April 11, 1939. P. S. DARNELL 2,154,232

ADJUSTABLE INDUCTANCE

Filed May 15, 1937

FIG. 1

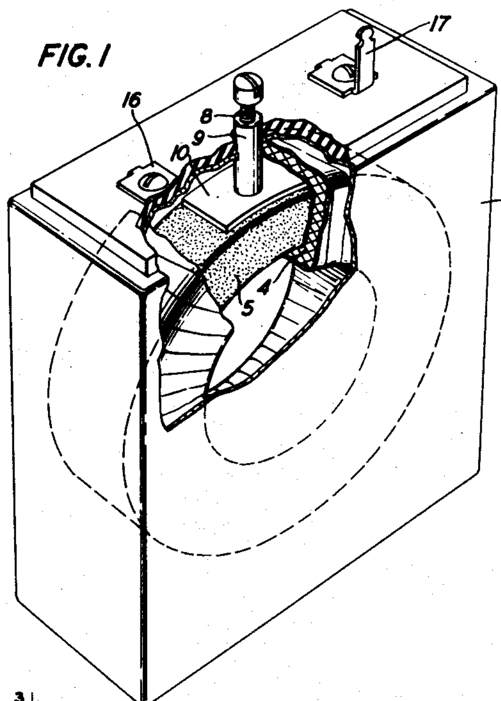


FIG. 2

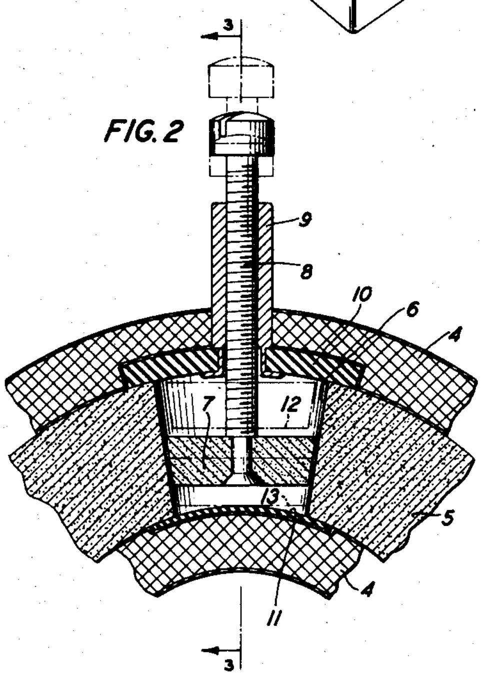
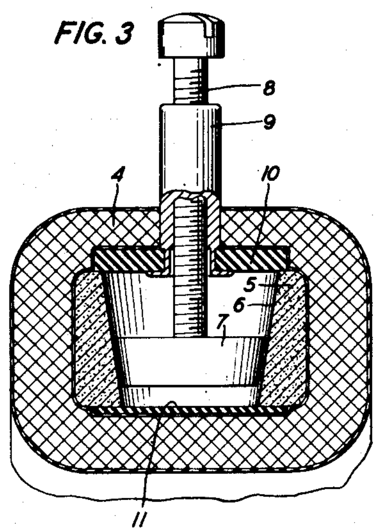


FIG. 3



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ADJUSTABLE INDUCTANCE

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4 Claims. (Cl. 171—119)

This invention relates to adjustable inductances and more particularly to toroidal coils, the inductance of which may be varied.

Toroidal coils have gone into wide use as loading or filter coils, transformers and the like due to the inherent efficiency of the magnetic circuit and other recognized advantages. However, the use of such coils in places where a high degree of accuracy of inductance is required has been limited due to the difficulty of adjusting the inductance of such coils to the accuracy required. Even with care in manufacture it has been found that coils will differ sufficiently in inductance from the required value to make their use difficult for certain purposes. For example, placing toroidal coils in an enclosed case, impregnating the windings or mounting the coils in proximity to other apparatus may vary their inductance.

An object of this invention is a toroidal coil whose inductance may be varied.

