May 22, 1934. M. OSNOS 1,959,543

TUNING COIL

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Fig. 1

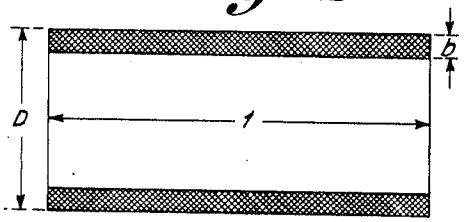


Fig. 2

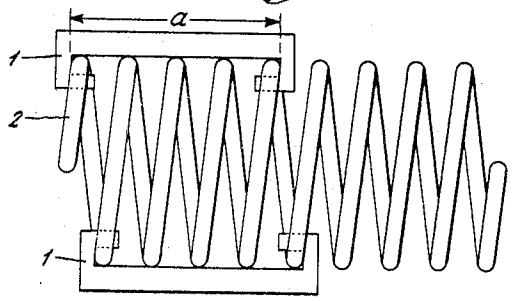


Fig. 3

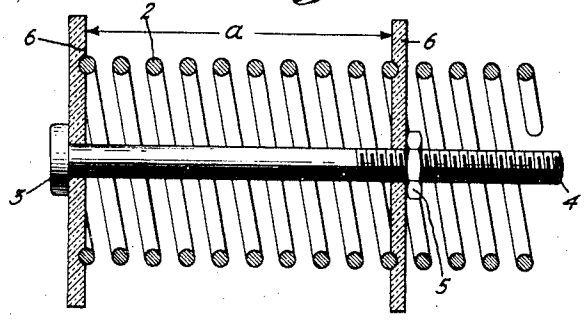
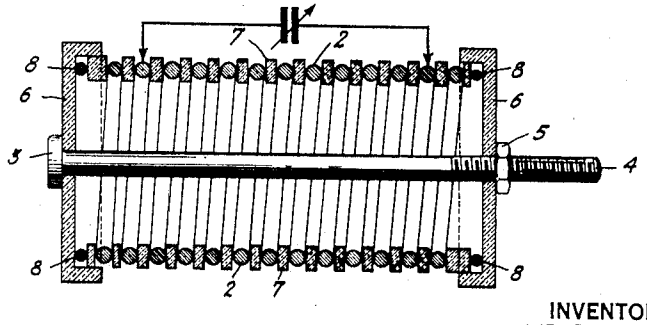


Fig. 4



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TUNING COIL

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9 Claims. (Cl. 175—359)

This invention relates to an improved tuning coil arranged so that the self inductance whose dependency on the temperature is adjustable as may be desired, or controlled respectively as may be desired, or totally or approximately eliminated.

The self induction of a copper coil generally increases with increasing temperature. For a coil as shown for instance in Figure 1 for which

$$O<\frac{D}{U}<\lambda$$

(see Rein-Wirtz "Radiotelegraphisches Praktiktikum 1921 3d edition, page 128) the self induction is approximately

$$L=10{,}5\times N^2\times D\sqrt[4]{\frac{D}{U}}\text{cm} \quad \text{---------(1)}$$

wherein

N=total number of turns
D=average diameter of the coil in cm.
$U=2\times(l+b)$

and since

$$\left.\begin{aligned} D&=D_o\times(1+\alpha t)\\ U&=U_o\times(1+\alpha t)\end{aligned}\right\} \quad \text{----------(2)}$$

(α signifies the heat expansion coefficient and L_o, or D_o, or U_o respectively represent the corresponding values of L, or D, or U respectively for $t=0°$ C.)
it further follows that:

$$L=L_o\sqrt[4]{\frac{(1+\alpha t)^5}{(1+\alpha t)}}=L_o\times(1+\alpha t) \quad \text{-------(3)}$$

It can be seen from Equation 3 that the self induction of the coil is proportional to the value of $1+\alpha t$.

According to the present invention the dependency on the temperature t of the self induction of a coil can be made adjustable or controllable respectively as may be desired. The invention affords in particular to render the self induction totally or approximately independent of the temperature. This is accomplished by determining the distance between the individual elements of a part of the coil by one or several members the heat expansion coefficient of which is greater than the heat expansion coefficient of copper or the electric conductor of the coil respectively.

