# United States Patent

**Elberger**

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## [54] MINIATURE INDUCTANCES


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[21] Appl. No.: **112,252**

**Related U.S. Application Data**

[63] Continuation-in-part of Ser. No. 810,718, March 26, 1969, abandoned.

[52] **U.S. Cl.**.....**336/221,** 336/100, 336/208, 336/210

[51] **Int. Cl.**.....**H01f 17/04**

[58] **Field of Search**.....336/198, 208, 210, 221, 213, 336/100



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[57] **ABSTRACT**

Improved insulation for inductances, such as ring-shaped miniature transformers, is disclosed. An inductance is provided with a pair of similar axial end caps made of insulating material and interposed between core and winding.


**3 Claims, 6 Drawing Figures**

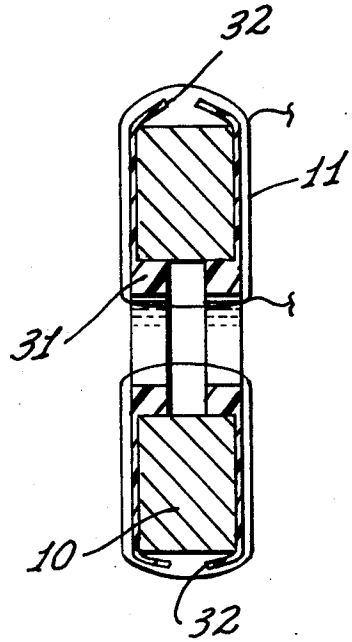


Fig. 1

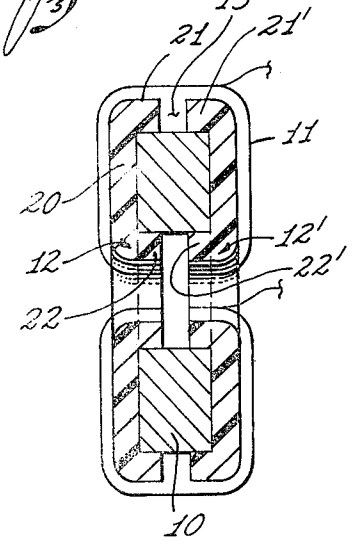



Fig. 2

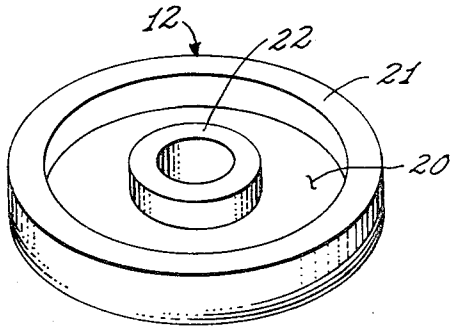



Fig. 3

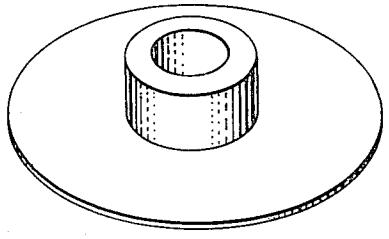


Fig. 4

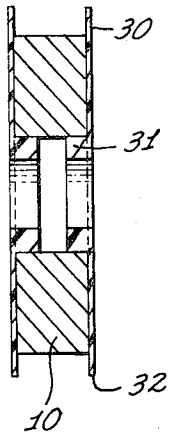



Fig. 5

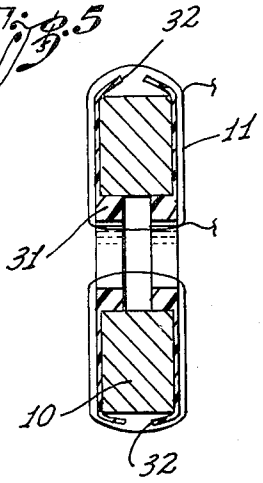
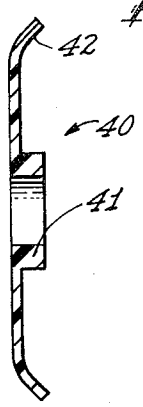



Fig. 6




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# MINIATURE INDUCTANCES

This is a continuation-in-part application of my application Ser. No. 810,718 filed Mar. 26, 1969, now abandoned.

The present invention relates to improvements in the construction of inductances, such as miniature transformers, or the like. The background of the invention having lead to the improvements disclosed herein shall be discussed first. Large scale digital memory systems usually employ memory cores arranged in a matrix pattern and accessed through an XY addressing wire system, whereby coincidence of currents in one direction in each of a pair of such XY wires traversing the same core switches the magnetic state of the core for "-writing" a particular bit into the core unless such switching is inhibited otherwise. For reading the content of the memory core, current is driven through the same two wires but flowing in the opposite directions.

