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INDUCTANCE COIL

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FIG. 1

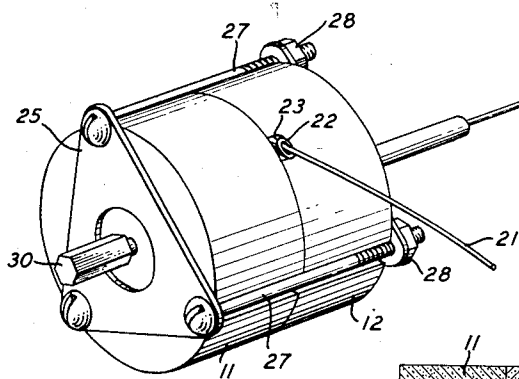


FIG. 3

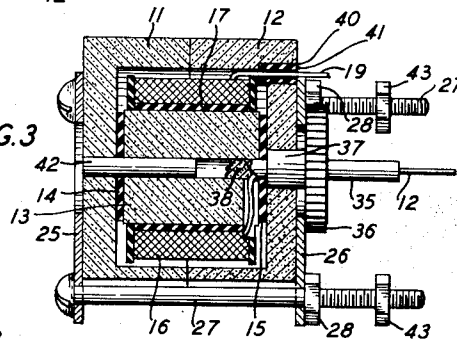
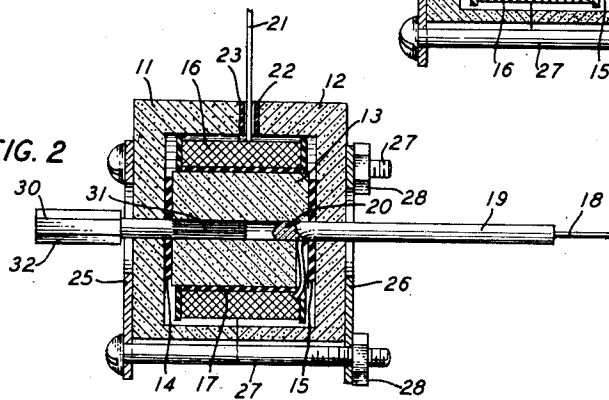


FIG. 2



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INDUCTANCE COIL

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This invention relates to inductance coils and more particularly to such coils especially suitable for use in channel filter circuits for broad band carrier systems.

In one such system, twelve channel filters may be employed to select the lower sideband derived from the modulation of speech signals and carrier frequencies spaced every four kilocycles in a frequency range of from sixty-four to one hundred and eight kilocycles. Inductance coils are associated with these channel filters and because of the close spacing of the channels it is advantageous that the inductance of these coils be both very accurately initially determined and also be very stable. High Q , which is ratio of reactance of resistance, and good stability in the coil are desired to give the required selectivity under operating conditions. The very precise adjustment of the filter by proper adjustment of the inductance of the coil is advantageous to tune the filter exactly to the desired frequency band.

In prior coils employed with channel filters accurate adjustment of the inductance has been attempted by selecting or adjusting the number of turns in the winding or by varying the length or size of air gaps in the magnetic circuit. The former method has been used primarily with coils wound toroidally on single piece ring cores by which adjustment can be made to the nearest whole turn. The latter method is applicable to cores assembled from two or more magnetic members. This method of course requires very accurate mechanical dimensioning involving precise grinding operations. Such grinding has certain inherent disadvantages, and particularly so when the core material is of the ceramic ferro-magnetic material known as ferrite which is advantageously employed because of its very high permeability and low losses but which requires special grinding techniques because of its hardness. But grinding cores to dimensions for adjustment is to be avoided for the additional reason that if the inductance of a coil when assembled is not within the prescribed limits it is necessary to take the coil apart to perform the grinding operation and then to reassemble it, with possible minute variations entering because of the different orientation of the coil members when reassembled, in addition to the delay and expense of repeated reassembling and the increased possibility of faulty assemblies.

It has also been priorly proposed to adjust the inductance of the magnetic circuit by introducing or withdrawing magnetic members from air-gaps in the magnetic circuit. It has been found, however, that this causes harmful concentrations

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of magnetic flux in the portion of the magnetic member inserted into the air-gap causing a decrease in the Q of the coil and that it is difficult to mechanically secure the moving member sufficiently to insure high stability of the magnetic circuit. Thus in order to maintain the desired Q and stability of the coil it has been found desirable to maintain a predetermined air-gap.

