

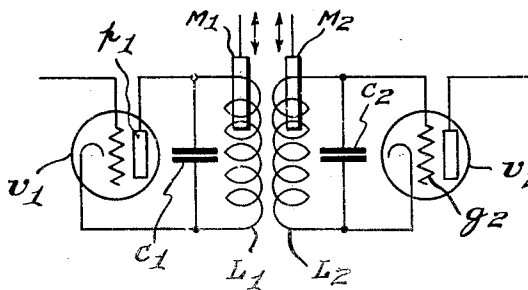
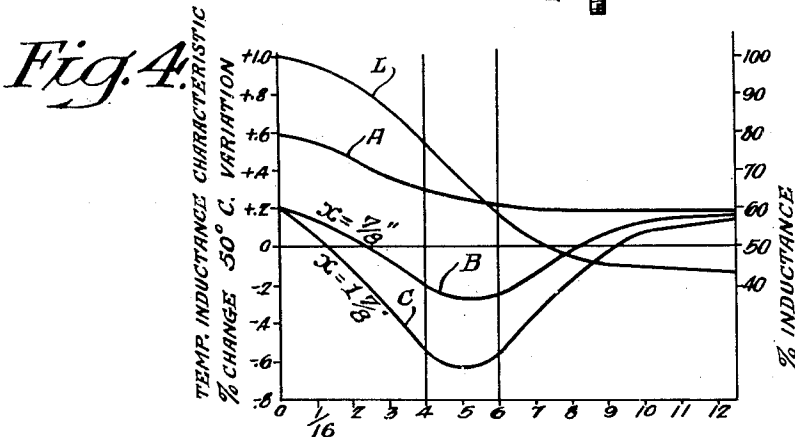
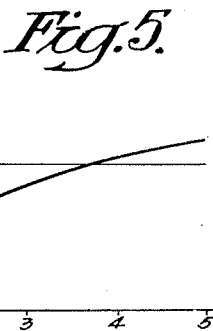
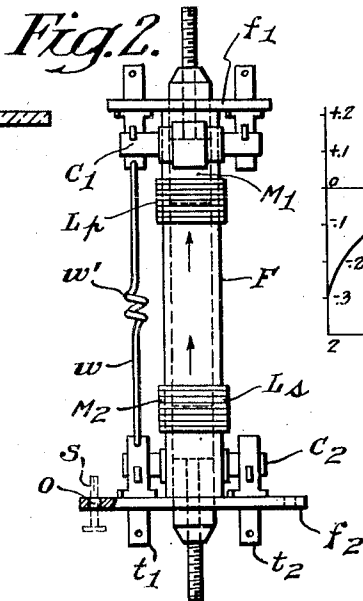
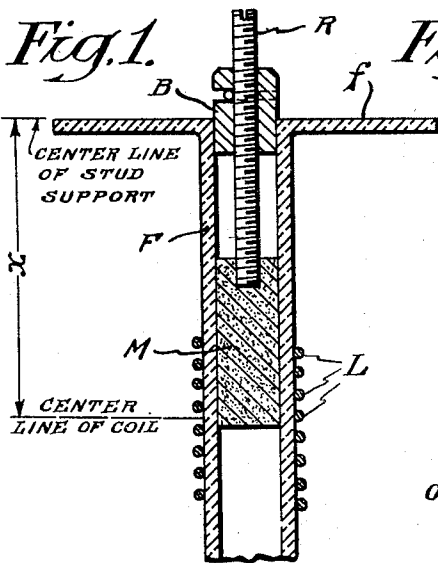
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TEMPERATURE COMPENSATED MAGNETIC CORE INDUCTOR

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TEMPERATURE COMPENSATED MAGNETIC
CORE INDUCTOR

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8 Claims. (Cl. 171-119)

This invention relates to magnetic core inductance devices for use in radio and other systems for the communication of intelligence and has special reference to the provision of improvements in magnetic core inductors for tuned circuits designed to be operated at a predetermined fixed frequency.

While the invention will be described as applied to coupling units designed for use in the intermediate frequency stages of a superheterodyne radio receiver, it will be understood that the disclosure in this respect is merely illustrative for purposes of explaining the inventive concept.

An object of the present invention is to provide a magnetic core inductor which shall exhibit a substantially zero temperature coefficient of inductance or a temperature coefficient of inductance of either sign and of a desired low value.

