May 29, 1956 A. GARCIA 2,748,357

TUNABLE INDUCTOR

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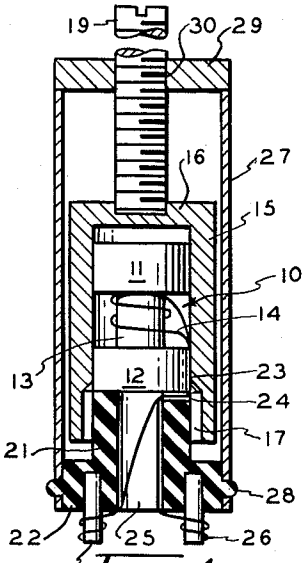



FIG. 1

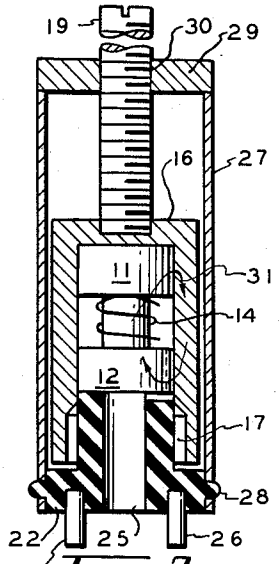



FIG. 2

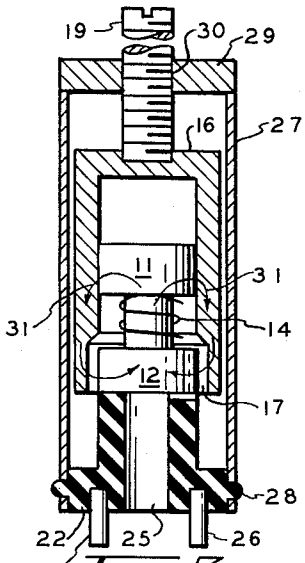



FIG. 3

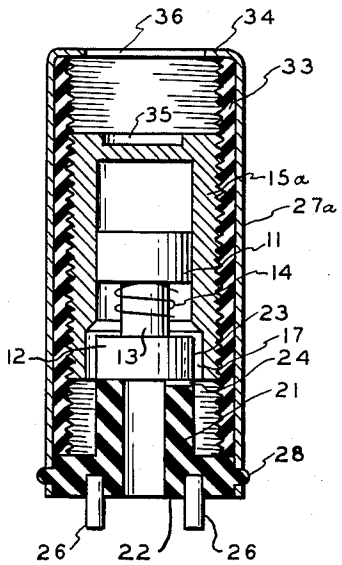



FIG. 4

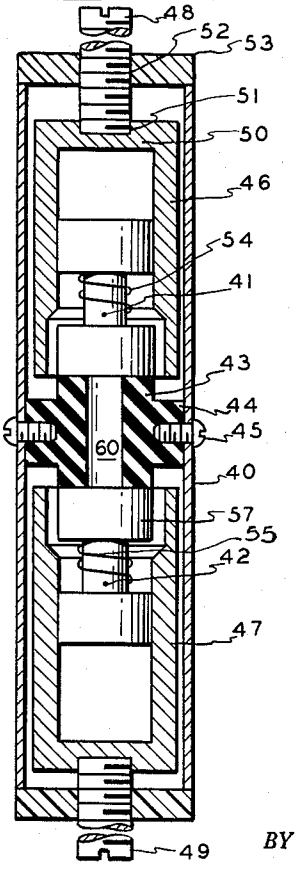



FIG. 5

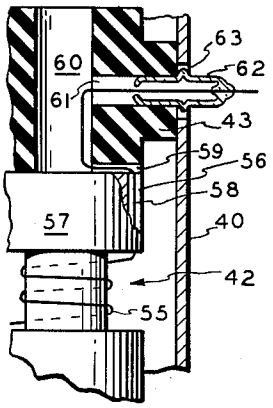



FIG. 6

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TUNABLE INDUCTOR

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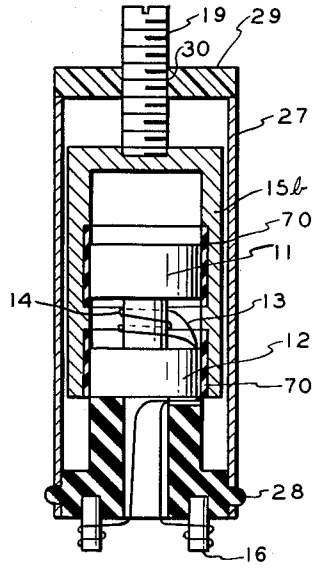



