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VARIABLE INDUCTOR

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Fig. 1

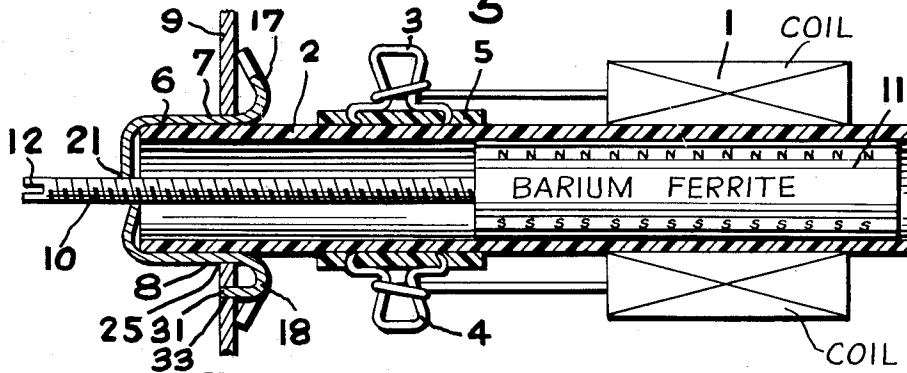
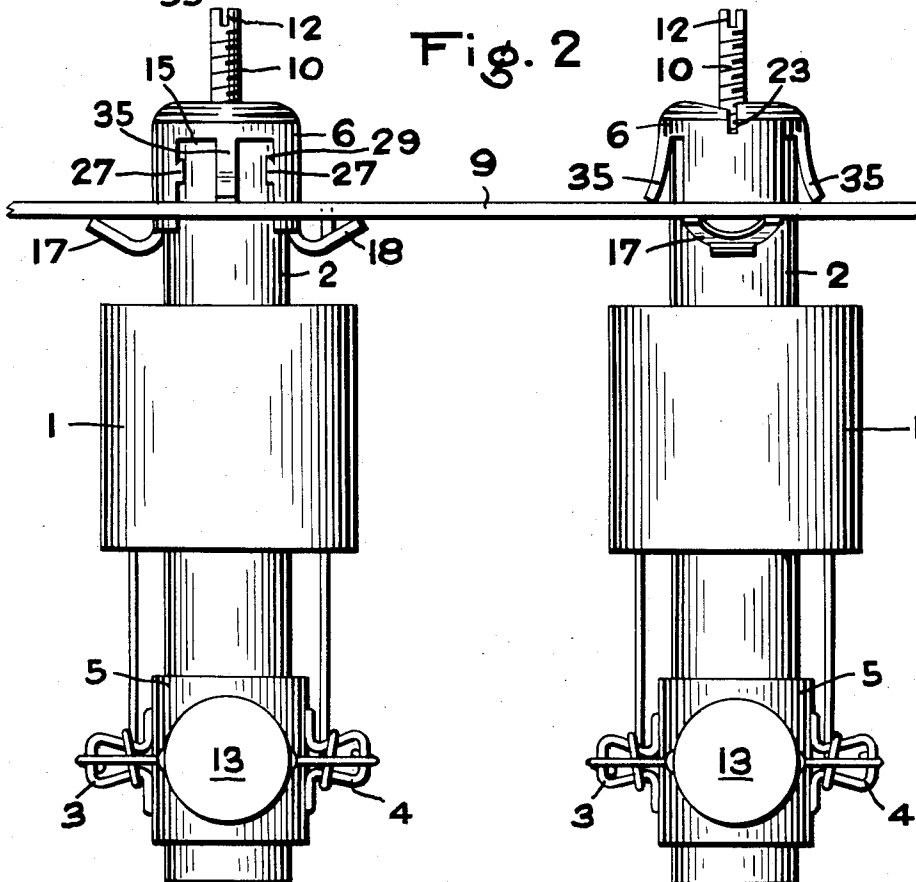


Fig. 2



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VARIABLE INDUCTOR

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2 Claims. (Cl. 336—110)

My invention relates to an inductance device, the inductance of which may be varied or adjusted, and particularly to such a device adapted for use at very high radio frequencies.

There are ways of varying the inductance of a coil having self-inductance but the method now preferably used is to vary the permeability of the core which the wound coil defines. This technique of varying the permeability of the core so as to achieve a change in the effective inductance of the inductor is of two general forms, one of which is to introduce a metallic body into the core which results in the production of eddy currents within the metallic body reducing the self-inductance of the coil, and the other to increase the permeability of the core by the introduction of ferro-magnetic material which effects an increase in the self-inductance of the coil as the ferro-magnetic material moves inwardly. Typical magnetic materials which are introduced into the core of a coil possessing self-inductance to decrease the self-inductance are brass and copper, while iron core and iron dust bodies have been the most successful of the ferro-magnetic materials for inductance tuning. All of these presently used materials, however, suffer from the distinct disadvantage that at frequencies within the very high radio frequency spectrum their losses are so substantial that it is impossible to obtain reasonably high Q's. For the operation of today's television and radio receivers, it is essential that the inductance devices used in the circuitry exhibit extremely low to negligible losses, so that Q's in excess of 100 can be achieved, which, in turn results in wave traps and tuned circuits of exceptional selectivity, and elements of substantial impedance within this frequency spectrum.