Another object of the invention is to provide a low loss intermediate or high frequency magnetic core inductor and one characterized by a high degree of stability irrespective of aging and varying conditions of temperature and humidity.

Another object of the invention is to provide a magnetic core inductor wherein the effect of changes in the diameter and in the spacing of the turns of the inductor or due to miscellaneous changes in external circuit components, caused by variations in the ambient, will be obviated by compensating changes in the relative position of the coil with respect to the core.

Still another object of the invention is to provide a simple, inexpensive, trouble-free temperature compensated magnetic core inductor and one which lends itself readily to mass production methods.

Other objects and advantages, together with certain details of construction, will be apparent and the invention itself will be best understood by reference to the following specification and to the accompanying drawing, wherein—

Figure 1 is an enlarged longitudinal sectional view of so much of a magnetic core inductor as is necessary for an understanding of the principle of the invention;

Figure 2 is a side elevational view of a magnetic core coupling unit, and form therefor, constructed in accordance with the invention;

Figure 3 is a diagram of two magnetically coupled circuits which will be referred to in explaining the invention;

Figure 4 is a chart comparing the operating characteristics of the device of Fig. 2 with prior art devices; and

Figure 5 is a chart showing the effect of the thickness of the coil form of Figs. 1 and 2 upon the temperature-inductance characteristic.

Like reference characters designate the same or corresponding parts in all figures.

In order to obviate changes in inductance due to changes in temperature, the prior art dictates the use of coil forms and other parts constituted of quartz and other materials having a substantially zero coefficient of expansion. (See, for example, Marrison 1,836,808, and Llewellyn 1,910,957.)

In accordance with the present invention, a magnetic core is presented to the interior of a coil which is mounted upon the outer surface of a hollow form comprising an insulating substance which has a very large coefficient of expansion. The magnetic core is maintained in a fixed position within the core so that, when the device is subjected to increased temperatures, the form expands and the coil is moved with respect to the magnetic core to thereby compensate for changes in the inductance of the coil incident to the expansion and elongation of its turns. When the material constituting the form is properly chosen, substantially any desired low temperature coefficient of inductance may be achieved simply by varying the length and thickness of the coil form or by altering the position of the coil thereon. In addition to exhibiting a large coefficient of expansion, the material of which the coil form is constituted should be substantially immune to moisture and should possess certain other desirable mechanical and electrical properties.

As evidenced by the comparative table below, polystyrene (or polystyrol, as it is sometimes called) meets all of the above requirements and, further, is inexpensive both as to its initial cost and cost of processing.

	Polystyrene	High grade phenol formaldehyde resin-tubing	Ms. mag. ceramic
Water absorption, percent.	.05	1.2	.02-.05
Coefficient of linear expansion	$65-102 \times 10^{-6}$	$20-30 \times 10^{-6}$	6×10^{-6}
Power factor 1000 kc.	.002	.035	.006
Dielectric constant 1000 kc.	2.6	5	6
Dielectric strength volt./mil.	500-525	-----	200
Resistivity	10^8	10^8	10^9

In Fig. 1, F designates generally a hollow form made of polystyrene, upon the outer surface of which an inductance coil L is wound or mounted

in any suitable manner. Form F is preferably provided with an integral mounting flange f adjacent an end thereof. Presented to the interior of the form F and coil L is a magnetic core M which is preferably constituted of comminuted insulated granules of the ore magnetite or of powdered iron, molded in a known manner. The diameter of the core M is such as to give it a sliding fit within the bore of the form F when a moving force is exerted thereon as through a threaded brass or like rod R. One end of the threaded rod R is preferably embedded in the core material during the molding operation and its free end extends through a threaded knurled metal bushing B which is force fitted into the otherwise open end of the coil form F. In order to insure a tight fit the end of the coil form may be softened by preheating prior to receiving the knurled end of the bushing B. The bushing B may be bifurcated as indicated at b to cause it to grip the rod R and thereby prevent undesired movement of the core L within the cylinder F once its position has been fixed. As in prior art, magnetic core inductors, the relative position of the core and coil determines the effective inductance of the coil, thus, maximum inductance is achieved when the core is entirely within the coil.

