Feb. 5, 1952 D. MACKEY 2,584,723

VARIABLE INDUCTANCE DEVICE

Filed Aug. 18, 1947

Fig. 1

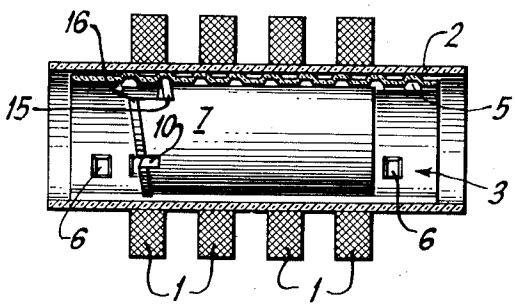


Fig. 3

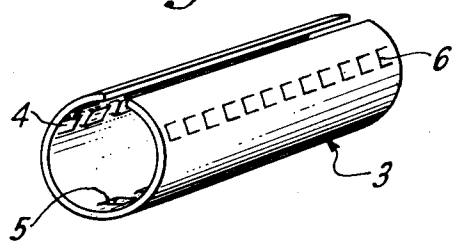


Fig. 2

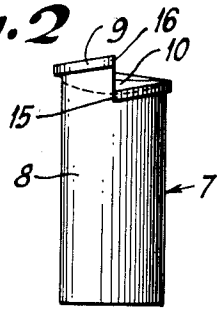


Fig. 4

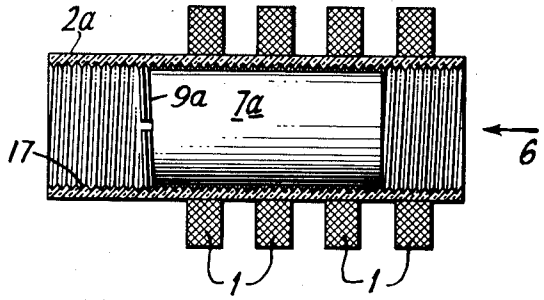


Fig. 5

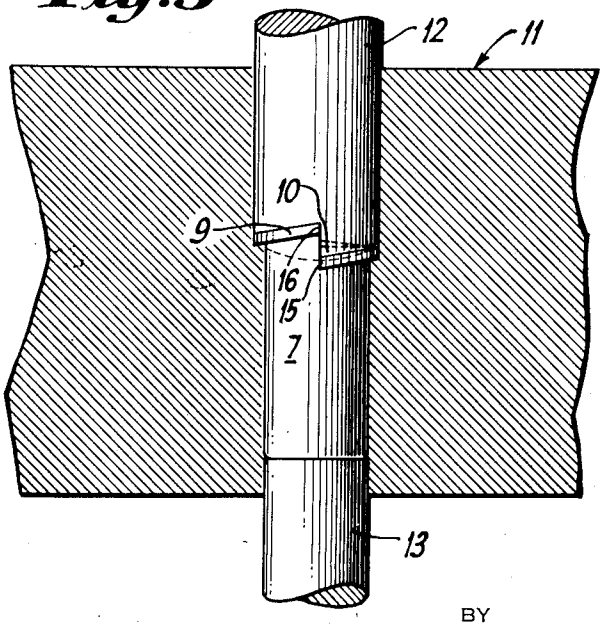
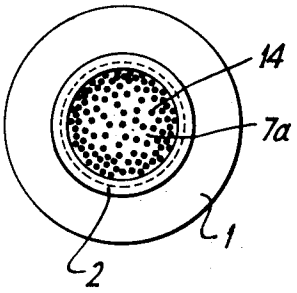


Fig. 6



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UNITED STATES PATENT OFFICE

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VARIABLE INDUCTANCE DEVICE

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Application August 18, 1947, Serial No. 769,202

1 Claim. (Cl. 171—242)

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This invention relates to electrical inductance devices and methods and more particularly to devices including a coil or coils and a core which controls the inductance of one or more of the coils.

Although certain aspects of my invention are not limited thereto, but may be applied structurally to cores of various compositions, I now prefer to employ cores of molded magnetic material. Examples of the use of inductance devices employing my invention and containing cores of such type are in the intermediate frequency circuits of standard broadcast (amplitude modulation) superheterodyne receivers and in the higher intermediate frequency circuits used in frequency modulation broadcast receivers.