It is an object of this invention to overcome the foregoing and related disadvantages of present day devices.

It is a further object of the invention to produce a variable inductance device produced from readily accessible materials which exhibits a substantially constant Q over a wide spectrum at very high frequencies.

Further objects of the invention will be apparent from the following specification and appended claims.

These objects of the invention have been achieved by the production of a variable inductance comprising a coil having self-inductance with a body of barium ferrite disposed in the interior of said coil and means to move said body relative to said coil to vary the self-inductance. The invention is featured by the utilization of a permanently magnetized barium ferrite body as the movable member in a permeability tuned inductor, which body exhibits negligible losses up to frequencies in excess of 100 megacycles.

Perhaps to best understand the invention reference should be made to the appended drawings in which:

Fig. 1 presents a cross-section of a variable inductor constituting one form of the invention, and

Fig. 2 shows a pair of inductors such as shown in Fig. 1 in combination with fixed capacitors.

In the drawings corresponding elements of the various figures have been designated by corresponding reference numerals.

Referring now to Fig. 1 the coil presenting self-inductance is indicated as consisting of windings 1 provided about a hollow, cylindrical supporting structure formed

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of insulating material and generally designated 2. The coil 1 is connected to terminal elements 3 and 4 which extend away from the body of the inductance element. The terminal elements 3 and 4 are provided on a sleeve or collar 5 made of insulating material and encircling the member 2. At one end of the coil holding member 2 is a non-magnetic end-cap 6 which is provided with mounting ears 7 and 8 for mounting the member 2 on a support plate 9 after the end of the member 2, carrying the cap 6, has been inserted through an opening 25 in the support member. The end-cap 6 is provided with a centrally positioned opening 21 through which a threaded rod 10 extends. The opposite end of the threaded rod 10 is connected to a cylindrical member 11 formed of sintered and subsequently permanently magnetized barium ferrite, this cylindrical member being enclosed within the hollow member 2. On the exposed end of the threaded rod 10 is formed a slot 12 which serves to hold a screwdriver used in adjusting the threaded member axially. This axial adjustment of the threaded member 10 and its connected cylindrical member 11 serves to adjust the inductance of the device.

Fig. 2 illustrates two variable inductors of the type shown in Fig. 1 in position on the support member 9. The structure of each of the variable inductors illustrated in Fig. 2 is similar to that shown in Fig. 1. The terminals 3 and 4 are connected to a fixed ceramic capacitor generally indicated at 13. This capacitor 13, in combination with the variable inductor, forms a resonant circuit. This resonant circuit is tuned by varying the position of the member 11 by means of the threaded member 10. It has been found that the variable inductor combined with the fixed capacitor yields tuned circuits of extremely high Q which do not change appreciably with the frequency of resonance over the spectrum of from 1 to 100 megacycles. The arrangement of Fig. 2 is susceptible of numerous modifications such as positioning the coils possessing self-inductance about a single supporting member and varying the inductance of one or both by movement of the barium ferrite within the coil. Alternatively, these tuned circuits can be used as wave traps or impedance elements of extremely high Q. The variable inductance can be connected in series with a capacitor.

In the form shown, end cap 6 is made of springy metal such as high carbon steel for example, and its ears 7, 8 are arranged to be bowed toward each other. For this purpose the portion of the cap between the ears 7, 8 is cut away to a substantial depth, as indicated at 15 in Fig. 2. Projecting laterally from the ears into this cut-away portion are teeth 27 having inwardly directed pointed ends that are deformed so that they point internally or towards the longitudinal axis of the cap. With this construction the cap is very readily mounted on coil form 2 by merely forcing the cap down over its open end. The outwardly curving portions of the ears 7, 8 cam out the normally bowed-in ears and when the cap is fully mounted, the ears tightly grip the coil form. At the same time, the sharpened ends 29 of the teeth 27 dig into the external surface of the form and keep the cap from being removed and from being rotated.

The opening 21 in the cap is shown as a portion of a slot 23 which extends completely across the top of the cap and can also continue to some extent down along its side walls, as better shown in Fig. 2. The portions of the slot 23 on each side of the opening 21 can be of reduced width, and opposite sides of the opening 21 are off-set in height relative to one another so as to act as a thread-engaging and securing anchor for threaded rod 10. The springy nature of the cap material can also be taken advantage of to cause the side edges of the open-

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ing 21 to frictionally bind against the thread of rod 10 as by having the edges of the opening resiliently urged toward a common plane.

The cap 6 is arranged to be readily received and mounted in a hole 25 in a support plate 9, by arranging for the hole to have substantially the same diameter as the external portions of the cap when fixed in place on the coil form. For secure mounting, the ears 7, 8 terminate in reversely curved fingers 17, 18 that project out in a generally radial direction. These fingers act as stops and limit the amount that cap 6 can be inserted in its mounting hole 25. The ears may also carry a locating finger 31 which curves backwardly more than the stop fingers and can be received in an indexing hole 33 adjacent the main mounting hole 25. In this way the rotation of the form-carrying cap 6 can be prevented.