Addressing of a core, per se, by selective operation of a particular pair of such wires within the XY system is an operation which is functionally independent from the purpose of the addressing (the purpose being either writing or reading). The direction of current flow defines the purpose. Thus, it is necessary, within the chosen wiring diagrams, to isolate voltage potentials as provided by the addressing logic, including some or all of the decoding circuit, and providing signals for addressing a core through a pair of XY wires, from the sources driving switching currents through the XY wires.

Therefore, it is common in digital memories to interpose transformers, particularly miniature type pulse transformers, between the circuitry receiving addressing signals and decoding same on one hand, and the XY drive system on the other hand. The transformers can be small because voltages and currents transmitted are quite small. Moreover, the transformers should be small because they must fit into the overall modular construction pattern usually employed, according to which all circuit elements are mounted on relatively small printed circuit boards.

Logic elements, amplifiers, and other signal processing circuitry used today is solid state. This includes particularly the decoding and amplifying circuit of a memory system, as described. The transformers within that system are, therefore, from a standpoint of modern development, the "oldest" type circuit elements employed. Surprisingly, it is that element which has proven to be most troublesome within the system. The transformers employed comprise a small ring-shaped core with thin insulated wires wound thereupon in a few turns. It was found that the core abrades the insulation from the windings and the baredwire is short circuited to the core.

Often such short circuit can be detected immediately upon testing the transformer, prior to installation because the abrasion occurs primarily during the wire winding process. However, it was found also that in many cases there is some abrasion initially, but insufficient to establish immediately metal-to-metal contact between partially abraded wire and core. Even though the signal frequencies transmitted by the transformer are very high, there is still some mechanical interaction between wires and core. More importantly, however, there is thermal expansion. Such mechanical action causes additional abrasive action between core and wires during operation, which, in turn, causes the insulation to be scraped off, particularly in those places where there was already some abrasion during the winding process.

It was found that actually such seemingly minor damage could cause operational breakdown of an entire computer system. There is, therefore, a definite need for improvement in the reliability of such miniature high-frequency, high speed pulse transformers.

The obvious solution to the problem of avoiding core-to-wire contact where wire insulation has been abraded is to provide the core with an insulating coating. This has been tried; however, such coating poses more problems than it solves. It was found, for example, that an epoxy coating, or the like, after hardening constricted the ferrite cores used for pulse transformers, as described. As ferrite is a magnetostrictive material, the magnetic properties of the core were materially



altered. Inductance changes up to 25 percent have been observed. Other coating material was tried, but the thermal curing process required proved also detrimental to the magnetic properties of the core.

Still other coatings were found to form thick layering so that the central aperture of the ring-shaped core became too small for threading through the required number of turns, at least in a sufficiently fast operation. To accommOdate a thicker coating, it would be required to make the cores somewhat larger, but the transformer should be made as small as possible so that any constraint requiring increase in size but not having to do with the operation proper should be avoided.

Vapor deposition of an insulating material on the core has been tried also, but it was found that sharp metallic gratings on the core are insufficiently covered therewith, producing both abrasion of wire insulation and metal-to-metal contact with the bared wire thereafter.

In accordance with the invention, a solution to the problem, posed by these transformers, was found. The improvement in accordance with the present invention, however, will find utility for other core-coil constructions as well. In accordance with the invention, it is suggested to make individual end caps of insulating material and to place the insulating end caps on a ring core, prior to winding wires thereon so that the end caps provide insulative spacing between the subsequently placed wires and the core. There are two end caps for each core, each end cap having a central hub preferably for frictional engagement with the surface of the ring core defining the central aperture thereof. Each end cap forms a smooth surface side wall gripping around the periphery of the core and extending along the cylindrical circumference thereof to serve as a spacer for the wires. The end cap yields resiliently to the tensioning force to establish a gently curving configuration matching the contour of the wire loops. Some resilient reaction tensions the wire, but quite gently, so that there is no loose fit. The frictional engagement of end cap portions by the core must be limited to just such engagement without exerting significant constricting forces upon the core, when made of ferrite, so as to avoid magnetostrictive action therein.

