Nov. 16, 1926. 1,606,816

G. H. STEVENSON

INDUCTANCE DEVICE

Filed April 28, 1923

Fig. 1.

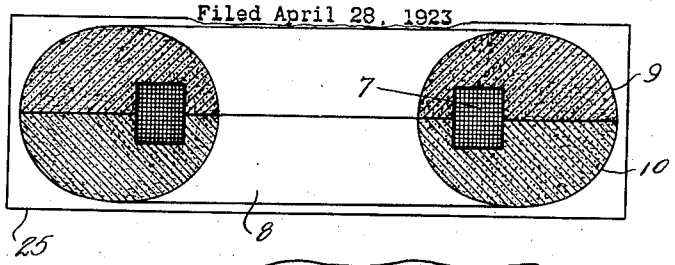


Fig. 2.

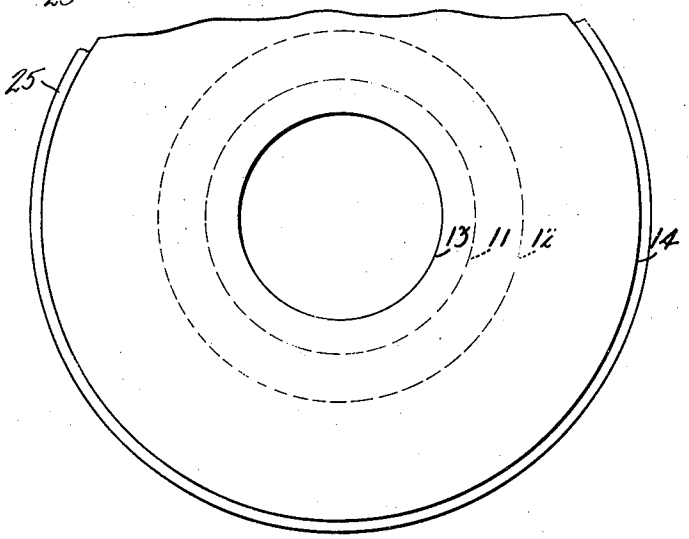


Fig. 3.

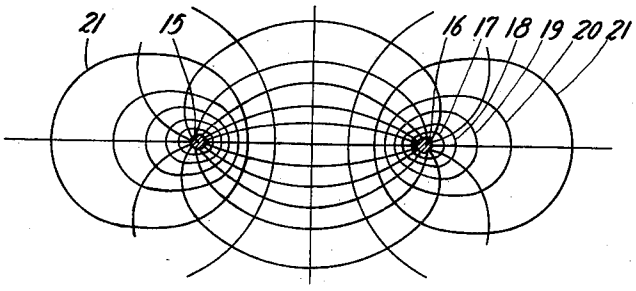
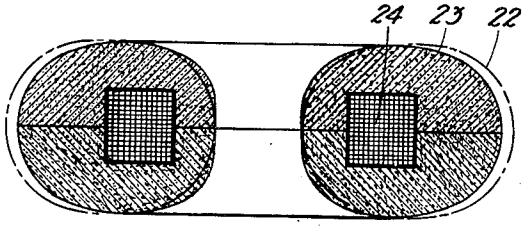


Fig. 4.



Inventor:
George H. Stevenson.
by Joel C. Palmer Att'y

Patented Nov. 16, 1926. 1,606,816

UNITED STATES PATENT OFFICE.

GEORGE H. STEVENSON, OF NEW YORK, N. Y., ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

INDUCTANCE DEVICE.

Application filed April 28, 1923. Serial No. 635,183.

This invention relates to inductance devices and more particularly relates to inductances of the type in which the winding is substantially entirely imbedded in the core material.

An object of this invention is to reduce the proportion of the external magnetic field of an inductance device with respect to the amount of the magnetic field confined in the magnetic core material.

Another object is to reduce the effective resistance losses in an inductance device due to the presence of conductors in the field of the coil.

Another object of this invention is to increase the efficiency of an inductance device for the transmission of signaling frequency currents.