In addition to very finely adjusting the inductance of the coil to tune the filter to the desired frequency band and to maintaining its high Q to give the desired selectivity, it is also desirable to completely enclose the core within the magnetic circuit to minimize possible flux leakage which could provide coupling with the other equipment and coils of the channel bank. When inserts into the air-gap are employed to accurately determine the inductance of the coil either they must extend in some way through the magnetic casing around the core or the casing must be taken apart and reassembled each time the position of the insert is varied during the final adjustment of the inductance. Additional perforations of the magnetic casing are, however, undesirable if flux leakage is to be minimized and repeated disassemblies and reassemblies are to be avoided as time consuming and as too prolific a source of inaccuracies in the value of the inductance. Further ferrite does not easily lend itself to accurate perforations or close edges such as would be required for any threaded perforations if the adjustments were to be made by threaded means extending through the casing.

It is an object of this invention to adjust the inductance of such coils facily and accurately.

A further object of this invention is to adjust the inductance of such coils accurately without altering the size of the air-gaps or other elements of the magnetic circuit, varying the position of any inserts in such air-gaps, or in other ways altering the magnetic circuit or affecting the stability thereof.

A further object of this invention is to reduce to a minimum the number of perforations that must be made in the magnetic casing surrounding the coil and further to reduce to a minimum the number of adjusting controls and mechanical parts required.

A further object of this invention is to very finely adjust the inductance of such coils without having to remove the coil from the casing and then reassemble the coil after adjustment.

These and other objects are accomplished in accordance with one specific embodiment of this invention in a coil comprising a pair of cup-shaped members of ferromagnetic material, such

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as ferrite, joined together to form a casing enclosing the winding. The winding is wound on a spool securely mounted on a hollow center post of ferromagnetic material. The center post, which completes the magnetic circuit, is rotatably supported along the axis of the casing. One end of the winding extends through an aperture at the center of the base of one of the cups and the other end extends through an aperture in the side of one of the cups adjacent the juncture of the two cups. Predetermined air-gaps are provided between the center post and the ends of the casing by the spacers rotatably supporting the center post.

When the coil is assembled and the two cup-shaped members firmly fastened together, a spindle is introduced through one end of the casing into the hollow center post. The inductance of the coil may then be accurately adjusted by changing the number of turns of the winding, the outer end of the winding extending through the side of the casing being pulled to rotate the winding form and center post on the spindle thereby unwinding a portion of the coil. The coil may be rewound if necessary by turning the spindle extending into the center post.

After adjustment of the inductance, the center post and winding may be immobilized in any of several ways, such as by cementing the outer end of the winding securely in the casing, by injecting a cement or binder into the casing, or by a mechanical clamping.

In another specific embodiment of this invention adapted to be end mounted, the spindle to rotate the center post forms part of the insulation surrounding the one end of the coil extending axially out of the casing. A second spindle permanently extends into the casing and into the center post, thus serving to position the center post and prevent sidewise movement of it. The other end of the winding is also brought out through the one end of the casing. The inductance is adjusted by pulling the outer end of the winding and by rotating the knob on the combined spindle and insulator surrounding the inner end of the coil to alter the rotational position of the center post.

It is one feature of this invention that the winding be supported in an enclosed casing by a rotatable center post, that one end of the winding be brought out along the axis of the center post, and that other end of the winding be brought out through the casing in such position as to effect rotation of the center post when that other end of the winding is pulled.

It is a further feature of this invention that the center post be hollow and that there be an aperture in the casing end along the axis of the post opposite from the end through which the one end of the winding is brought, the hollow post being formed to receive a mating spindle which is insertable therein.

A complete understanding of this invention and of the various features thereof may be gained from consideration of the following detailed description and the accompanying drawing, in which:

Fig. 1 is a perspective view of an inductance coil illustrative of one embodiment of this invention;

Fig. 2 is a sectional view of the coil of Fig. 1; and

Fig. 3 is a sectional view of an inductance coil illustrative of another embodiment of this invention.

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Referring now to the drawing, the casing comprises two cup-shaped members 11 and 12 of magnetic material; specifically the cup-shaped members may be of a ceramic ferromagnetic material, such as is known as ferrite and may specifically be of a manganese-zinc ferrite. A center post 13, which may also advantageously be of ferrite, is positioned axially in the casing and forms together with the casing the magnetic circuit of the coil. The post is positioned in the casing by the apertured spacers or washers 14 and 15, which may be of paper or other insulating material, between it and the base of the cup-shaped members. These spacers provide bearing surfaces for the post 13 so that it is free to rotate inside the closed cylindrical casing. The winding 16 is wound on a spool 17 which is cemented directly to the center post 13 and therefore is free to rotate with the post. One end 18 of the winding is brought out through an aperture in the base of cup-shaped member 12, the end extending through the spacer 15. Insulator 19 surrounds the end 18 and may be secured to the post 13 as by a cement 20. The other end 21 of the winding is brought out through the side of the casing, as through an aperture 22 in the cup-shaped member 12 adjacent the side of the casing where the two cup-shaped members are joined together. An insulating grommet 23 is positioned in the aperture around the end 21.