FIG. 7

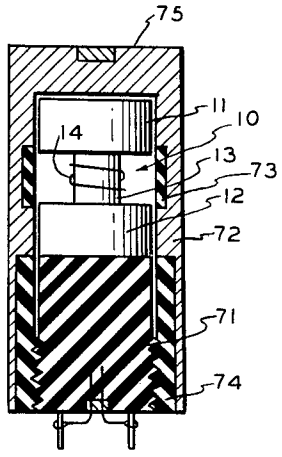



FIG. 8

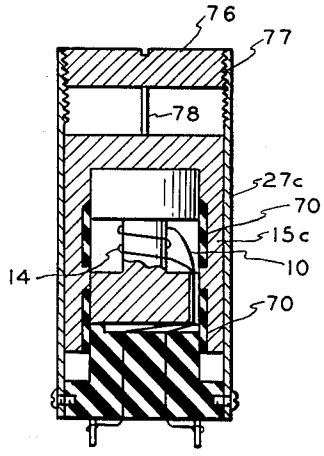



FIG. 9

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2,748,357

# TUNABLE INDUCTOR

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Application August 27, 1953, Serial No. 376,845

14 Claims. (Cl. 336—83)

The present invention relates generally to tunable inductors, and more particularly to tunable indicators of the type having a stationary coil bobbin of magnetic material, the bobbin having shoulders of magnetic material, and an axially movable sleeve of magnetic material encompassing the bobbin, in snug fitting relation to the shoulders.

In recent years extensive changes have taken place in the design of tunable radio frequency inductors, for use in radio frequency tuners, filters, and the like. The use of powdered iron magnetic circuits has become common, and these include magnetic circuits of ceramic ferromagnetic material, such as certain species of ferrite. Suitable materials are disclosed in U. S. Patent 2,452,529 to Snoek and in an article by Snoek, Physica, June 1936, page 463. Such materials have extremely high permeabilities, and moreover lend themselves readily to fabrication by molding and machining processes. The use of moulded iron powder cores has lead to the design of extremely small inductors, having high Q, and capable of operation at relatively high radio frequencies. The inductance of such inductors is usually adjustable by modifying the magnetic circuits of the inductors, as by providing a variable air gap, or a movable magnetic plunger, or a magnetic circuit of variable length or cross section.

It is desirable that radio frequency inductors be well shielded, in order to prevent stray flux in circuits adjacent the inductors. This shielding is normally attained by enclosing the inductors in metal shield cans. However, this mode of shielding envisages that stray flux will induce eddy currents in the shield can, and these eddy currents represent losses which reduce the effective Q of the inductors. I therefore provide a tunable high frequency inductor which is self-shielding, over the entire tuning range, and in which the shielding is accomplished by the structure of the inductor itself.

A shield can may then be employed, additionally, but will have very slight effect on the Q of the inductor since the shield can will be subjected to but slight leakage flux from the inductor.

I further provide an inductor having a relatively short main magnetic circuit, of low reluctance, which is closed on itself, in order to attain the smallest possible physical size for a given inductance. I provide an inductor which does not restrict the size of the parts employed, or their form factors, since these elements of the design can usually be so selected as to improve performance, if the designer has free choice.

Briefly describing the structure employed, in its essentials it consists of a coil bobbin of magnetic material, having a central portion of relatively small diameter and end shoulders of greater diameter, and a magnetic sleeve which is of an inner diameter suitable to fit the shoulders of the bobbin. This sleeve is axially movable with respect to the bobbin. The walls of the sleeve provide a magnetic path from one shoulder to the other, so that a substantially closed magnetic circuit may be traced from one shoulder to the other internally of the bobbin and via



the sleeve for all positions in which both bobbin shoulders touch the sleeve. When the bobbin is in a position of maximum inductance, the sleeve and bobbin provide a totally closed path of magnetic material. The sleeve is of expanded internal diameter for a short distance axially at one or more portions therealong, to provide an air gap of variable magnitude, adjustable in response to movement of the sleeve. When the sleeve is in a position of minimum inductance, the maximum air gap exists between a shoulder of the bobbin and the section of the sleeve which is of enlarged diameter. Between positions of maximum and minimum inductance the effective length of the air gap is varied and the contacting areas of bobbin shoulder and sleeve are varied. At all times, in accordance with the invention, the bobbin is wholly contained within the sleeve.