The particular form of this invention hereinafter described in detail is embodied in a toroidal loading coil of the iron clad type, that is, one in which the inductance winding is imbedded in the core material. In accordance with this invention the leakage of flux from the core about a coil is substantially reduced by designing the core so that the rate of generation of magnetic potential at the surface of the core, due to current in the coil, is everywhere equal to the rate of consumption of magnetic potential by the reluctance of the path, that is, so that with respect to points outside the core, the outer surface of the core is everywhere at the same magnetic potential. This may be done by regulating the reluctance of a core of uniform material through varying the cross section of the magnetic path in the proper proportions from point to point. This design results in a core the external surface of which around the coil closely approximates the path of a tube or line of force in the field of the coil.

Referring to the drawings, Fig. 1 represents this invention embodied in a loading coil in which the inductance winding is embedded in the coil material, Fig. 2 is a plan view of the loading coil of Fig. 1, Fig. 3 illustrates the magnetic field and the equal potential surfaces around a coil through which an electric current is passing, and Fig. 4 is a modification of Fig. 1.

Referring more particularly to Figs. 1 and 2, an inductance device is disclosed therein in which the inductance winding 7 is completely imbedded in the core material 8. The core material 8 is composed of two annular rings 9 and 10 having opposed parallel surfaces which are placed in contact with each other to form a core having a toroidal cross section. Space for the winding 7 is obtained by a groove of suitable width and depth in each of the annular rings 9 and 10. While various kinds of magnetic material may be employed in the core, it has generally been found preferable to employ iron dust material such as that disclosed in Speed U. S. Patent No. 1,274,952 of August 6, 1918.

As will be noted by inspection of Fig. 1 the greater part of the magnetic material is external to the coil as compared to the amount of material on the interior of the coil. This is clearly shown in Fig. 2, for example, where lines 11 and 12 indicate the width of the groove in which the winding 7 rests and the distance between lines 13 and 11 indicates the width of the magnetic material on the interior of the coil, while the distance between the lines 12 and 14 represents the width of the magnetic material external to the coil. While the arrangement of the core material around the coil 7 is not the most economical use of the material per unit of the inductance, the arrangement has been found particularly advantageous in reducing the external magnetic field of the coil so as to prevent excessive cross-talk between a plurality of adjacent loading coils of the type shown in Fig. 1. When such a coil as shown in Fig. 1 is surrounded in the usual manner by a solid magnetic shield 25 the eddy-current losses in the shield are small, which results in a low value of the effective resistance of the coil.

The arrangement of the magnetic material around the coil 7 will be better understood by reference to Fig. 3 which shows the magnetic field and the equal potential surfaces around the coil traversed by electric current. The coil carrying the current is shown at the points 15 and 16 and the lines 17, 18, 19, 20 and 21 represent the lines of force around the wire assuming the wire to be surrounded by an infinite medium of constant permeability. If we consider a tube of force bounded by the lines 20 and 21 for example, the rate of generation of magnetic potential is everywhere equal to the rate of consumption of the potential,

that is, the magnetic force generated in a given length of the path is equal to the reluctance drop over that path. This is evident from the figure for the tube of force bounded by lines 20 and 21 is narrow inside the coil and grows wider as it passes towards the outside, that is, the reluctance is larger within the coil and smaller without. The equal potential surfaces also are crowded together inside the coil and separated as they pass toward the outside so that the rate of generation of potential is greatest where the reluctance, the consuming factor, is greatest. This means that there is no tendency of the lines of force within the tube to pass out of it to produce an external field, since the potential of all points on the surface of the tube with respect to any point outside the core is the same. If now a core is formed whose surface follows the outline of the line 21 and if the space occupied by the winding is so small that it can be neglected, this core may be placed about the coil without distorting the shape of the magnetic field surrounding it. No flux will pass through the surface of such a core. If such a coil with its core is placed within a magnetic shield, some flux will pass from core to shield if the latter is sufficiently close to the core to distort the field about the coil so that it no longer remains tangent to the core surface at the surface. If, however, the permeability of the core is fairly high, 30 to 50 for example, and the clearance between the core and the shield is moderate the shield will produce little distortion. The effect of the pressure of the shield can be compensated by modifying the surface of the coil so that it follows the outline of a line of force in the distorted field.