Two end plates 25 and 26 fit against the bases of the casing and are clamped together by the screws 27 and nuts 28, thereby clamping the coil in compact assembly.

After the coil has been assembled, a spindle 30, which may be of Lucite, is inserted through an aperture in the cup-shaped member 11, the spacer 14, and into the hollow center post. Adjustment of the inductance of the coil is then accurately made by pulling the end 21 of the winding 16 to rotate the spool 17 and center post 13, to which it is joined, as a reel, the spindle providing an axis of rotation and preventing any transverse motion of the post.

The inner end portion 31 of the spindle 30 is serrated to grasp the inside of the hollow post 13. Thus the end 21 of the coil 16 can be rewound on the spool 17 by turning the handle 32 of the spindle 30 to rotate the post 13 in the opposite direction.

The outer end 21 can be secured after the accurate adjustment has been made as by being cemented to the grommet 23 or in any of the other ways mentioned above. The spindle may also be removed after the fine adjustment has been made.

In one specific embodiment of this invention that was constructed as illustrated in the drawing, the change of inductance with the number of turns unwound was found to be as follows:

Complete Turns Unwound	Number of Turns	Inductance L (Microhenries)	Percentage change in L	
			One Turn	Total (Based on initial value)
0	42	938.4		
1	41	890.6	5.2	5.2
2	40	841.1	5.5	10.4
3	39	798	5.4	15.0
4	38	758	5.0	19.3
5	37	717	5.4	23.6
6	36	677	5.6	27.8

These data were taken at a test frequency of 100 kilocycles and with a current of .001 ampere. While, as the table shows, the inductance was changed approximately 5 per cent per turn, the inductance could readily be adjusted to any smaller percentage or value equivalent to a very small fractional unwound turn. The inductance in fact is easily adjustable to any desired value within the order of a microhenry for the winding described. The precision of adjustment depends partially upon the accuracy with which the rotation of the center post can be set and the number of turns in the winding. Micrometric adjustment of the post position could be obtained by suitable mechanical means if desired. While the inductance is thus capable of being very accurately set over a wide range, the per cent change in the Q of the coil concomitant with the inductance change is very small, being less than 5 per cent for the approximately 30 per cent inductance change shown.

When the coil is assembled there will normally be no need to change the inductance by 30 per cent. Instead the core structure may be assembled from parts of merely nominal dimensions, thereby obviating the necessity of accurately dimensioned parts or the necessity for adjustment of air-gaps by precise grinding and trial and error assembly. When assembled a rough frequency adjustment can be made in the shop, which will generally require only the removal or addition of a few turns at most. The outer end 21 can be clipped to a nominal length and tinned, but left loose in the grommet 23. A final fractional turn adjustment to attain the high degree of accuracy desired can then be made during the assembling of the filter unit, after which the end 21 and spool 17 can be secured in any of the manners discussed herein.

However, the large changes of inductance of the coil that may be made by varying the number of turns, as shown by the above exemplary data, affords another advantage in this novel structure and the inductance adjustments possible thereby. In many filter applications, such as in certain channel filters whether employing crystals or not, the circuit design will advantageously require a number of inductances in the circuit of similar but slightly different inductances. Thus the inductance between successive coils on either side of a capacitance, forming a T-unit of the filter, may vary by from 5 to 10 per cent. However, by employing coils constructed in accordance with this invention the same component part may be used and each coil merely adjusted to the different inductances in the fabrication of the coils in the shop, as explained above. These coils can then be directly incorporated into the filter, or if used to accurately tune the filter, can be finely adjusted in the circuit as explained above. However the whole series of coils employed, each having a slightly different inductance, may all be fabricated from the same piece parts and with the same predetermined optimum air-gaps, with concomitant savings in the cost of the coils and improvements in their electrical characteristics.

Various modifications may be made without departing from the scope of this invention. The spindle 30 may be replaced by a fluted key which will lock the spool 17 when pushed in, but will permit the spool to rotate when pulled partially out. In that instance the key will remain in the post 13, whereas the spindle 30 may be removed after the inductance has been permanently ad-

justed to the desired value. If a fluted key is employed the post 13 and spool 17 must be rotated in discrete distances each time so that the fluted key can fit inside the fluted holes or bushings in the ferrite parts; however the number of sides to the key could be made sufficiently large so that the steps would be small enough to permit accurate adjustment of the inductance.

