

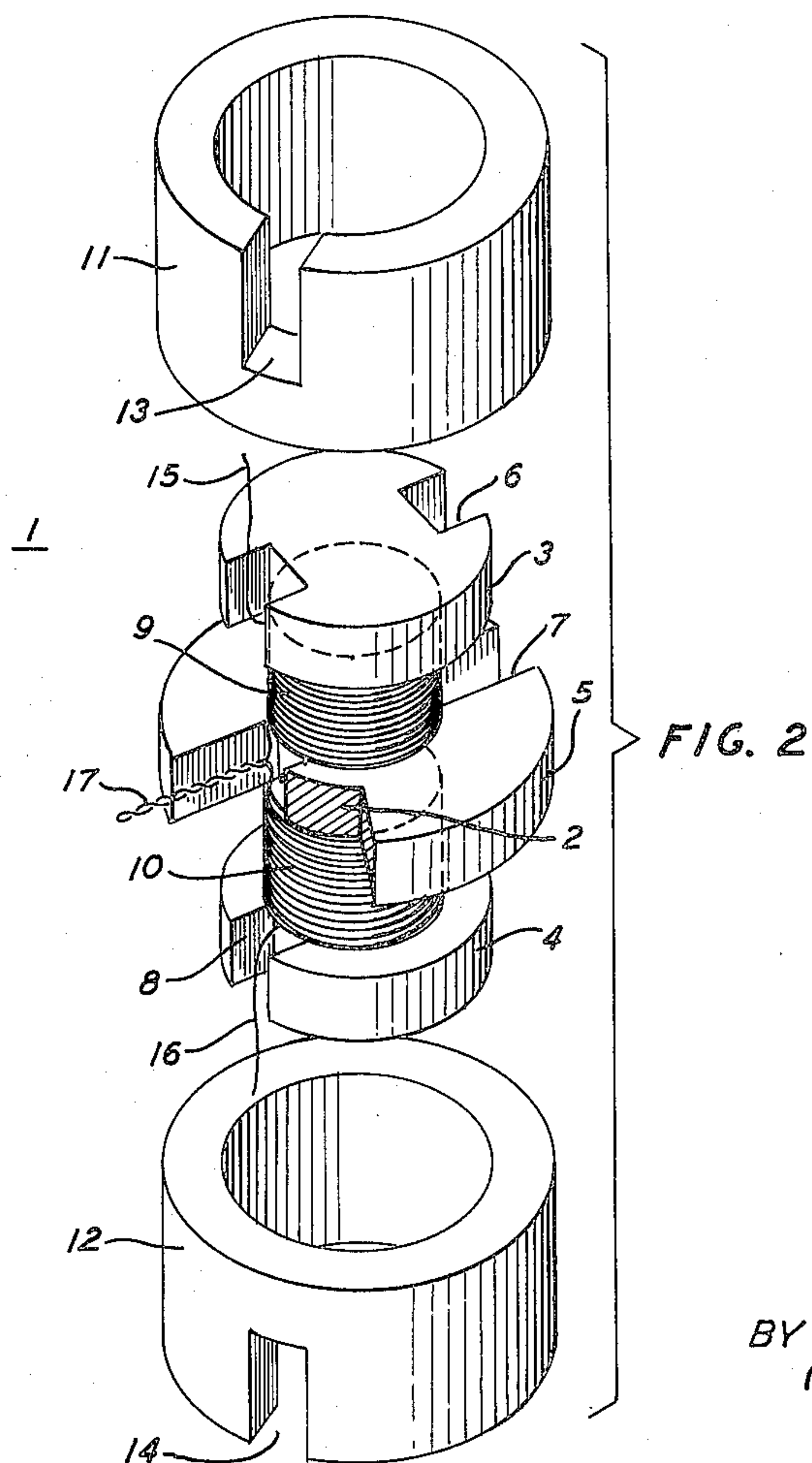
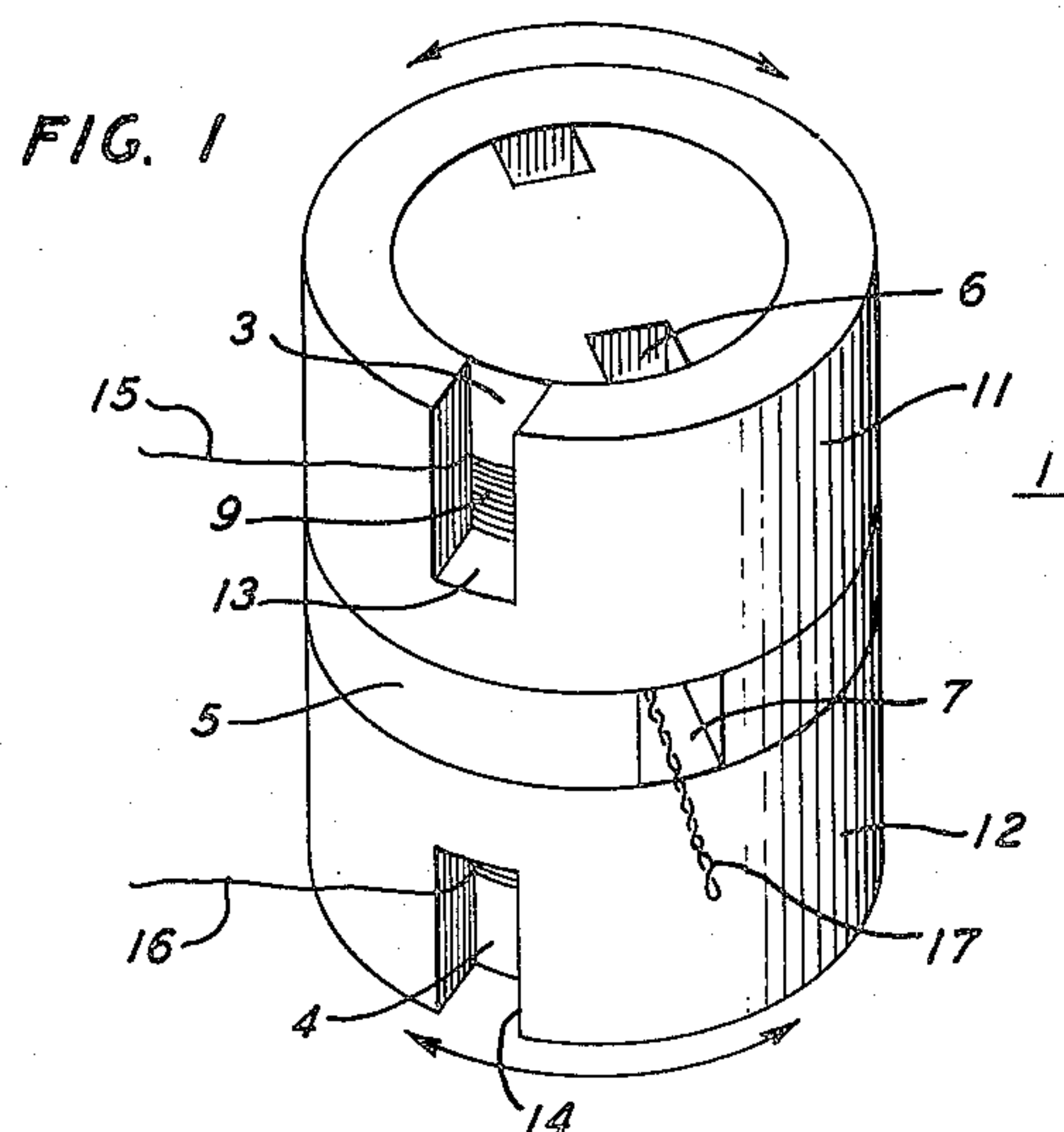
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MINIATURE TAPPED ADJUSTABLE INDUCTOR

