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E. B. PAYNE

INDUCTANCE DEVICE

Filed May 8, 1923

Fig. 1.

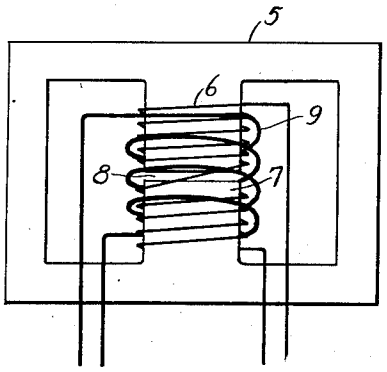


Fig. 2.

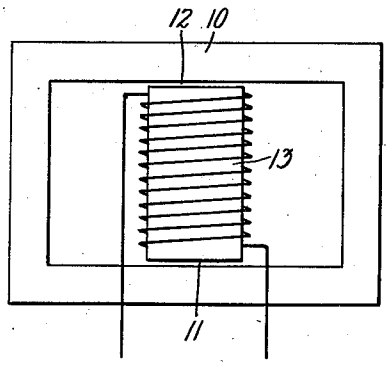
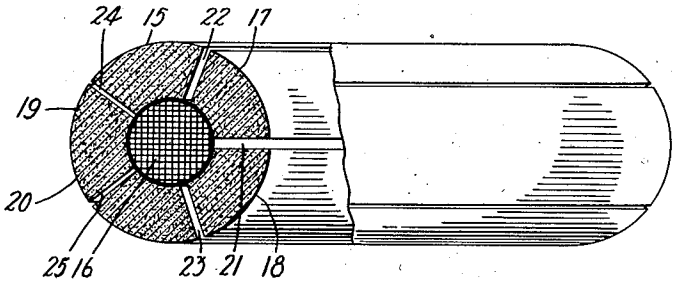


Fig. 3.



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UNITED STATES PATENT OFFICE.

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INDUCTANCE DEVICE.

Application filed May 8, 1923. Serial No. 637,453.

This invention relates to inductance devices and more particularly it relates to inductances of the type surrounded by magnetic shields to confine external stray fields.

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 surrounding the coil with a magnetic shield.

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 concerned with the reduction of the magnetic leakage from the core of an inductance device to its surrounding shield, a result which must be minimized in order to produce a high quality inductance device with low effective resistance. In accordance with this invention, leakage of flux about a coil to its shield is prevented by employing air gaps in the magnetic path in such a manner that the rate of generation of magnetic potential at the surface of the core due to the current in the coil is everywhere substantially equal to the rate of consumption of magnetic potential by the reluctance of the core. In a two-mesh core, for example, having the winding or windings upon the common branch, one or more air gaps may be provided in the common branch since the rate of generation of magnetic potential at the surface of the core is greatest on the part of the core surrounded by the coil and the one or more air gaps proposed will increase the reluctance of the core at the points where the rate of generation of magnetic potential is greatest until there is an approximate equality between the rate of generation of magnetic potential and the consumption of magnetic potential by the reluctance of the core.

When this invention is applied to a toroidal core having a winding completely embedded therein, the rate of generation of magnetic potential is greatest along the surface of the core within the coil while the generation of magnetic potential is less along the surface outside the coil. This is compensated for by providing a plurality of air gaps in the core material of varying width, the air gap of greatest width being within the coil and the air gaps gradually diminishing in width until the exterior part of the core is reached.

Referring to the drawings, Fig. 1 represents this invention embodied in a two-mesh core inductance device in which an air gap is provided in the center of the common branch of the core; Fig. 2 is a modification of the two-mesh core inductance device of Fig. 1 in which air gaps are provided at the junction of the common branch with the rest of the core structure, and Fig. 3 shows how this invention may be applied to that type of inductance device in which the winding is completely embedded in the core material.

Referring more particularly to Fig. 1, a two-mesh core 5 is disclosed therein having inductance windings 6 and 9 wound on the common branch of the two meshes.