While the specification concludes this claim, particularly pointing out and distinctly claiming the subject matter which is regarded as the invention, it is believed that the invention, the objects and features of the invention, and further objects, features and advantages thereof, will be better understood from the following, taken in connection with the accompanying drawings, in which:

FIG. 1 illustrates a radial section view through a ring-shaped transformer provided with end caps in accordance with the present invention;

FIG. 2 illustrates a perspective view of the end cap as used in the transformer shown in FIG. 1;

FIG. 3 illustrates a perspective view of another end cap;

FIG. 4 illustrates a radial section view through a transformer core provided with an end cap, as shown in FIG. 3, prior to winding wire onto the core;

FIG. 5 illustrates the core with end caps, as shown in FIG. 4, but after winding wires thereon; and

FIG. 6 illustrates a radial section view through still another end cap in accordance with the invention.

A coil core structure, such as a miniature transformer, improved in accordance with the first embodiment of the present invention is illustrated in FIG. 1. The transformer includes an essentially ring-shaped or toroidal core **10**, illustrated in the Figure in a considerably enlarged scale. The outer diameter of such a transformer core is usually less than one fourth of an inch, if the transformer serves as pulse transmitter in core memory drive circuits. Core **10**, when serving as a transformer core, carries windings, denoted generally as windings **11**, and including primary and secondary windings in a conventional manner and wound upon the core usually manually. The wires, however, are not wound directly on the core.

In accordance with the feature of the present invention there are provided two end caps such as end caps **12** and **12'**.

These two end caps are similar and are thus disposed symmetrically to an axial central plane through ring core **10**. The caps are termed end caps as they abut oppositely oriented axial end faces of the cylindrical ring core **10**. Cap **12** is illustrated separately in FIG. **2** and in perspective view.

The end cap has a flat, ring-shaped portion, or annulus **20** which abuts one of the axial faces of core **10** when the core is placed thereon, as shown in FIG. **1**. The outer diameter of annulus **20** is larger than the outer diameter of the core. End cap **12** has, in addition, an annular wall **21**. After placement of the end cap on ring-shaped core **10**, wall **21** extends axially parallel in relation to the center axis of the core. Thus, the wall **21** grips around the outer circumference of the core.

End cap **12** has, furthermore, tubular portion **22** extending from the central aperture of annulus **20** and resembling a hub. Outer wall **21**, hub **22** and bottom annulus **20** define a ring or annular trough, and one can say that upon placing the cap on the core, the core is seated in the trough but projects therefrom. Core **10**, in particular, is snugly received in that trough and, therefore, positively positioned therein.

There are provided, as shown in FIG. **1** and as already mentioned above, two of these end caps, **12** and **12'**, for each core. The end caps are similar, i.e., the same type of caps are used for each of the two axial end faces of a core. There is no principle necessity for such similarity but it is practical to use one type of cap. It appears, therefore, that the wires **11** are wound in reality on these end caps. The two end caps thus serve as spacers for the wires.

The end caps could be constructed such that the two axial extending side walls **21** and **21'** abut with the axial surfaces, but this would require unnecessary high precision. Therefore, in order to ensure snug seating of each of the two end caps on core **10**, it is preferred to leave a gap, such as gap **13**, in-between the two axially aligned side walls **21** and **21'**. Analogously, there is a gap **14** between the two axially aligned hubs **22** and **22'**. The dimensions are chosen such that wires **11** will span the two gaps at a sufficient distance from the core.

It can thus be seen that nowhere can the wires engage core material directly so that even if the insulation of the wires is abraded to some extent, during the winding process and/or afterwards, there will be no metal-to-metal contact with the core. Moreover, the plastic material for the end caps can be chosen such they have rather soft surfaces so that there is little or no abrasion during winding of the wires onto the end caps, nor will there be significant abrasion subsequently under the influence of electrical and thermal forces when wires may tend to vibrate physically or to move otherwise relative to the structure to which they are mounted. This way insulation, usually lacquer, on the wires will not, or will hardly, be damaged. The end cap illustrated can preferably be made of nylon which has been proven to satisfy the requirements.

Since miniature transformers of the type envisioned here are usually wound manually on the core, there is practically no additional work involved for positioning the end caps on the core prior to winding wires thereon. The dimensions of the end caps should be chosen so that they fit snugly over the core, i.e., in press-fit. The ring trough, as defined by ring **20**, wall **21** and hub **22**, should have an inner ring width slightly smaller than the ring width of the core to frictionally receive the core such that, once end caps are placed on the core, they will not fall off by themselves, but will require additional force to be removed, which force, of course, is normally not applied. This is important as it permits handling of the cores freely during the wire winding process; thus, after the end caps have been placed onto the core the wires can be wound thereon in a conventional manner.