It is a broad object of the present invention to provide a novel tunable inductor comprising two magnetic members, one slidable within the other, one of said members being formed with an enlarged internal diameter to provide a variable air gap and to permit variations of the contacting areas of said members, and means for confining one of said members to containment within the other.

It is a further object of the invention to provide a tunable inductor comprised of a magnetic bobbin, on which a coil is wound, the inductor being tunable by means of an axially movable magnetic sleeve encompassing the bobbin.

It is a more specific object of the invention to provide a tunable inductor having a magnetic coil bobbin provided with shoulders of greater diameter than the body of the bobbin, and tuned by means of a magnetic sleeve snugly fitting the shoulders.

Another object of the invention resides in the provision of a tunable inductor, having provision for varying an air gap in the magnetic circuit simultaneously with variation of the contacting areas of magnetic members in that circuit.

It is a more specific object of the invention to provide a variable inductor having a magnetic coil bobbin provided with enlarged terminal shoulders, a magnetic sleeve which surrounds the bobbin and is axially movable with respect thereto, and a metallic enclosure which is secured to sleeve-positioning means and has a coefficient of expansion appropriate to cause the sleeve to move in a direction compensatory of inductance drift caused by temperature changes.

It is a still more specific object of the invention to provide a variable inductor having a magnetic coil bobbin provided with enlarged shoulders, and a magnetic sleeve which surrounds the bobbin and is axially adjustable with respect thereto, and is of expanded diameter internally, at one or more positions axially of the sleeve, to provide air gaps within the magnetic circuit comprising the bobbin, its shoulders, and the sleeve, all in series.

In accordance with the invention, there is provided an adjustable inductor comprising, in combination: first, a winding of electrically conductive material; second, a winding support of magnetic material formed with a reduced central portion about which the winding is disposed and enlarged end portions providing a magnetic flux path of low reluctance; third, a sleeve of magnetic material formed with an internal diameter approximating the external diameter of said enlarged portions, said winding support being slidably disposed within said sleeve, said sleeve being formed with an enlarged internal diameter at one section thereof comparable in length to the axial length of one of said enlarged portions, and means for adjustably axially positioning said winding support within said sleeve in such a manner that the winding support is adjusted through a range of positions

at one extreme of which a closed magnetic circuit is defined by both of said enlarged portions and said sleeve and at the other extreme of which a magnetic circuit is defined by said sleeve, said winding support and an air gap between the portion of said sleeve which is of enlarged internal diameter and one of said enlarged portions, both of said enlarged portions at all times being within said sleeve.

In the drawings:

Figs. 1, 2, and 3 are elevational sectional views of the preferred embodiment of the invention, Figs. 2 and 3 illustrating, respectively, the minimum and maximum reluctance positions;

Fig. 4 is an elevational sectional view showing a modified embodiment of the invention in which adjustment of the magnetic sleeve is provided by external screw threads fitting into a complementary insulating member;

Fig. 5 is an elevational sectional view of a double-ended modified form of the embodiment of Figs. 1 through 3;

Fig. 6 is a fragmentary elevational sectional view of the Fig. 5 embodiment, showing the details of the lead-out for the terminal of the inductor;

Fig. 7 is an elevational sectional view of a modified embodiment of the invention in which the magnetic sleeve is provided with internal grooves;

Fig. 8 is an elevational sectional view of still another modified form of the invention in which an internal groove is formed in the sleeve and in which adjustment is effected by an externally threaded member, fitting into an internally threaded insulating insert; and

Fig. 9 is an elevational sectional view of still another modified form of the invention which features a threaded plug and connecting wire for positioning the sleeve.