In order to fully understand the advantages derived from the provision of the air gap 8 in the branch 7 of the core, reference is had to the shape of the magnetic field and the equi-potential surfaces around a circular coil carrying an electric current, assuming the coil to be located in a homogeneous medium of constant permeability. As we follow a tube of force around such a coil, the rate of generation of magnetic potential is everywhere equal to the rate of consumption of the magnetic potential, that is,—the magnetic force generated in a given length of the path is equal to the flux reluctance drop over that path. This is evident from the fact that the flux tube with such a coil is narrow inside the coil and grows wider as it passes toward the outside, that is,—its reluctance is larger within the coil and the smaller without. The equi-potential surfaces are crowded together inside the coil and separated further as we pass toward the outside so that the rate of generation of magnetic potential is greatest where the reluctance, the consuming factor, is greatest. This means that there is no tendency to produce an external field since the potential of all points on the surface of the assumed tube of force with respect to any point outside is the same. If, now, an inductance device is made in such a manner that the rate of generation of magnetic

potential at the surface of the core is everywhere equal to the rate of consumption of magnetic potential by the reluctance of the core, so that with respect to points outside the core, the outer surface of the core is everywhere at the same magnetic potential, it follows that there will be no leakage of the flux from the core to a surrounding shield or other adjacent metallic objects. Such an arrangement would, therefore, reduce the effective resistance losses in such an inductance device by reducing the proportion of the external magnetic field with respect to the amount of the field confined in the core thereby increasing the efficiency of such a device for the transmission of the signaling frequency currents such as telephone currents.

Since the rate of generation of magnetic potential is greatest along the surface of the limb 7 of Fig. 1, compared to the rest of the core surface, the reluctance of the magnetic path through the branch 7 should be increased until the rate of generation of magnetic potential along the surface of branch 7 is substantially equal to the rate of consumption of magnetic potential by the reluctance of branch 7. This increase in the reluctance may be brought about by providing one or a series of air gaps in the branch 7 so spaced and designed as to approximate the desired equality between the magnetic potential and its consumption by the reluctance of the core. For example, in Fig. 1, one air gap 8 is disclosed, placed at the center of the branch 7. In one specific case, for example, an inductance device of the type shown in Fig. 1, was provided with an air gap at the point 8 of a width equal to approximately .1 inch thus approximating the ideal case previously mentioned. The presence of this air gap produced a substantial reduction in the leakage of the flux from the core to the surrounding shield.

This increase in the reluctance of the common branch of a two-mesh core may be made by an air gap or air gaps provided at other points than the middle point as shown in Fig. 1. For example, in Fig. 2, a two-mesh core 10 is disclosed having two air gaps 11 and 12 occurring at the junctions of the common branch of the core to the rest of the core. The presence of these two air gaps aids in producing the ideal case desired, that is,—one in which the reluctance of the common branch 13 is increased so as to consume substantially entirely the amount of magnetic potential generated along this surface.

The ideal case, of course, would be to provide a large number of air gaps around the entire core structure, having the air gaps of greatest width at the points where the rate of generation of magnetic potential is the greatest and having them diminish in width as the rate of generation of magnetic potential decreases. The number of air gaps employed in any particular case, therefore, will depend upon how near it is desired to approximate the ideal case.

This invention is, of course, applicable to transformers or inductance devices having cores of any type and is not limited in its application to the type of core disclosed in Figs. 1 and 2. Fig. 3, for example, discloses this invention embodied in that type of inductance device having a toroidal core with the winding or windings completely embedded within the magnetic material resulting in the so-called "iron-clad" type of coil structure which has been found to be of particular utility in loading coils for telephone lines. The torodial core 15 is shown only in part, since the complete structure is not required to illustrate this invention. The core 15 composed, for example, of uniform magnetic material such as the iron dust material described and claimed, for example, in the U. S. patent to Speed, No. 1,274,952 of August 6, 1918, which completely surrounds a coil or winding 16. In such an inductance device, the rate of generation of magnetic potential is greatest along the surface within the coil such as at the points 17 and 18 while the rate of generation of magnetic potential is less on the outside of the coil such as the points 19 and 20. Since the coil 16 is to be centered within the core 15, the reluctance of the core, assuming no air gaps, is the same inside and outside the coil so that there is an excess of generated magnetic potential particularly along the surface of the core inside the coil. This excess of generated potential, unless it is corrected for, will produce leakage to the surrounding shield for the device or to other adjacent metallic objects, so that in case a plurality of inductance devices such as that shown in Fig. 3 are employed for loading a plurality of telephone lines, cross talk would thereby be produced between the circuits or else if grounded metallic shields are interposed, the effective resistances of the coils will be excessive due to losses of the shields. This excess of generated magnetic potential, however, may be taken care of by providing a plurality of air gaps in the core 15 of varying width, the air gaps of the greatest width being provided on the interior of the coil where the rate of generation of magnetic potential is the greatest while the air gaps of the smallest width are located outside the coil at the points where the difference between the rate of generation of magnetic potential and its consumption by the reluctance is not so great. Accordingly, an air gap 21 is provided on the interior of the coil, and air gaps 22 and 23 are provided of a width considerably less than the width of air gap 21 since the rate of generation of