The spool 17 may also be secured against undesired motion after adjustment of the inductance by providing notched or serrated edges to the spool ends, these detents to engage a knob or boss on the inside of the casing. Alteration of the number of turns of the winding 16 would then adjust the inductance to a sequence of closely spaced values dictated by the closeness of the detent notches on the spool ends.

The rotation of the spool 17 and winding 16 may be further facilitated by mounting the center post 13 on bearings, as of phenol fibre tubing or rod, to serve as a permanent internal shaft extending from holes in the center post through holes in the casing. The inner end 18 of the winding 16 could then be brought out through the tubing or rod at the one end of the casing and a screw-driver slot could be placed in the tubing or rod at either end of the casing to permit rewinding of the coil if necessary.

If it is desired to have a single side mounted coil with mounting studs, terminals, and adjusting means all located on one end of the casing, the outer end of the winding may be guided out through the end of the casing instead of the side and the insulation surrounding the inner end of the winding could be incorporated into a spindle and employed to rotate the center post. One illustrative embodiment of this invention incorporating these features is shown in Fig. 3. Referring now to that figure, the casing comprises the two cup-shaped members 11 and 12 in which is centrally located the center post 13 positioned by the end spacers or washers 14 and 15. The winding 16 is wound on the spool 17 on the center post. The inner end 18 of the winding extends through an axial aperture in the base of the cup-shaped member 12 and is surrounded by an insulating sleeve 35. The sleeve 35 has an inner portion 37 directly secured to the center post 13, as by a cement 38, and has a serrated knob 36 attached to it. The sleeve 35 can thus itself be rotated to alter the rotational position of the center post 13 and thus the inductance of the coil.

The outer end of the winding 16 is brought out through an aperture 40 also in the base of the cup-shaped member 12 but adjacent the periphery thereof. An insulating grommet 41 surrounds the end 19 in the aperture 40.

A phenol fibre rod 42 extends axially through the cup-shaped member 11 into the center post 13 and serves as a permanent internal shaft to position the center post and prevent sidewise motion of the center post.

Adjustment of the inductance of the winding and immobilization of the center post are achieved as described above with reference to the embodiment of Fig. 1. However the adjustment may be made after the coil has been end mounted, by the mounting studs 43 on the bolts or screws 27, as both ends of the winding extend through the one end of the cup-shaped member 12.

It is to be understood that the above-described arrangements are illustrative of the application of the principles of the invention. Numerous other arrangements may be devised by those

skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. An inductance coil comprising an enclosed cylindrical casing of a ferrite material, said casing having apertures at both ends along the axis thereof and an aperture through one side thereof, a single rotatable core of a ferrite material axially in said casing between the ends thereof, a spacer member rotatably positioning said core closely adjacent each of said ends and determining air-gaps between said core and said ends, a spindle secured to said core and rotatable therewith, and a winding on said spindle, said core and said winding substantially completely filling said cylindrical casing, one end of said winding extending through one of said end apertures and the other end of said winding extending through said side aperture whereby the inductance of said winding may be varied by pulling said other end to rotate said core and reduce the number of turns of said winding on said spindle, the portion of said winding removed from said spindle being brought outside of said casing.

2. An inductance coil in accordance with claim 1 wherein said rotatable core has an aperture axially therein cooperating with the other of said end apertures to allow a tool to be inserted into said core to rotate said core in the other of said directions to increase the number of turns of said winding on said spindle if too many of said turns have been removed by pulling said other end.

3. An inductance coil comprising a first cup member of a ferrite material having an aperture centrally in the base thereof, a second cup member of a ferrite material having an aperture centrally in the base thereof, one of said cup members having a second aperture adjacent the lip thereof, means securing said cup members together to form an enclosed casing, a single rotatable center post of a ferrite material axially in said casing, said center post having a central

aperture axially therethrough and communicating with the apertures in the bases of said cup members, a pair of washers rotatably positioning said center post closely adjacent the bases of said cup members and determining the air-gaps between said post and said bases, a spool secured to said post, a winding on said spool, said core and said winding substantially completely filling said casing, one end of said winding extending through one of said washers and the aperture in the base of said first cup member, the other end of said winding extending through said side aperture, an insulating grommet in said side aperture surrounding said other end whereby said post is rotated in one direction to reduce the number of turns on said spool by pulling said other end to bring a portion of said winding through said side aperture outside said casing, and a rod member extending into said central aperture in said post through the second of said washers and the aperture in the base of said second cup member for rotating said post in the other direction to increase the number of turns of said winding on said spool if too many of said turns have been removed from said casing, whereby the inductance of said winding may be very accurately adjusted.

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