Referring now more specifically to the accompanying drawings, the reference numeral **10** identifies a coil bobbin of powdered iron, and which may be specifically of high permeability material, such as certain ferrites. Powdered iron is preferred to ferrites in applications where large temperature changes exist. The bobbin **10** comprises two cylindrical shoulders **11**, **12**, of a first predetermined diameter, and a cylindrical center portion **13** joining the shoulders, and which is of considerably smaller diameter. In one specific embodiment of the invention, which I have extensively tested, the bobbin had a length of $\frac{3}{8}''$, a shoulder diameter of .245", and a center diameter of $\frac{1}{8}''$.

A coil **14** may be wound on the center portion **13** of the bobbin **10**, and may be wound of Litz or multiple wire, and/or in pie-winding arrangements, in order to provide reduced distributed capacitance.

Surrounding the bobbin **10** is a cylindrical sleeve **15**, preferably fabricated of the same magnetic material as the bobbin **10**. The sleeve **15** is closed at one of its ends, **16**, and open at its other end, **17**, and is of uniform internal diameter, substantially equal to the outer diameter of the shoulders **11**, **12**, except at and adjacent the open end **17**, where the inner diameter of the sleeve is slightly increased.

In the practical embodiment above referred to, wherein the bobbin shoulders have outer diameters of .245", the inner diameter of the sleeve **15** may be .250", except at and adjacent to its open end **17**, where the inner diameter may increase to $\frac{5}{16}''$, for a distance axially of $\frac{3}{16}''$. The outer diameter of the sleeve may be uniform over its entire length, and equal $\frac{3}{8}''$. Molded into the closed end **16** of the sleeve **15**, and extending axially of the sleeve **15**, is a bolt **19**.

The bobbin **10** is positioned internally of the sleeve **15**, and the bobbin **10** and sleeve **15** are relatively axially movable, the inner diameter of the sleeve **15** being so related to the outer diameter of the shoulders **11** and **12** of the coil bobbin **10**, that substantially a slide fit exists.

A cylindrical phenolic cap **21** is cemented to the shoulder **12**, and extends co-axially therewith, being of the same outer diameter except for a flanged end **22**, of substantially greater diameter. A notch **23** parallel to its central axis is formed along the outer periphery of shoulder **12** to provide for lead-out of the ends of coil **14**. A radial aperture or port **24** is formed in the wall of the cap **21**. This port opens out into communication with notch **23** and an internal bore **25** in cap **21**. The ends of the coil **14** are threaded through the notch **23**, and the notch **24**, and via the axial aperture **25** to terminal pins **26**, molded in the flanged end **22** of the phenolic cap **21**.



A metallic shield can **27** is provided, which has an inner diameter equal to the diameter of the flanged end **22** of the phenolic cap **21**. In the specific example of my invention above referred to this inner diameter is .400", which is sufficiently greater than the outer diameter of the sleeve **15** to provide clearance. The flanged end **22** of the phenolic cap **21** fits snugly into one end of the shield can **27**, and is secured immovably with respect thereto, as by radial projections **28**, extending through mating apertures in the shield can **27**. The other end of the can is closed by a metal plug **29**, having a central threaded aperture **30**, threadedly engaged by the bolt **19**.

Rotation of the bolt **19** causes axial motion of the magnetic sleeve **15**, relative to the stationary bobbin **10**, and this relative motion varies the inductance of the coil **14** by varying the reluctance of the magnetic circuit associated therewith.

Reference is made to Figures 2 and 3, which illustrate positions of minimum and maximum reluctance of the magnetic circuit associated with the coil **14**. In Figure 2 the bobbin **10** is fully disposed within the sleeve **15**. The magnetic circuit extends from the coil **14**, through the shoulders **11**, **12**, and through the portions of sleeve **15** located intermediate the shoulders **11**, **12** via path **31**. In Figure 3 the total reluctance of the magnetic circuit is maximum. Similarly, in Figure 2 the total reluctance of the magnetic circuit associated with the coil **14** is at a minimum.

The end portion **17** of sleeve **15** is of greater internal diameter than the main body of the sleeve **15**; when this end portion is aligned with the shoulder **12**, an air gap is provided intermediate the shoulder **12** and the sleeve **15**, which further increases the reluctance of the magnetic circuit. This air gap develops gradually, as the sleeve **15** is drawn upwardly into the shield can **27**, and represents the significant variable tuning control factor. As sleeve **15** is drawn upwardly, the contacting areas of sleeve **15** and shoulder **12** decrease.