An important advantage of the invention is that a core of molded material readily may be positioned with respect to its associated coil by means of a thread formed wholly by molding, without machining, whereas threads previously formed on molded cores have been objectionable for various reasons. When threads have been molded they have been imperfect due to roughness along the parting line of the mold, and when they have been cut they have been unduly expensive since each small pellet individually must be mounted in the lathe instead of being turned automatically in a screw machine, as a similar article would be made from a solid rod. When they have been ground in automatic thread-grinding machines they have been expensive because of the high cost and relatively low rate of production of the machine. Furthermore, machine threading has removed a valuable portion of the molded surface, which is superior to the interior of the core electrically and mechanically.

Fundamentally, the problem in adjustable-core tuning is to adjust the inductance of a coil by positioning a core with respect thereto precisely and positively, in order that the relative position will not change subsequently, in a simple manner to avoid unnecessary labor, and with inexpensive parts suitable for large-quantity production. Ordinarily the core is partially within the coil so that inductance variation is achieved most readily by moving the core lengthwise of the coil, but lateral movement of the core may also vary the inductance somewhat and if lengthwise movement is accompanied by inadvertent lateral movement the ensuing irregular variation of inductance makes adjustment tedious and costly. In intermediate frequency and other circuits in which an inductance is to be adjusted to a precise value which is afterward normally preserved in use, some form of screw adjustment of the core position has heretofore proven superior to other mechanisms such as levers or racks and pinions, and various threaded devices have been proposed but none have been wholly satisfactory for production in large quantities since they have been expensive and more or less troublesome.

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The principal object of the invention is to provide an improved inductance device that may be made cheaply in large quantities, that readily may be adjusted by smooth, longitudinal movement of the core without accidental lateral movement thereof, and that retains all of the good qualities of a molded core surface as distinguished from a machined surface.

The technique of molding cores suitable for high-frequency electrical fields is well known. The comminuted particles are coated with some insulating material and then molded under pressures usually in the neighborhood of 25 or 30 tons per square inch. This is roughly 2000 times the pressure of an ordinary city water supply; so it is apparent that the molds must be strongly constructed. In molding a core of the type having an external thread it is necessary to open the mold along a line lengthwise of the cavity in order to remove the molded core therefrom. Such a mold inherently would be subject to excessive wear. Thin edges must be maintained on the moving parts of the mold to minimize the size of the ridges which are formed lengthwise of the core on opposite sides thereof at the parting line. The removal of these ridges by machine operation is slow and costly.

A further object of the invention is to provide a core having a thread of a single turn, or less, that may be end-molded in a mold constructed of solid metal except for two oppositely acting plungers. Since the thread consists of not more than one turn, the core readily may be forced endwise from a solid mold without rotary movement.

It should not be thought, however, that omitting all but one turn of the threads of prior cores sacrifices any desirable performance characteristics. On the contrary, the operation of the mechanism thereby is improved for several reasons. First, the smooth, unthreaded body of the core more readily may be guided with respect to the coil since the crest of the engaging internal threads may bear firmly against it, whereas if the core were threaded throughout its length a certain amount of lateral play ordinarily would be necessary to avoid excessive friction that would

render adjustment difficult. It is apparent that a plurality of turns are not required in order for the thread to have sufficient strength merely to support the core. Second, the end-molded core has no flash or other roughness to distort a flexible coil form when the core is rotated, thereby producing spurious inductance variations. A slot for a screw driver, or similar adjusting means, may be positioned directly in the plane where resistance to turning occurs, thereby minimizing any tendency of the core to move laterally during adjustment. A single-turn thread may prevent the core moving under vibration by compressing a resilient liner against a coil form without unduly close tolerances, whereas a full thread similarly compressing a resilient liner would offer too much frictional resistance for nice adjustment unless the tolerances were extremely close. It is considered that this method of preventing undesired rotation, though permitting smooth adjustment, is superior to that shown, for example, in Patent No. 2,204,086 to Kamenarovic, wherein the flexing of a member, rather than its compression, is relied upon to prevent rotation.