Referring now back to Fig. 1 there will be no substantial leakage of flux from the core 8 to its shield when the core is so designed that the rate of generation of magnetic potential at the surface of the core, due to the current in the coil 7, is everywhere equal to the rate of consumption of magnetic potential by the reluctance of the core, that is so that with respect to points outside the core the outer surface of the core is everywhere at the same magnetic potential. This is done in Fig. 1 by regulating the reluctance of the core 7 by varying the cross section of the magnetic path in the proper proportion from point to point. A convenient method for determining the surface of the core 8 is to send a current through the winding 7 in the absence of any core material and to trace the magnetic field of the coil 7 in air. The path of one of the lines of force about the coil 7 may then be taken for defining the external surface of the core 8.

This method for obtaining the outline of the core material may be used to take into account that when space for the winding 7 is cut in the core sections 9 and 10 of higher permeability than air, the distribution of the reluctance of the magnetic path about the current center of the winding cross section is distorted. For the form of winding illustrated in Fig. 4 the actual effect is that the reluctance of that part of the core inside the coil is increased more in relation to its value in the simple case than the reluctance of the core outside the coil center. In Fig. 4 the external surface of the core as defined by the dotted line 22 corresponds to the simple case obtained by tracing a path of a tube of force in air surrounding a coil of very small cross section and the full line 23, indicates the approximate shape which the core should take to correct for the effect of the size and shape of the cross section of the actual coil shown.

Similarly the method may be used to correct for the influence of the surrounding shield which may be present.

It is to be understood that the above described method for determining the formation of a core may be applied to various types of inductance devices and loading coils of various configurations without departing in anywise from the spirit of the invention as defined in the appended claims: Multi-winding inductance devices such as transformers may be constructed in accordance with this invention.

The invention claimed is:

1. An inductance device comprising a winding and a substantially closed path magnetic core surrounding said winding that part of said core on the outer side of said winding having a smaller reluctance per unit length of path than that part on the inner side of the winding.

2. An inductance device comprising a coil, a magnetic core surrounding said coil to form a substantially closed magnetic path for the flux produced by current flowing in said coil and having a surface substantially outlining an equi-magnetic potential surface for currents flowing in said coil.

3. A coil substantially completely surrounded by uniform magnetic material, the amount of said material exterior to said coil being considerably in excess of the amount of said material on the interior of said coil.

4. A coil of wire substantially completely imbedded in iron dust core material, the amount of said material external to said coil being considerably in excess of the amount of said material on the interior of said coil.

5. A coil substantially completely surrounded by uniform magnetic material, the magnetic material in a plane through the coil at right angles to its axis having a minimum thickness on the interior of the coil

and a maximum thickness on the exterior of the coil, the material gradually increasing in thickness from the minimum region to the maximum region.

6. A toroidal core of magnetic material and a coil of wire imbedded in said core, the mean diameter of the coil being different from the mean diameter of the core material.

7. A toroidal core of magnetic material and a coil of wire imbedded in said core, the mean diameter of the coil being less than the mean diameter of the core material.

8. A toroidal core of magnetic material, and a coil of wire imbedded in said core, the area defined by a cross section of said core around the coil corresponding substantially to the area defined by the path taken by a line of force around the coil when it carries an electric current.

9. A toroidal core of magnetic material, and a coil of wire imbedded in said core, the area defined by the cross-section of said core around the coil corresponding substantially to the area defined by the path taken by a line of force around a wire surrounded by an infinite medium of constant permeability when the wire is carrying an electric current, but departing therefrom in having slightly less core material in the part of said core external to the coil.

10. An inductance device comprising a winding and a substantially closed path magnetic core surrounding said winding, that part of said core on the outer side of said winding having a smaller reluctance per unit length of path than that part on the inner side of said winding, the reluctance of said core per unit length of path gradually changing from a maximum to a minimum while progressing from the inside to the outside.

11. An inductance device according to claim 1 and having a metallic shield surrounding the magnetic core.

In witness whereof I hereunto subscribe my name this 26th day of April A. D., 1923.

GEORGE H. STEVENSON.