Another object of the invention is a toroidal coil whose inductance may be accurately adjusted after the wound core has been impregnated with a suitable compound.

In accordance with the preferred embodiment of this invention a toroidal core of magnetic material is provided with a cylindrical or tapered hole whose axis coincides substantially with a radius of the torus and within the hole is adjustably mounted a relatively thin disc or plate of magnetic material with the axis of the disc substantially coinciding with the axis of the hole. A winding of a suitable number of turns is then applied to the core and the wound core impregnated in the usual manner and suitably mounted in the casing after which the inductance of the winding may be accurately adjusted to the required value by the movement of the disc. The maximum inductance will occur when the disc is at the inner periphery of the torus while the minimum inductance will occur when the disc is at the outer periphery, intermediate positions of the disc giving intermediate values of inductance.

Referring to the drawing,

Fig. 1 is a perspective view in partial section of a toroidal core inductance coil embodying features of this invention;

Fig. 2 is a longitudinal sectional view of a portion of the wound core of Fig. 1; and

Fig. 3 is a cross-sectional view of the core of Fig. 1 taken along the line 3—3 of Fig. 2.

Referring now to Fig. 1 a multi-layer winding 4 is shown uniformly mounted upon a toroidal core 5 made preferably of highly compressed insulated magnetic particles, for example, of the type disclosed in the W. C. Ellis Patent 1,943,115, issued January 9, 1934.

The core as shown more clearly in Figs. 2 and 3, has a tapered hole 6 drilled completely through the core, the axis of the hole coinciding with a radius of the torus. Within the hole is located a movable disc 7 of magnetic material mounted on the end of a screw 8 of non-magnetic material such as brass, which screw is adapted to move in an internally threaded brass sleeve 9 suitably secured to a plate 10 of Bakelite or other insulating material which serves as a closure for the outer end of hole 6 while the inner end of the hole is closed by a plate 11 of insulating material such as fibre. Plates 10 and 11 may be suitably held in place, for example, by being cemented to the surfaces around the core opening 6. It will be apparent that by turning screw 8 the disc 7 of magnetic material may be moved upwardly or downwardly to the dotted positions 12, 13, its upper position being reached when the upper edge of disc 7 strikes plate 10, and the lower position being reached when the lower surface of disc 7 strikes cover plate 11. It thus will be noted that the movement of disc 7 is confined to a region lying wholly within the periphery of the core. The dimensions of disc 7 are preferably such that the side walls of the disc fit snugly against the walls of hole 6 when the disc is in its lowermost position 13.

Since as previously stated the disc 7 moves entirely within the limits of the core surface, it follows that the multi-layer winding 4 may be uniformly distributed around the toroidal core except for the space occupied by sleeve 9, so that the winding space lost by the use of the adjustable feature of this invention is not determined by the diameter of hole 6 but merely by the diameter of the small sleeve 9.

After the hole 6 has been drilled in the core, the core may be coated with a suitable enamel to prevent wax during the impregnating process from being absorbed into the dust core and altering its permeability-temperature characteristic, and also to prevent the wax from entering the hole 6. After the enameling the disc assembly 7, 8, 9, 10 may then be mounted in place after which the core is ready to be wound with a suitable number of turns and layers to give the approximate desired inductance with the disc 7 in its middle position. The wound core is then mounted within a suitable casing 15 and the remaining space filled with a suitable potting compound such as wax, or the coil may be centered in the case in any other suitable manner. The ends of the winding are brought out to terminals 16 and 17 mounted at any convenient place on a suitable terminal plate while the head 18 of the adjusting screw 8 projects through an aperture in the case to permit adjustment of disc 7 after the wound core has been potted. By means of a screw-driver or other tool the inductance may be brought accurately to the desired value by turning screw 8 in the proper direction after which the screw 8 may be locked in any suitable manner to prevent further turning.