To increase the security of the mounting, the cap can also be provided with locking fingers 35, shown more clearly in Fig. 2, as projecting from the recessed edges of the cut-outs 15. The locking fingers 35 resiliently hold themselves bowed outwardly a small amount with respect to the general outer surface of the ears 7, 8. The insertion of the form-carrying cap in its mounting hole forces the locking fingers down against the ear. When the cap becomes fully seated in the hole, the locking fingers, which are of suitable short length, are released to spring outwardly and bear against the adjacent surface of mounting place 9. This securely locks the cap in place in the mounting hole.

The coil form upon which the coil possessing self-inductance is wound, may be of any non-inductive material and is preferably a low loss resin or paper or a combination thereof. Alternatively, the coil itself may be self-supporting and used without a separate form. The windings of the coil may be of any common type such as solenoid, universal, progressive universal and variable pitch. The particular windings used and their configuration does not form any part of this invention and the only requirement is that they possess self-inductance.

The manner of moving the ferro-magnetic material relative to the foil is susceptible to many modifications. As indicated it can be a slug which is threaded, which slug might either be a tubular rod, or of rectangular shape, etc. Another method is to move the core by an adjustable member which is connected to the end of the core member opposite the cap and which could project from that end of the core.

The magnetic material which is inserted into the volume defined by the coiled conductor to permeability tune the inductor has been indicated to be a sintered barium ferrite, such as discussed in the recent article, "Ferroxdur, A Class of New Permanent Magnet Materials" by J. J. Went et al., appearing in the Philips Technical Review, volume 13, pages 194-208, January 1952. It possesses properties much different from the ferrites reviewed by Snoek in his monograph on "Ferromagnetic Materials" for it is susceptible to permanent magnetization. In the course of investigation of this material which has been found to suffer negligible losses over the frequency range of from 1 to 100 megacycles, it has been found that a substantial increase in effective permeability of the material occurs when the barium ferrite is magnetized with its field perpendicular to the axis of the coil into which it is placed for purposes of varying the inductance. This then forms a preferred embodiment of my invention. However, it is possible to achieve moderate changes in inductance with the barium ferrite not magnetized in such fashion and in fact, when not magnetized at all.

As an indication of the remarkable characteristics of this variable inductor forming my invention the following data is representative of its performance. A coil of 8 turns of bare No. 33 wire was wound about a paper tubular form having a circular cross section ¼ inch in outside diameter, the turns extending over a linear distance of ½ inch. A cylindrical rod of barium ferrite

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1½ inches long and 0.2 inch in diameter was magnetically saturated in a magnetic field perpendicular to its long axis and placed in the form. A comparison of the Q of the coil with the core inserted and removed was made by a "Q" meter. The results are:

F, mc.	Q _o	Q _m
25.....	168	173
30.....	185	190
40.....	220	218
50.....	242	230
60.....	250	225
70.....	218	190

Q_o=the Q of the coil in air (the core removed from the form).
Q_m=the Q of the coil tuned with the barium ferrite core inserted.

The inductance of the coil in air was 1.82 mh. and the inductance of the coil with the slug fully inserted was 1.96 mh., a change of approximately 9%. The permeability of the magnetized barium ferrite was about 1.1.

The advantages of this invention, which is concerned with the tuning of variable inductors over a narrow inductance range, are readily seen in that it is possible to vary the inductance of the device by 9% and yet bring this change about without changing the Q of the coil appreciably from that of the Q of the coil with an air core. This makes possible high Q circuit elements extremely satisfactory for present day electronic equipment operating in the very high frequency range.

As many apparently widely different embodiments of this invention may be made without departing from the spirit and scope hereof, it is to be understood that the invention is not limited to the specific embodiments hereof except as defined in the appended claims.

By way of example, the mounting structure for the coil, as well as the core, can be arranged in any desired manner, although the specific construction details of Figs. 1 and 2 form an extremely satisfactory unit.

What is claimed is:

1. A variable inductor comprising a hollow cylindrical body of insulating material, a coil surrounding and connected to said cylindrical body, turns of said coil producing a field longitudinal to said coil by alternating current in said coil a core of barium ferrite disposed within said cylindrical body and variably positionable axially of said coil, said core being permanently premagnetized throughout its length in a direction perpendicular to the axis of said coil a cap at one end of said body having means thereon for connecting said body to a support, and actuating means extending through said cap and connected to said core for moving said core relative to said body.

2. A variable inductor comprising a coil having a self-inductance, turns of said coil producing a field longitudinal to said coil by alternating current in said coil, a body of barium ferrite disposed in said coil and variably positionable axially of said coil, said body being permanently premagnetized throughout its length in a direction perpendicular to the axis of said coil and means to move said body relative to said coil to vary said self-inductance.

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