It will be noted that the relationship of the shoulders **11**, **12** with the sleeve **15** and the fact that bobbin **10** is always contained in sleeve **15** assure that a substantially closed magnetic circuit of slight path length exists at all times, and that the shoulders **11**, **12** serve to guide the magnetic flux from the bobbin **10**, into the sleeve **15**. Leakage flux is thereby minimized, for all tuning positions of the inductor. Such leakage flux as unavoidably exists external to the magnetic sleeve **15** is cancelled by the action of the shield can. However, the fact that magnetic sleeve material at all times surrounds the coil and its core, and that no substantial open magnetic circuits exist in the structure, for all settings, assures that the presence of the shield can **27** does not materially lower the Q of the coil. The shield can may be omitted, with consequent slight increase of Q, provided the attendant small amount of leakage flux can be tolerated.

Referring now more specifically to Figure 4 of the accompanying drawings, there is illustrated a modification of the structure of Figures 1–3, inclusive, directed primarily to the mode of varying the position of the sleeve **15**, of the embodiment of Figures 1–3. In the system of Figure 4 an internally threaded phenolic sleeve **33** is fitted into a shield can **27***a*, which is open at its upper end, and turned over at its edge, as at **34**, to provide a means for clamping the sleeve **33** against the flanged end **22** of the phenolic cap **21**. The magnetic sleeve **15**, of the embodi-

ment of my invention illustrated in Figures 1–3 of the accompanying drawings, is replaced by an externally threaded magnetic sleeve 15*a*, which threadedly engages the internally threaded phenolic sleeve 33, so that rotation of the magnetic sleeve 15 effects axial motion thereof. A screw driver slot 35 is provided on the closed end of sleeve 15*a*, to facilitate rotation, and the shield can 27*a* is open-ended, as at 36, to provide access to the screw driver slot 35.

Electrically and magnetically the embodiments of my invention illustrated in Figures 1–3, and in Figure 4, are substantially identical.

The inductor structure and arrangement of Figures 1–3, inclusive, may be utilized in providing a double tuned transformer, by including two tunable inductors in a single shield can. Reference is made particularly to Figures 5 and 6 of the accompanying drawings, for illustration of such an arrangement. The sleeves and bobbins of Figures 5, 6, and the sleeve actuating unit, may be identical with those illustrated in Figures 1–3, inclusive, and hereinbefore particularly described.

A shield can 40 is provided, which is of sufficient length to accommodate two inductors, end to end. The bobbins 41, 42 are cemented each to an opposite end of a phenolic divider 43 having a shoulder 44 centrally of its axis which is of a diameter suitable to effect a snug fit within the shield can 40, and secured fixedly to the shield can by means of radial slots (or rivets) 45. The magnetic sleeves 46, 47 extend in opposite directions over the bobbins 41, 42, respectively, and tuning of each inductor separately and independently is accomplished by means of tuning screws 48, 49. The tuning screw 48 is molded into the closure 50 of the magnetic sleeve 46, or cemented in a suitable aperture 51 therein, and extends outwardly of the shield can 40, via a threaded aperture 52 in a metal end closure 53 for the shield can. An identical construction is employed for axially actuating the magnetic sleeve 47, in response to rotation of tuning screw 49.

Coils 54, 55 are mounted on the central portions, of small diameter, of the bobbins 41, 42, respectively. The structure employed for bringing the coil ends out of the shield can 40 is illustrated more particularly in Figure 6 of the accompanying drawings, as applied to coil 55. To this end there is provided a notch 56 in the outer wall of that shoulder 57 of the bobbin 42, through which a coil end 58 is threaded, and a joining notch 59 is provided on the phenolic divider 43. The coil end 58 proceeds through the notch 59 to the internal axial aperture 60 of the divider 43, and via a suitable seal 62 in the radial aperture 61, and a mating aperture 63 in the cylindrical wall of the shield can 40.