It will be noted that when the disc is in its lowermost position there is practically no air-gap between the disc and the main core since in this position the disc fits snugly against the walls of hole 6, but as the disc is moved upwardly there is a gradually increasing air-gap between the disc and the core due to the increasing size of the hole.

In explanation of the change in inductance with change in position of disc 7 we may assume that hole 6 is cylindrical and that disc 7 is also cylindrical and fits snugly into the hole in all positions. It can be shown under such conditions that the flux density at the inner periphery of the torus is substantially

$$\frac{r_2}{r_1}$$

times that at the outer periphery, where r_1 is the inside radius and r_2 the outside radius of the torus. Hence, by completing the magnetic circuit at the inner periphery the flux in the core will be greater than if the magnetic circuit is completed at the outer periphery. When both the hole and the disc are slightly tapered as shown in the drawing with the disc fitting snugly into the hole only at the inner periphery of the torus, the inductance variations result from two actions, the variation in air-gap and the alteration in flux density, and the two actions are mutually aiding, thereby increasing the overall variation of the inductance with change in position of disc 7.

As previously stated, the disc 7 is preferably of higher permeability than the main core although both the core and the disc 7 may be composed of finely divided magnetic material insulated and compressed in accordance with the above-mentioned Ellis patent, where the magnetic material employed may be molybdenum permalloy as disclosed in G. W. Elmen, U. S. Patent 1,768,443 issued June 24, 1930. In one example, the magnetic material of the core 5 had an effective permeability of 13.5 while the magnetic material of disc 7 had an effective permeability of 125. With the construction shown in the drawing, it has been found that a variation of 2 per cent of the inductance of the coil can be readily secured by the described arrangement and it has also been found that with the shown construction the percentage change in inductance is practically linear with change in position of disc 7 along the axis of tapered hole 6. The thickness of disc 7 should preferably be small compared to its length of travel; for example, it has been found satisfactory to have the thickness of the disc about one-sixth of its length of travel.

While it is preferred to have hole 6 slightly tapered it is also contemplated that both the hole 6 and disc 7 may be cylindrical.

It is to be understood that this invention is applicable to a coil having a plurality of windings and is not limited to a coil having only a single winding as described. The adjustable feature may also be modified from that shown and the invention is, therefore, to be limited only by the scope of the appended claims.

What is claimed is:

1. An inductance device comprising a toroidal core of magnetic material, a winding on said core, said core having a hollow chamber extending substantially between the inner and outer peripheries of said core, a movable member of magnetic material located wholly within said chamber, means for moving said member along an axis extending between the inner and outer peripheries of said core, said member having in the direction of its movement a thickness substantially less than the distance between the inner periphery and the outer periphery of said core, and means for confining said movement between the inner periphery and the outer periphery of said core.

2. An inductance device comprising a toroidal core of magnetic material, a winding on said core, said core having a hole extending substantially between the inner and outer peripheries of said toroid, with the axis of said hole substantially coinciding with a radius of said toroid, a thin plate of magnetic material mounted within said hole with the plate located substantially at right angles to the axis of said hole, a non-magnetic cover for the inner and outer ends of said hole, said winding extending over a substantial proportion of said cover, and means projecting through said cover for moving said plate in a direction along the axis of said hole.

3. An adjustable inductance in accordance with claim 2 in which said plate is a disc and in which the surface defining said hole constitutes a portion of the surface of a cone with its greatest diameter at the outer periphery of the toroid, the diameter of said disc being substantially equal to the diameter of said hole near the inner periphery of said toroid.

4. An adjustable inductance device comprising a toroidal core, a winding on said core, said core having a hole extending through said toroid with the axis of the hole substantially coinciding with the radius of the toroid, a non-magnetic cover for the inner end of said hole, a non-magnetic cover for the outer end of said hole, said outer cover having an aperture substantially coinciding with the axis of said hole, a sleeve extending beyond the outer periphery of said toroid with the axis of said sleeve substantially coinciding with the axis of said hole, a screw extending through said sleeve into said hole and a disc of magnetic material within said hole and mounted on said screw.

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