The correctness of the inventive idea will now be proven on hand of Equation 1.

For the sake of simplicity it is assumed that b is much smaller than l so that

$$\frac{l}{b}$$

can be neglected.

According to the invention the length l of the coil is determined by a suitable retaining member, the expansion coefficient of which may be generally taken as being k times greater than the expansion coefficient of copper so that:

$$l=l_o(1+K\alpha t) \quad \text{----------(4)}$$

Therefore:

$$L=L_o\sqrt[4]{\frac{(1+\alpha t)^5}{(1+K\alpha t)}} \quad \text{----------(5)}$$

As compared with l the value αt is generally small so that:

$$(1+\alpha t)^5\cong 1+5\alpha t \quad \text{----------(6)}$$

and therefore

$$L=L_o\sqrt[4]{\frac{1+5\alpha t}{1+K\alpha t}} \quad \text{----------(7)}$$

If the retaining member determining the dimension l is formed of hard rubber whose heat expansion coefficient is 5 times as great as for copper the following is obtained:

$$L=L_o\sqrt[4]{\frac{1+5\alpha t}{1+5\alpha t}}=L_o \quad \text{----------(8)}$$

therefore totally independent of t.

If however a member is used having an expansion coefficient which is greater than that of hard rubber as for instance zelluloid with $K=6{,}6$ then

$$L<L_o \quad \text{----------(9)}$$

Coils for which the value of

$$\frac{D}{U}$$

is between 1 and 3 behave still more favorably since, as is known the following equation is approximately correct

$$L=10{,}5\times N^2\times D\times\sqrt{\frac{D}{U}}\text{cm} \quad \text{---------(10)}$$

and it is therefore approximately

$$L=L_o\frac{1+3\alpha t}{1+K\alpha t} \quad \text{----------(11)}$$

which shows that the separator determining the length of the coil must have an expansion coefficient $K\times\alpha=3\alpha$ in order that

$$L=L_o$$

In the drawing several embodiments are shown by way of example.

In the drawing like numerals refer to similar parts throughout the several views.

Fig. 1 is a cross section of an inductance coil

indicating the principal parts to be compensated as described by the above formulæ;

Fig. 2 is a side elevation of an inductance coil with suitable retaining members;

Fig. 3 is a cross section of an inductance coil with retaining end members with central adjusting means;

Fig. 4 is also an inductance coil with retaining end members, a central adjustable securing means and interposed insulating material between the conductor turns.

Referring now to Fig. 2, the reference numeral 1 designates a separator and retaining member having hook-like ends, this retaining member being composed of insulating material having a high heat expansion coefficient.

2 indicates an expansion type spring copper coil.

3 shows a bolt of the same or similar insulating material as for retaining member 1 above mentioned.

4 refers to the bolt rod having a threaded portion and also indicates a variable condenser in parallel with the conductor turns.

5 is a nut formed of the same or similar material as used for members 1, or 4.

6 designates round caps or elongated press discs of insulating material, as also shown in Figure 4.

7 are intermediate layers of insulating material suitably of a similar characteristic as 1 and 4 and

8 represents elastic rubber rings.

According to Figures 2 and 3 only a part of the coil which is about one half of its length is somewhat compressed by the retaining members against the springy force of the windings so that the distance (*a*) between the outer windings of this retained part is always determined by the retaining members or separator. If the retaining members should expand due to the heat, the distance (*a*) between the outer windings becomes greater, and the self induction of this retained part of the coil is correspondingly reduced. If, however, the retaining members shrink due to the cooling off, the retained coil distance becomes smaller and the self induction will increase in the same proportion.

From Figure 3 can be seen that the part of the coil retained between the separators as well as the space between the conductor windings of this part of the retained coil can be very finely adjusted in any desired way.

The embodiment according to Figure 4 is suitable for coils having a comparatively large number of conductor turns. In this case suitable insulating material 7 is provided between the individual conductor turns. The insulation material parts 4 and 7 expand due to the heat which in turn reduces the self induction of the coil.

During the cooling off of the coil the insulation material shrinks. This alone would however not be sufficient in order to contract the total coil. This is being accomplished by the bolt 3, 4, and nut 5 which determines the space between the outer windings of the coil. When the cooling off occurs the bolt and accordingly the coil contracts and the self induction is thereby effected in the sense of the contraction.