As previously set forth, the coil form F is constituted of a material which has a large coefficient of expansion. Where, as in the instant case, the coil form is made of polystyrene, its coefficient of linear expansion is substantially six times that of the metal (i. e., brass) of which the adjusting rod R and bushing B are formed. Accordingly, when the coil form is subjected to an increase in temperature, it will expand and be elongated to a much greater extent than the bushing B and the rod R to which the core C is affixed. Since the coil L is intimately attached to the core form F, elongation of the form will cause the coil to be moved with respect to the core M thereby altering the effective inductance of the coil no less certainly than if the core had been moved with respect to the coil by a sliding force exerted through the adjusting rod R.

As will hereinafter more fully appear, the degree of compensation is a function of the distance between the center line of the bushing or stud-support B and the center line of the coil L, i. e., distance x in Fig. 1. Thus substantially any desired degree and sign of compensation may be achieved by simply altering the mechanical length of the form and the position of the coil thereon. The general rule is the greater the value of x , the more negative the temperature coefficient of inductance. The degree of compensation may also be controlled to a useful extent by altering the thickness dimension of the coil form and by using materials having a coefficient of expansion other than that of brass for the bushing B and adjusting rod R.

Fig. 2 shows a high frequency coupling unit constructed in accordance with the principle of the invention. The coil form F here comprises a hollow cylinder constituted of polystyrene and provided with outwardly extending flanges f^1, f^2 , one at each end of the cylinder. One of these flanges, say flange f^2 , is preferably provided with orifices O which receive mounting studs s for attachment to the chassis base of a radio receiver, in which case the opposite end of the form is left free to permit of unrestrained expansion and contraction due to temperature changes. The opposed surfaces of the flanges f^1, f^2 may

each be used for mounting fixed capacitors C^1, C^2 and terminal elements t^1, t^2 through which connections may be made to the circuits with which the device is to be associated. The conductor w which serves to connect upper capacitor C^1 to the bottom terminal t^1 may be provided with a slack portion w^1 to prevent the application of any restraining force to the coil form when it is elongated due to increased temperatures.

A primary coil L^1 and a secondary coil L^2 are mounted in suitably spaced energy transfer relation on the outer surface of the coil form. Each coil is provided with a magnetic core M^1, M^2 , respectively, mounted for slidable movement, as described in connection with Fig. 1, within the bore of the cylindrical form F.

Fig. 3 shows, symbolically, a coupling device of the type described in connection with Fig. 2 suitably connected in the intermediate frequency amplifying stages of a superheterodyne receiver. The primary winding L^1 has the fixed capacitor C^1 connected across its terminals and the resonant circuit thus formed is connected to the plate p^1 of a thermionic amplifier v^1 . The secondary winding L^2 of the coupling unit has the fixed capacitor C^2 connected across its terminals and the resonant circuit thus formed is connected to the input electrode g^2 of the amplifier v^2 . As previously described, and as indicated by the conventional symbols in Fig. 3, the inductance, and hence the frequency of the resonant circuits L^1C^1, L^2C^2 may be adjusted by relative movement of the cores M^1, M^2 with respect to the coils individual thereto.

In constructing a coupling unit for use in a particular circuit, the combined temperature characteristic of the tube, capacitor, wiring, etc., of the circuit should first be determined. This will usually be found to be of positive value. The proper value of x (see Fig. 1) to exactly compensate for such temperature characteristic should then be determined and the coupling unit designed with this value in mind.

Referring now to Fig. 4 which shows four curves A, B, C and L: Curve L shows how the inductance of a unit, constructed in accordance with the invention, changes when the position of its magnetic core is altered. At zero, on the bottom scale, the core is in register with the coil (i. e., completely within the coil). Between the limits $4/16''$ and $6/16''$, read on the same scale, the change in inductance is maximum, that is to say, the greatest change of inductance is achieved for a given movement of the core when it moves between the limits. Curve A shows the temperature-inductance characteristic of a unit having a coil form constructed of a phenolic compound is of a positive sign throughout the entire range of movement of the core. Curves B and C show the temperature inductance characteristic of two magnetic core inductors having coil forms constituted of polystyrene. The only physical difference between these two units is in their value of x (see Fig. 1). It will be noted in connection with both curves B and C that their minimum slope occurs between the same range (i. e., $4/16''$ to $6/16''$) that the maximum change in inductance (curve L) occurs.