The end caps shown in FIG. **1** and FIG. **2** are comparatively expensive as their manufacturing requires some lathing operation. FIGS. **3**, **4** and **5** illustrate a simpler configuration for such end caps. The configuration is chosen such that they can be made through injection molding. In this particular embodiment there is a flat ring **30** which is rather thin and pliable. Outer diameter of the ring is again larger than the diameter of the core upon which the cap is to be placed. A hub-like ring **31** extends axially from the center of ring-shaped disc **30**.

As illustrated in FIG. **4**, these thin end caps are slipped onto a core **10** with the hub portion **31** of a cap being inserted in the central aperture of a ring-shaped core **10**. Again, the dimensions of the hub should be chosen wide enough so that there is press-fit through frictional engagement between hub and core. The thin disc **30** projects beyond the outer diameter of the core **10**. As wire is wound around the core, preferably under tension, the projected portions of the ring disc **30** are bent axially as they yield resiliently. The resulting smoothly curved, axially bent portion serves as resilient spacers for the wires. Some resilient reaction of the bent portion of the disc tensions the wire and is thus instrumental in maintaining the wire in position. Even as the wire is wound on the core and the edge of disc **30** is yieldingly bent, there is little danger of abrasion, due to smooth curving of the soft surface disc as bent. The bending is not regular around the periphery of the core, but bending occurs only where the wire engages edge **32** of ring **30**. Nevertheless, as a result of winding the wires over the core, a side wall is established by bending the disc axially, on the periphery.

Nylon was found to be the most suitable material for such type of end caps, and, as stated, these end caps can be made by injection molding of nylon. For this reason they are actually more economical than the end caps shown in FIGS. **1** and **2**, but they still suffice for the desired purpose. They provide adequate spacing for the wires for separating them from the core to prevent abrasive action and to prevent contact with the metal of the core if abrasion did occur. As stated, the cap is retained on the core by press-fit of the hub, particularly prior to and during winding of wire thereon. Of course, once the wire is wound upon the structure, the wire serves additionally to retain the end caps on the core.

FIG. **6** illustrates a still further embodiment for an end cap which can be made also of nylon but can possibly be made also of a polycarbonate called Lexan. End cap **40**, illustrated in this Figure, has a hub **41** and a beveled wall **42**. An end cap having such configuration can be less resilient as the outer circumference does not have to be bent over the core by the wire. Lexan is less resilient than nylon, but Lexan is suitable particularly because such an end cap can be made by hot stamping. Alternatively, of course, nylon could be used with injection molding being the most suitable way of preparing such end caps.

The invention is not limited to the embodiments described above but all changes and modifications thereof not constituting departures from the spirit and scope of the invention are intended to be included.

I claim:

**1.** A miniature inductance element having ring-shaped core means extending around an axis for magnetic interaction with one or more electrical windings, a pair of similarly shaped end caps made of soft-surface, resilient and yielding plastic and being individually mounted on the core means in symmetrical relation to each other and with reference to an axial plane running through the center of the core means, the windings being wound around and disposed on smooth surface portions of the caps as placed onto the core means, the caps each having a hub extending into the central aperture of the ring of the core means and axially facing the hub of the respective other caps, each cap further having a flat annulus from which the respective hub extends, each annulus having a bevelled peripheral portion extending adjacent a portion of the outer periphery of the core toward the bevelled portion of the respective other annulus to maintain the windings in spaced apart relationship to the core means, the bevelled portions of the end caps as well as the hubs spaced apart from each other.

**2.** A miniature inductance element having ring-shaped core means extending around an axis for magnetic interaction with one or more windings, a pair of ring-shaped discs each disc having a central aperture and disposed on the core means, coaxial thereto each disc having a hub extending axially from

the respective central aperture of each disc, the discs further disposed symmetrical to a plane normal to the axis and running through the center of the core means, the inner diameter of each the central aperture of the discs being smaller than the inner diameter of the central aperture of the ring of the core means, the outer diameter of each of the discs being larger than the outer diameter of the ring of the core means, each of the discs constructed from soft-surface resiliently yielding plastic material;

electrical windings wound about the discs, the windings



bending and holding the peripheral portions of the discs axially along the outer periphery of the core means, the peripheral portions of the discs tensioning the electrical windings, whereby the windings are held in a tight fit position about the discs.

3. The miniature inductive element as set forth in Claim 1, the outer diameter of the hub being slightly larger than the diameter of the center opening of the core means to be frictionally retained therein.

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