In the accompanying drawing:

Fig. 1 is a longitudinal section of a variable electrical inductance system embodying the invention;

Fig. 2 is a side elevational view of the core member of Fig. 1;

Fig. 3 is a perspective view of the partially threaded liner of Fig. 1;

Fig. 4 is a longitudinal sectional view of a modification of the structure shown in Fig. 1;

Fig. 5 is a sectional view of a mold for making the core of Fig. 2; and

Fig. 6 is an end view taken in the direction of the arrow 6 in Fig. 4, the electromagnetic flux distribution being indicated thereon diagrammatically.

Coil sections 1 may be of the conventional universal type or any other suitable inductance member (which may or may not constitute a transformer) may be utilized. Coil form 2 may be of Bakelite or some similar material and liner 3 preferably is made of Vinylite. This liner has rows 4, 5, and 6 of internal protuberances which may be considered as forming a partial, or pseudo, thread on the interior surface of liner 3. These rows of threads may be formed by suitable toothed wheels, not shown, either after the liner is bent into cylindrical form or previously while the material is flat. This operation may be as described in an application of Knauf and Mackey, Serial No. 739,270, filed April 4, 1947, now abandoned.

Core 7, shown more clearly in Fig. 2, comprises a smooth cylindrical body 8 having a single-turn square type thread 9 preferably at one of its ends. This thread may be of the conventional V-shape, as shown at 9a in Fig. 4, or it may have any other desired sectional shape but a square thread will result in longer life of the mold since sharp edges thereby are avoided. Screwdriver slot 10, or any other equivalent construction, is provided for use in rotating the core. This core may be molded by placing a suitable quantity of comminuted magnetic material in mold 11, shown in Fig. 5, with plunger 12 withdrawn and plunger 13 partially withdrawn. Plunger 12 is then thrust downward and plunger 13 upward compressing the comminuted material into the solid core 7 having thread 9 and slot 10 formed therein. When plunger 12 is withdrawn, plunger 13 may be thrust upward to force core 7 out of the mold. It is evident from the construction shown in Fig. 2 that core 7 can be thus removed from the mold only if thread 9 is less than one turn in length so that leading end 15 thereof will clear the portion of the mold that forms trailing end 16. This rudimentary thread preferably should be only slightly less than one turn in length in order that it shall be as nearly as possible concentric about the axis of core 7 in order that radial pressure exerted against the thread shall be equal in all directions thereby avoiding lateral displacement of the core material in the mold. The thread thus end-molded will be uniform circumferentially, since there is no longitudinal joint in the mold as would be necessary with a longer thread, and therefore adjustment of inductance with the necessary smoothness may be achieved.

As indicated in Fig. 6 the hypothetical electromagnetic lines of force, indicated by dots 14, are somewhat more concentrated near the conductors of coil sections 1 than at the centers of the coils. Thus lateral movement of core 7a will vary the number of lines of force within the core thereby varying its effectiveness in changing the inductance of coil 1. Such lateral movement of core 7 cannot readily be controlled and therefore should be prevented. It may be prevented in a wholly satisfactory manner by making the diameter of body 8 such that it will fit snugly within the crests of threads 4, 5, and 6.

If body 8 and thread 9 of core 7 are not substantially perfectly concentric, rotation of the core wil cause body 8 to tend to wobble in an uncertain manner within coil form 2. Also if thread 9 were positioned near the middle of core 7, the latter would tend to pivot about the thread, resulting in unintentional variations in inductance. Certain application of variable electrical inductances require exceedingly accurate adjustment. For example, in tuning an intermediate-frequency circuit of a radio receiver a very slight movement of the magnetic core may cause substantial changes in inductance and therefore in the frequency to which the circuit is tuned. In order that the inductance may be adjusted smoothly and accurately, core 7 should be made in a carefully constructed mold so that body 8 and thread 9 will be precisely concentric. Thread 9 should be at the end of core 7 in order that liner 3 may serve accurately to guide body 8, and screwdriver slot 10 preferably should be at the same end of body 7 in order that force exerted thereon will not move core 7 laterally. However, to facilitate mold construction in some cases it may be desirable to form the screwdriver slot in the opposite end of the bore by a suitable protuberance, not shown, on plunger 13.