Assuming now as a specific example that the tube, capacitor and wiring of one of the circuits (i. e., primary or secondary) of Fig. 3 has been found to exhibit a temperature-capacitance characteristic of $+2\%$. It is obvious that to achieve a circuit having a zero temperature-frequency characteristic the inductor must exhibit a tem-

perature coefficient of inductance of $-.2\%$. Referring, therefore, to curve B of Fig. 4, we find that this temperature-inductance characteristic (as read on the left-hand scale) is achieved when the value of x (Fig. 1) is substantially $\frac{1}{8}''$.

In the above example, it is assumed that the thickness of the coil form is substantially $\frac{1}{8}$ of an inch. Fig. 5 shows how the thickness of the coil form affects the temperature compensation when the core is within the working range shown in Fig. 4. Referring to Fig. 5, it will be noted that it is possible to have a zero or any reasonable positive or negative temperature-inductance characteristic by simply altering the thickness dimension of the form upon which the coil is mounted.

Various modifications of the invention will be apparent to those skilled in the art. It is to be understood, therefore, that the foregoing is to be interpreted as illustrative and not in a limiting sense except as required by the prior art, and by the spirit of the appended claims.

What is claimed is:

1. A temperature compensated inductor comprising a coil form, a coil mounted on said form, a magnetic core for altering the effective inductance of said coil mounted for movement adjacent said coil and form, adjustable means for maintaining said core in a relatively fixed position with respect to said coil, said form being constituted of an insulating substance having a temperature coefficient of expansion which is relatively large with respect to the temperature coefficient of expansion of said adjustable means, and having its length so proportioned with respect to its mass that when it is subject to temperature changes it will cause that degree and direction of movement between said coil and core required to produce a desired change in the effective inductance of said coil.

2. A temperature compensated inductor comprising a hollow cylindrical form, a coil mounted on the outer surface of said form remote from an end thereof, a magnetic core mounted for slidable movement within said form, adjustable means for maintaining said core in a relatively fixed position with respect to said end of said form, said form being constituted of an insulating substance having a coefficient of linear expansion substantially greater than that of said first-mentioned means whereby said coil is moved with respect to said core when said form is subjected to variations in temperature.

3. The invention as set forth in claim 1 and wherein said core-adjusting means is comprised of brass and said form is constituted essentially of polystyrene.

4. A temperature compensated inductor comprising a hollow cylinder constituted essentially of polystyrene, a coil intimately secured to the outer surface of said cylinder, a magnetic core

within said cylinder, and means comprising a rod connected to said core and a bushing connected to said cylinder for moving said core with respect to said coil, said rod and bushing having a coefficient of linear expansion which is substantially less than that of the material of which said coil form is constituted.

5. A device for coupling two tuned circuits, said device comprising a coil form constituted essentially of polystyrene, primary and secondary coils mounted in energy transfer relation on said coil form, magnetic cores individual to said coils for regulating the effective inductance thereof, means secured to said form and having a temperature coefficient of linear expansion substantially less than that of polystyrene for relatively moving said cores with respect to said coils over a range of movement calculated to produce a maximum change of inductance in said coils, the dimensions of said coil form and the relative positions of said coils thereon being so chosen that said device exhibits a temperature coefficient of inductance of a desired sign and value over said range of maximum change in inductance.

6. A temperature compensated inductor comprising a coil form, a coil mounted on said form, a magnetic core mounted for movement adjacent said form and coil, means mounted on said form for adjusting the position of said core with respect to said coil whereby to change the effective inductance of said coil, said form being constituted of an insulating substance having a coefficient of linear expansion substantially greater than that of said core adjusting means, whereby said coil is moved with respect to said core when said form is subject to variations in temperature.

7. The invention as set forth in claim 6 and wherein said core adjusting means is comprised of metal and said coil form is constituted essentially of polystyrene.

8. A temperature compensated inductor comprising a coil form constituted of an insulating substance having a coefficient of linear expansion of the order of $65-102 \times 10^{-6}$, a coil mounted on said form remote from an end thereof, a magnetic core for regulating the effective inductance of said coil, means supported adjacent said end of said form and having a substantially lower coefficient of expansion than said insulating material for moving said core with respect to said coil over a range of movement calculated to produce a maximum change of inductance in said coil, the dimensions of said coil form and the position of said coil with respect to said end of said form being so chosen that said device exhibits a temperature coefficient of inductance of a desired sign and value over said range of maximum change in inductance.

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