is a multi-layer one, for the sake of clarity all have been indicated on the diagram as a single layer. In order to indicate the inner and outer layer of each section, the subscripts "i" and "o" respectively have been applied to the ends of the several windings. The reason for identifying inner and outer layers is that the capacities with which this invention is concerned exist only or for the most part between surface layers of the winding, the central layers in each winding being shielded from capacity effects by the bulk of conductors surrounding them.

The connection of the several winding sections to form this specific balanced phantom circuit transformer is as follows: The outer layer of coils A and B are connected to the terminals of the respective lines 4 and 3. The inner layer of A is connected to the inner layer of the winding B', as is the inner layer of B to the inner layer of A'. The outer layers of the sections A' and B' are connected together and to a terminal which forms the phantom circuit tap 5. The outer layers of the sections C and D, which may both be formed of ordinary conductors, are connected to an external circuit through conductors 6 and 7, respectively.

The various capacities shown (by dotted lines) in the drawing represent the natural capacity effects existing between the surface layers of adjacent windings, between the windings and the magnetic core 1, and between the windings and the case 2.

Because the inner layers of coils A' and B' are adjacent the core, the capacity effects 10 and 11 are present. These capacities can have no unbalancing effect because the potential of the core is left "floating". Their only effect is to shunt the secondary winding. Between the outer layers of coils C and D and the grounded case 2, there are the capacity effects 8 and 9, respectively, but as there are no phantom currents in that side of the circuit, the phantom to side-circuit balance is not affected. Between conductor B and its sheathing conductor B' exists the capacity 14; similarly capacity 15 is due to the proximity of conductor A to its sheath A'. These

capacities, if unequal, cause an unbalanced condition. Using the compound conductor of this invention it is possible to obtain a better balance of these capacities than is ordinarily obtained when the conductors of each pair are twisted about each other. This is due to the greater uniformity in the distance between conductors of a pair which is inherent in applicant's construction.

Were it not for the electrostatic shielding effect of one of the paired conductors on the other, there would be capacities between the inner layer of coil C and the outer layer of coil A and a corresponding capacity between the inner layer of coil D and the outer layer of coil B. Inequality of these capacities would set up an unbalanced condition in the repeating coil, resulting in cross-talk between phantom and side circuits. This important source of cross-talk in coils of the prior art is eliminated by the present invention. Capacities 12 and 13, between the inner layers of coils C and D and the outer layers of coils A' and B', respectively, therefore, are the only direct capacity couplings between primary and secondary windings. While these capacities may be unequal, an unbalanced condition will not be established, inasmuch as the points they connect are both substantially at mid-line potential.

From the foregoing description it follows that the natural capacity effects existing between the various sections of the coil are either accurately balanced against each other or are confined to points where they can have no effect on the balance or unbalance of the repeater coil.

While particular stress has been placed on the improvement of capacity balance, it is equally essential that an inductive balance be maintained at the same time. As windings A and A' are formed of the compound conductor described they will be linked by the same flux and therefore, have the same inductance; and being on opposite sides of the phantom tap they contribute to an exact inductive balance of the coil. The two windings B and B' are similarly arranged on opposite sides of the phantom tap and have equal inductance.

The exact structure of the compound conductor described is not a feature of this invention. It is sufficient that the outer conductor shield the central conductor from external electrostatic effects. In the particular embodiment used for illustration the external conductor is formed of thin sheet material wrapped as a sheath about the central conductor and insulated from it by a cotton wrapping.

Various modifications of applicant's invention, involving the use of a shielding conductor to eliminate undesired capacity effects in an inductance device, can, of course, be made without departing from the spirit of the in-

vention. The present invention, therefore, is to be limited only by the scope of the appended claims.

What is claimed is:

5 1. In a transformer having sectionalized primary and secondary windings, means for reducing unbalanced capacity effects which comprises a hollow conductor concentric with and insulated from the conductor of another
10 section, said hollow conductor itself comprising a winding section.

2. In an inductance device comprising a core, a plurality of winding sections thereon and a case thereabout, means for balancing unsymmetrical capacities comprising a
15 conductor of one winding section disposed to electrostatically shield the conductor of another winding section.

3. A transformer which comprises a core,
20 a primary winding section on each side of said core, and a secondary winding comprising four multi-layer sections, two of said latter sections being wound with coaxial conductors on one side of said core and the other
25 two being wound with coaxial conductors on the other side of said core, said secondary sections being all serially connected, with the sections formed of the sheathing conductor of each coaxial pair electrically between those
30 formed of the central conductor, and with the layers of the sheathing conductor adjacent the primary sections connected together as a terminal; the layers of said primary winding sections adjacent said secondary
35 windings being connected together.

4. An inductance device which comprises a plurality of sections, the conductor of one section of each pair of said sections being concentric with the conductor of the other
40 section of the pair; said sections being so connected as to eliminate detrimental capacity effects.

5. An inductance element, comprising a plurality of coil sections wound with paired
45 conductors and requiring an accurate adjustment of the inter-conductor capacities of certain of said pairs of conductors, one of each of said pairs of conductors being concentric with and insulated from the other conductor
50 of the pair.

6. An inductance element comprising a plurality of winding sections, the conductor of one of said sections being concentric with the conductor of another of said sections,
55 whereby the inductances of said latter sections are accurately matched.

In witness whereof, I hereunto subscribe my name this 5th day of June, 1930.

WILLIAM L. CASPER.