Liner 3 may be cemented or otherwise fastened to coil form 2, if desired, but it is contemplated that thread 9 on core 7 shall compress the material of liner 3 against the interior wall of form 2 sufficiently to prevent core 7 working loose under vibration or recurring temperature changes. Liner 3 will thus be firmly held in position between core 7 and form 2 without any special fastening. Thread 9 will follow the partially formed threads in liner 3 even if these threads do not correspond to the shape of thread 9 because the material of liner 3 is yieldable, and the single-turn thread will not require an excessive turning force as a longer thread would. If thread 9 is shaped properly, it will be self-

threading and no threads will be required on liner 3, but it is deemed preferable to at least partially thread the liner since the thread crests serve also to guide the body of core 7.

The complete assembly may be constructed quickly and cheaply without any machine operation other than the simple rolling of partial threads in liner 3, assembly of the unit being accomplished merely by inserting liner 3 in coil form 2 and screwing core 7 therein to the position which gives the desired value of inductance of coil 1. Liner 3 and coil form 2 serve as a simple and reliable guide for positioning core 7.

Both liner 3 and coil form 2 may be sufficiently thin so that core 7 fills nearly all of the interior of coil sections 1 thereby achieving a maximum variation of inductance. In certain applications it may be preferable to dispense with liner 3 and to provide internal threads 17 directly on coil form 2*a* as shown in Fig. 4, although this construction is more expensive than that previously described. Threads 17 are shown as common V threads, for convenience, although it is preferable to use the pseudo type thread, as in Figs. 1 and 3. Many of the above-mentioned advantages are retained since core 7*a* may fit snugly against the thread crests thereby to prevent lateral movement of the core. Its single turn thread may fit so tightly in coil form 2*a* as to prevent loosening under vibration without offering enough frictional resistance to prevent easy adjustment. Also, the core having only a single-turn thread may be molded without any machining operation. If desired, suitably spaced pseudo threads may be formed, as by embossing, directly in form 2*a* as shown in the aforementioned application of Knauf et al., Serial No. 739,270. Fig. 3 will serve to illustrate how such pseudo type-threads comprising three rows of embossed protuberances may be used in coil form 2*a*, instead of the V thread shown, to receive the core of Fig. 2.

This molding of the core is a matter of importance not only because of its economy as compared to machining, but also because the molded surface of the core is more valuable both electrically and mechanically than the interior portion thereof. Comminuted magnetic particles coated with insulating material and molded under great pressure form a dense, relatively thin skin at the surface of the molded part. Being of greater density of magnetic particles, this skin has higher effective permeability and greater mechanical strength than the interior of the molded part. It follows that molded threads are superior to machined threads since machining removes a portion of the dense skin of the core. But long threads cannot readily be molded whereas the single-turn thread of the invention may easily be end-molded to form a highly satisfactory core.

The invention has been described for convenience as a magnetically variable electrical inductance. However, it will be apparent to those skilled in the art that the inductance of a coil to high radio-frequency currents also may be varied by moving a conducting member, instead of a magnetic member, with respect thereto. Thus what has been described as a magnetic core may be made of, or plated with, a conducting material such as copper or silver. Such construction retains the advantages of cheapness of parts and ease and permanence of adjustment previously described, and the advantage of a dense molded core surface, instead of a machined surface, is retained if the core is molded of some metal such as powdered copper.

What I claim is:

A core for varying the inductance of an inductance member held on a threaded core guide, said core comprising an elongated molded body portion substantially symmetrical about its longitudinal axis, and a single external thread on the end surface of said body positioned concentric which respect to said axis, the said thread not exceeding one turn in length whereby said core may be forced endwise without rotatory movement for removal longitudinally from the mold in which it was formed.

DONALD MACKEY.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,137,573	Kamenarovic	Nov. 22, 1938
2,149,848	Lampel	Mar. 7, 1939
2,204,086	Kamenarovic	June 11, 1940
2,461,397	Ross	Feb. 8, 1949

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Number	Country	Date
117,430	Germany	Feb. 11, 1901