magnetic potential at the points where the gaps 22 and 23 are located is less than the rate of generation of the point 21. Other air gaps. such as 24 and 25 may be provided outside to further bring about the desired equality between the rate of generation of magnetic potential and its consumption. These air gaps may be so adjusted that with respect to points outside core 15, the outer surface of the core is substantially everywhere at the same magnetic potential. It is, of course, obvious that as many air gaps may be employed as may be desired and the greater the number of air gaps, the more nearly will the ideal case be approached. It is to be understood, of course, that these gaps may be filled if desired with any suitable non-magnetic material such as wood.

A convenient method for obtaining the correct disposition and size of the air gaps is to place a cardboard sheet around the core and to note the arrangement of iron filings on the sheet when a current is passed through the coil associated with the core. At the places where the iron filings bulge out from the surface of the core indicating an excess of generated potential, an air gap should be placed of a width depending upon the degree of bulge. After the gap has been cut, the iron filings may again be placed around the core to see if the size and disposition of each gap is correct. This method may also be employed in connection with the type of inductance device described and claimed in the copending application to G. H. Stevenson, filed April 28, 1923, Serial No. 635,183, in which the cross-section of the core around the coil is varied until the desired equality between the generated magnetic potential and its consumption is attained. By placing the iron filings around a core the surface of which is to be tested any bulging of the lines of force as indicated by the iron filings should be corrected for by the addition of magnetic material along the bulging surface, the material being distributed so that the greatest amount is added at the point of least bulge, or by the cutting away of magnetic material at places diametrically opposite the bulging points. In order to determine how the surface of the core or the air gaps should be modified in order to compensate, for example, for the presence of a metallic shield which may be used in actual practice around the core. This shield may be placed around the core while testing the core with the iron filings and the effect of the shield will be automatically taken care of by modifying the core until the irregularities in the paths taken by the iron filings are overcome.

It is to be understood that this invention may possess embodiments differing widely from those described in detail above without departing in any wise from the spirit of this invention as defined in the appended claims.

What is claimed is:

1. An inductance device comprising a magnetic core and a winding associated with said core, said core having an air gap located at the point in the core where there is an excess of generated magnetic potential over its consumption by the reluctance of the core, said air gap being so proportioned with respect to the flux density of said core and to the magneto-motive force of said winding as to produce a substantial equality between the rate of generation of magnetic potential and its consumption by the reluctance of the core.

2. A coil embedded in uniform magnetic material and a plurality of spaced air gaps cut-in in said material to increase the reluctance of the magnetic path around said coil in those portions of the magnetic path in which the rate of generation of magnetic potential is highest.

3. A coil of wire embedded in iron-dust core material, and a plurality of air gaps cut in the core material to increase the reluctance of the magnetic path sufficient to cause the outer surface of said magnetic material to be substantially everywhere at the same magnetic potential.

4. A coil of wire embedded in uniform magnetic material and a plurality of spaced air gaps extending substantially radial of the cross-section of the magnetic material for increasing the reluctance of the magnetic path around the coil, said air gaps being of different widths, the greatest width being located in that part of the core on the interior of the coil.

In witness whereof, I hereunto subscribe my name this 28th day of April, A. D., 1923.

EDWARD B. PAYNE.