In a typical 500 microhenry inductor, constructed in accordance with the present invention, a tuning slope of 2 microhenrys/.001" of sleeve motion was found to exist. The inductance drift in the range 24° C. to 85° C. was found to be 2%. Accordingly, a .005" total mechanical movement of the sleeve could be expected to compensate for inductance variations which take place over the range of temperatures stated. Various ways of effecting temperature compensation are disclosed hereinafter. It is, however, clear that temperature compensation may be more readily effected if the tuning slope of the inductor is high and constant. For example, aluminum has a temperature coefficient of expansion of $23.8\times10^{-6}$ in./in./ degree C. The coefficient of expansion required in order to compensate the 500 microhenry inductor above described is $85\times10^{-6}$ in./in./ degree C. If the inductor is linear over its tuning range and has a sufficiently great tuning slope, however, the coefficient of expansion of aluminum may be sufficiently great to enable an aluminum shield can to provide substantially complete temperature compensation for the inductor. To illustrate, when bobbin 10 is assumed to be fixed relative to sleeve 15, the inductance of coil 14 increases by 2% with a temperature change from 24° to 85° C. However, in practice, can 27



expands with increasing temperature, causing sleeve 15 to move axially in the direction of decreasing inductance, compensating for the first-mentioned inductance increase. The converse operation also occurs, the contraction of can 27 causing compensation for the inductance decrease due to temperature decrease of coil 14. To prevent interference with this compensatory effect, cap 21 and stud 19 are of materials having a very low coefficient of thermal expansion.

I have, accordingly, devised an improved inductor, generally similar to that of Figures 1–3, inclusive, of the accompanying drawings, but in which the tuning slope is enhanced, and have illustrated the improved inductor in Figure 7 of the accompanying drawings.

In view of the similarity in arrangement and structure of the inductors illustrated in Figures 1–3, inclusive, and in Figure 7, respectively, identical parts are identified by the same numerical reference and their further description dispensed with.

In the embodiment of my invention illustrated in Figure 7, the magnetic tuning sleeve, denoted 15*b*, is provided with two internal annular grooves 70, separated axially by approximately the spacing between the shoulders 11, 12 of the bobbin 10, and having heights greater than these shoulders. The sleeve itself may be of uniform radius except for the grooves, and the grooves may be filled with phenolic material which has about unity permeability.

Accordingly, in the maximum inductance position of the magnetic sleeve 15*b*, the inductance of the unit will be about the same as that of a unit corresponding with that illustrated in Figures 1–3, inclusive. In the position of minimum inductance, on the other hand, which is the position illustrated in Figure 7, two effective air gaps exist in the magnetic circuit, rather than the one gap which exists in the system of Figures 1–3, when the magnetic sleeve 15 of those figures is in its minimum inductance position, illustrated in Figure 3. Accordingly, the maximum reluctance, in the embodiment of my invention illustrated in Figure 7 of the accompanying drawings, is increased, and correspondingly the tuning slope enhanced. By proper design of the unit of Figure 7 a numerical value of tuning slope may be accomplished which is compensatable by shield cans fabricated of conventional materials, such as aluminum, copper, zinc, or the like. The tuning slope can be varied and controlled, in the design of the inductor, by properly selecting the size of the air gap grooves—i. e., their lengths axially and their depths.

In the systems of Figures 1–3 and of Figure 4 a movable sleeve is employed and a stationary coil bobbin, having a shoulder on each side of its coil.

As an alternate mechanical arrangement, a coil bobbin may be employed comprising a central portion 13 of relatively small diameter and end portions 11, 12 of enlarged diameter, following the constructions employed in Figures 1–7, inclusive, of the accompanying drawings. One end of the coil bobbin 10 may be cemented to a phenolic plug 71, which is co-axial with the bobbin 10 and is threaded externally over a portion of its length.

A magnetic sleeve, 72, may be provided, having a phenolic annular insert 73 in its interior wall, located axially intermediate the shoulders 11, 12 when the bobbin is in the position shown in Fig. 8. A further internally threaded annular phenolic insert 74 may be included internally of the sleeve 72, and extending from the open end of the latter for a maximum distance approximating the height of the bobbin 10, although this is not critical. The external threads of the plug 71 may threadedly engage the internal threads of the annular insert 74, so that the relative rotation of the plug 71 and the sleeve 72 effects relative axial movement thereof. During such axial movement and assuming that the movement is such that the bobbin 10 is withdrawing from sleeve 72, the shoulder 11 approaches the insert 73, and the shoulder 12 ap-

proaches the insert 74. Thereby the reluctance of the closed magnetic path including the bobbin 10, its shoulders 11, 12, and the sleeve 72, is increased.