Fig. 4 also indicates a variable condenser arranged in parallel with the retained conductor turns of coil so as to provide a tuned circuit.

It is desirable to choose the bolt and the intermediate insulating layer 7 from the same material. In order to balance eventual differences between the heat expansion coefficient of the intermediate insulation 7 and the retaining bolt 4, it is advisable to compensate the distance determined by the retaining bolt or separator 4 by a substantial springy force for instance by a rubber ring 8 interposed between the round end caps 6 and the intermediate insulation 7.

It may under certain conditions be of advantage to connect the self inductance of the present invention in series, or parallel to ordinary non-temperature controlled self inductances, in order to vary the dependency of the resulting self inductance on the temperature in any desired manner, or to cause this dependency to follow any desired law, respectively.

In order to obtain the result mentioned, various parts of a coil can also be provided with insulating separators of various materials having different expansion coefficients or coils provided with various insulating separators may be combined.

I claim:

1. An inductance coil having a self inductance which is controlled by insulating material, a plurality of retaining members having a high heat expansion coefficient, some of said members disposed in the space between the individual conductor turns so that the total length of the coil is determined by a distance of said retaining members.

2. In an inductance coil whose inductance is subject to changes by temperature variations, means for controlling said inductance changes, said means comprising a plurality of retaining members of insulating material having hook-like ends located outside the inductance coil, said coil having conductor turns composed of metal having spring-like characteristics.

3. In an inductance coil whose inductance is subject to changes by temperature variations, means for controlling said inductance changes comprising a coil having a plurality of conductor turns of spring-like metal, a plurality of insulated members for retaining a portion of the conductor turns on said coil, said insulated retaining members having hook-like ends to secure the conductor turns in proper spaced relation.

4. In an inductance coil whose inductance is subject to changes by temperature variations, means for controlling said inductance changes comprising a coil having a plurality of conductor turns of spring-like metal, a plurality of members for retaining a portion of the conductor turns on said coil, said retaining members comprising two insulated discs of a larger outside diameter than said coil, a central insulated member passing through the said coil and the said discs.

5. In an inductance coil whose inductance is subject to changes by temperature variations, means for controlling said inductance changes comprising a coil having a plurality of conductor turns of spring copper, a plurality of insulated members for retaining a portion of the conductor turns on said coil, said retaining members comprising two insulated discs of a larger outside diameter than said coil, a central insulated member passing through the said coil and the said discs.

6. In an inductance coil whose inductance is subject to changes by temperature variations, means for controlling said inductance changes comprising a coil having a plurality of conductor turns of spring-like metal, a plurality of members for retaining a portion of the conductor turns on said coil, said retaining members

comprising two insulated discs of a larger outside diameter than said coil, a central adjustable insulated member passing through the said coil and the said discs.

7. In an inductance coil whose inductance is subject to changes by temperature variations, means for controlling said inductance changes comprising a coil having a plurality of conductor turns of spring-like metal, a portion of said coil being retained and another portion of said coil being free, a plurality of insulated members for retaining the retained portion of said coil, said insulated retaining members having hook-like ends to secure the conductor turns in proper spaced relation.

8. In an inductance coil whose inductance is subject to changes by temperature variations, means for controlling said inductance changes comprising a coil having a plurality of conductor turns of spring-like metal, a plurality of members for retaining a portion of the conductor turns on said coil, said retaining members comprising two insulated discs of a larger outside diameter than said coil, said discs having an outer rim, an insulating member interposed between each of said conductor turns, and an elastic compression and expansion member at each end of the coil located within the rims of said discs and said insulating member.

9. In an inductance coil whose inductance is subject to changes by temperature variations, means for controlling said inductance changes comprising a coil having a plurality of conductor turns of spring-like metal, a plurality of members for retaining a portion of the conductor turns on said coil, said retaining members comprising two insulated discs of a larger outside diameter than said coil, said discs having an outer rim, an insulating member interposed between each of said conductor turns, an elastic compression and expansion member at each end of the coil located within the rims of said discs and said insulating member, and a variable condenser arranged in parallel with said conductor turns so as to provide a tuned circuit.

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