The structure of Figure 9 is generally similar to that of Figure 7, the primary difference residing in the provision of an externally threaded plug 76, threadedly engaging internal threads 77 at one end of shield can 27c. The threaded plug 76 may be joined with the sleeve 11b by means of a connecting wire 78. Rotation of the threaded plug 76 results in axial adjustment of the sleeve 15c.

Thus it will be seen that the invention provides the combination of a winding support of magnetic material formed with a reduced center portion and enlarged shoulder portions at each end, a magnetic sleeve axially slidably embracing both of said shoulders through a part of a range of adjustment and so formed as to constitute, in combination with one of said shoulders, a variable air gap during said adjustment, and means for relatively adjustably positioning said sleeve and winding support in such a manner that said support is always entirely disposed within said sleeve.

The invention also provides electrically conductive enclosure means secured to the adjusting means and having a coefficient of expansion such as to cooperate with the adjusting means to position the sleeve in such a manner as to compensate for undesired inductance changes in said winding caused by ambient temperature changes.

While I have described and illustrated various preferred embodiments of my invention, I appreciate that modifications of detail, and of arrangement, may be resorted to without departing from the true spirit of the invention as defined in the appended claims.

I claim:

1. A variable radio-frequency inductor comprising a cylindrical magnetic bobbin, a coil on said bobbin, said bobbin having a shoulder of predetermined diameter at each end thereof, a hollow magnetic one-piece sleeve extending completely over said bobbin, said magnetic sleeve having a length greater than that of said bobbin and an internal diameter generally substantially equal to said predetermined diameter to provide a contacting fit but being formed with an enlarged annular bore opening out into one end thereof, and means for relatively axially moving said sleeve and said bobbin to move one of said shoulders into said enlarged bore.

2. A variable inductor for radio frequency circuits, comprising a powdered iron bobbin, said bobbin having flanged ends a coil mounted on said bobbin intermediate said flanged ends, a hollow one-piece powdered iron sleeve having one end closed and a length greater than that of said bobbin, said sleeve encompassing said bobbin to provide a sliding fit but having one end formed as an enlarged bore opening axially into said end, and means for relatively axially moving said sleeve and bobbin to move one of said shoulders into said enlarged bore.

3. A variable radio-frequency inductor comprising a metallic shield can, a magnetic bobbin secured immovably to and within said shield can, said bobbin having shoulders of predetermined diameter at each end and being of smaller diameter intermediate said ends, a coil mounted on said bobbin intermediate said ends, a one-piece magnetic sleeve having an internal diameter equal substantially to said predetermined diameter to provide a sliding fit, said magnetic sleeve closely encompassing said bobbin but having an enlarged annular bore opening out at one end of said sleeve and adapted to form an air gap with a bobbin shoulder, means for actuating said sleeve axially of said shield can, and a cap member projecting into said can to provide a support for said bobbin.

4. A magnetic structure for a variable radio-frequency inductor comprising a cylindrical magnetic bobbin having shoulders of relatively great diameter and a section joining said shoulders and of relatively reduced diameter, a one-piece magnetic sleeve surrounding said bobbin and formed to provide a sliding fit, said magnetic sleeve comprising at least one enlarged bore extending axially outwardly and located adjacent one of said shoulders, which bore is of greater internal diameter than the diameter of said one of said shoulders, and at least one additional portion which has substantially the same internal diameter as one of said shoulders, and a member for supporting said bobbin.

5. A magnetic structure for a variable radio-frequency inductor comprising a cylindrical magnetic bobbin, said bobbin having shoulders of relatively great diameter and a section joining said shoulders and co-axial therewith, said section of cross sectional area smaller than that of said shoulders, a one-piece magnetic sleeve for said bobbin, said magnetic sleeve having an internal diameter generally which is substantially equal to the diameter of at least one of said shoulders to provide a sliding fit, and having at least one enlarged bore opening out into the end of said sleeve, said bore and at least one of said shoulders being of comparable axial length and being relatively axially adjustable through adjacent axial positions, as shown and described herein.

6. A magnetic structure for a variable radio-frequency inductor comprising a cylindrical magnetic bobbin, said bobbin having at least one shoulder of relatively great diameter and having a coil supporting section integral with and co-axial with said at least one shoulder and of relatively reduced diameter, a one-piece magnetic sleeve encompassing said bobbin and formed to provide a sliding fit, and means for moving said magnetic sleeve axially of said bobbin, said magnetic sleeve constructed and arranged with a marginal wall of reduced cross section and enlarged internal diameter to complete a magnetic circuit for said bobbin through an air gap formed in part by one of said shoulders, as shown and described herein.

7. A magnetic structure for a variable radio-frequency inductor comprising a cylindrical magnetic bobbin, said bobbin having shoulders of relatively greater diameter and a section joining said shoulders and co-axial therewith, and of relatively reduced diameter, a one-piece cylindrical magnetic sleeve for said bobbin, said magnetic sleeve having an internal diameter generally which is substantially equal to the diameter of at least one of said shoulders to provide a sliding fit, and at least one annular portion of relatively decreased wall thickness and of axial length comparable with the axial length of at least one of said shoulders, means for relatively axially actuating said sleeve and bobbin, and means for confining at least one shoulder of said bobbin entirely within said sleeve.

8. The combination in accordance with claim 7 wherein is provided a cylindrical insulating support for said bobbin, said support having an external diameter less than the internal diameter of said sleeve, means securing said insulating support to one end of said bobbin, a shield can, means securing said shield can to said insulating support in encompassing relation to said sleeve, and screw means for axially actuating said sleeve with respect to said shield can.

9. The combination in accordance with claim 7 wherein is provided an insulating support for said bobbin, means securing said insulating support to one end of said bobbin, a shield can encompassing said sleeve and having two ends, means securing one end of said shield can to said insulating support, a closure for the other end of said shield can and comprising a threaded aperture, a screw secured to one end of said magnetic sleeve, said screw threadedly engaging said threaded aperture and extending co-axially of said sleeve.

10. The combination in accordance with claim 7 wherein is provided a cylindrical insulating support for said bobbin, said support having an external diameter less than the internal diameter of said sleeve, means securing said insulating support to one end of said bobbin, a pair of terminals extending from and secured to said insulating support, a coil surrounding said section of said bobbin

which joins said shoulders, and coil leads extending from and secured to said insulating support.

11. The combination in accordance with claim 7 wherein is provided means for compensating for variations of inductance with temperature of said variable inductor, said last means comprising temperature responsive means including an aluminum shield can for relatively actuating said sleeve and bobbin.

12. A variable inductive radio-frequency device comprising at least one cylindrical powdered iron magnetic bobbin having shoulders of relatively greater diameter and a section joining said shoulders and co-axial therewith, and of relatively reduced diameter, a one-piece cylindrical magnetic sleeve for said bobbin, said magnetic sleeve having an internal diameter generally which is substantially equal to the diameter of at least one of said shoulders to provide a sliding fit, and at least one annular portion of relatively reduced wall thickness and of axial length comparable with the axial length of at least one of said shoulders.

13. An adjustable radio-frequency inductor comprising, in combination: first, a winding of electrically conductive material; second, a winding support of magnetic material formed with a reduced central portion about which the winding is disposed and enlarged end portions providing a magnetic flux path of low reluctance; third, a one-piece sleeve of magnetic material formed with an internal diameter approximating the external diameter of said enlarged portions, said winding support being slidably disposed within said sleeve with at least one shoulder contacting said sleeve, said sleeve being formed with an enlarged internal bore opening out at one end thereof and comparable in length to the axial length of one of said enlarged portions, and means for adjustably axially positioning said winding support within said sleeve in such a manner that the winding support is adjusted through a range of positions at one extreme of which a closed magnetic circuit is defined by both of said enlarged portions and said sleeve and at the other extreme of which a magnetic circuit is defined by said sleeve, said winding support and an air gap between the portion of said sleeve which is of enlarged internal diameter and one of said enlarged portions, at least one of said enlarged portions at all times being within said sleeve.

14. The combination, in a radio-frequency inductor, of a winding support of magnetic material formed with a reduced center portion and enlarged shoulder portions at each end, a one-piece magnetic sleeve axially slidably contacting and embracing both of said shoulders through a part of a range of adjustment and so formed as to constitute, in combination with one of said shoulders, a variable air gap during said adjustment, and means for relatively adjustably positioning said sleeve and winding support in such a manner that said support is always entirely disposed within said sleeve.

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