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MINIATURE TAPPED ADJUSTABLE INDUCTOR

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This invention relates to inductive devices and to methods for making the same. More particularly, the invention relates to miniature inductive devices and to means and methods for adjusting their electrical characteristics.

The invention is specifically directed to miniature tapped inductive devices having adjustable windings for providing assigned inductance values. These devices may be used in various types of electrical equipment as, for example, in an electromagnetic delay line having a considerable number of these inductive devices arranged in an array with such close spacing as to be virtually touching each other. The design of such a delay line ordinarily involves strict electrical requirements which generally necessitate precise adjustments of the inductance values about the taps of the inductive devices and also accurate adjustments of the coefficient of coupling between the windings of each of the devices. These adjustments are usually difficult to accomplish because the tiny size of these inductive devices and the minute gauge of the fragile wire used in their windings render the making of adjustments a delicate and protracted procedure.

Accordingly, an object of this invention is to provide an improved miniature inductive device having a tap at an intermediate position.

Another object of the invention is to provide an improved method of making a tapped inductive device having adjustable inductance values on opposite sides of the tap.

An additional object of the invention is to provide an improved method for quickly and precisely adjusting the electrical characteristics of an inductive device.

A further object of the invention is to provide improved means for varying the windings of a tapped inductive device.

These and other objects of the invention are attained by employing a double bobbin as the core of an inductive device and by providing the bobbin with a slotted flange at each end and a larger slotted flange at an intermediate point, such as at its center. Two windings are formed on the bobbin with each winding being located between the central flange and a respectively different one of the end flanges. Each winding has a lead extending up through the slot in the middle flange for forming an intermediate tap. In addition, each winding has another lead extending into the slot in its respectively associated end flange. These windings are individually enclosed by cylindrical sleeves. Each sleeve is rotatably mounted on a respectively different one of the end flanges and abuts against a respectively different side of the middle flange. A slot is formed in the outer end of each sleeve for receiving the lead from the slot in its associated end flange. Thus, rotation of any one of the sleeves will carry the respectively received lead with it thereby forcing the lead to be wound upon the

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core when the sleeve is rotated in one direction, and to be unwound from the core when the sleeve is rotated in the opposite direction. In other words, the rotation of any one of the sleeves will change the length of its associated winding thereby producing a corresponding change in the electrical characteristics of the inductive device.

These and other features of the invention are more fully discussed in connection with the following detailed description of the drawing, in which:

FIG. 1 is a perspective view of one exemplary embodiment of an improved inductive device constructed in accordance with this invention, and

FIG. 2 is an exploded perspective view, partly in section, of the same inductive device.

The illustrative embodiment of the invention shown in FIG. 1 is represented as a substantially cylindrical center-tapped inductive device 1 which is approximately 0.180 inch in height and 0.200 inch in diameter. It is to be understood that, if desired, the tap may be located at a different intermediate point other than the precise center. The inductive device 1 is provided with a double bobbin core 2 made of suitable magnetic material and formed with two end flanges 3 and 4 and a larger intermediate or central flange 5. Each of the flanges 3, 4, and 5, which are integral with the core 2 has means defining slots therein, as is represented by the reference numerals 6, 7, and 8, for receiving or accommodating winding leads. The inductive device 1 further comprises two windings or coils 9 and 10 with the upper winding 9 being wound on that portion of the double bobbin core 2 that extends between the intermediate or central flange 5 and the upper end flange 3, while the lower winding 10 is formed on the bobbin part of the core 2 which lies between the middle flange 5 and the lower end flange 4.

The windings 9 and 10 are individually enclosed by means of cylindrical sleeves 11 and 12 which are each rotatably mounted on a respectively different one of the end flanges 3 and 4 while abutting against respectively different sides of the intermediate or middle flange 5. As is indicated in FIG. 1, the sleeves 11 and 12 have means defining slots 13 and 14 in their outer ends through which protrude leads 15 and 16 which are brought up from the windings 9 and 10, respectively, through the slots 6 and 8 as is more fully explained hereinafter. Each of the windings 9 and 10 has another lead which extends out through one of the slots 7 in the middle flange 5. These last-mentioned leads are joined together for the purpose of forming an intermediate or center tap 17. Thus, the inductive device 1 can be connected to any suitable electrical circuit or equipment by means of the middle tap 17 and the leads 15 and 16.

The electrical characteristics, particularly the inductance values, of the inductive device 1 can be adjusted or varied by manually rotating one or both of the sleeves 11 and 12 in either a clockwise or counterclockwise direction. When one of the sleeves 11 or 12 is rotated in one direction, it will carry with it the associated lead 15 or 16 which will be wound upon the core 2 thereby increasing the length of the respectively associated winding 9 or 10. Conversely, rotation of the sleeve 11 or 12 in the opposite direction will carry with it the associated lead 15 or 16 which will now become unwound

from the core 2 thereby decreasing the length of the associated winding 9 or 10. These changes in the length of the wire in either or both of the windings 9 and 10 produce corresponding changes in the overall electrical characteristics, or inductance values, of the inductive device 1. Due to this novel construction, extremely precise adjustments of the inductance 1 can be quickly accomplished through proper rotation of the sleeves 11 and 12.

In the manufacture of the inductive device 1, the flanged double bobbin core 2 and the sleeves 11 and 12 are fabricated from a suitable powdered magnetic material, such as carbonyl TH. The material for the core 2 and the sleeves 11 and 12 may be supplied in the form of molded slugs having the appropriate diameters and lengths. If desired, the material may be supplied in the form of molded rod stock having the required outside diameter, such as 0.200 inch. In this latter case, a section having the appropriate length or height for the core 2, such as 0.180 inch, would be cut off from the rod stock and then formed, such as by a suitable grinding process, into the desired double bobbin shape. The sleeves 11 and 12 could also be cut from the same rod stock and have their central bores formed by drilling.

The central flange 5 and the sleeves 11 and 12 retain the diameter of the rod stock, but the end flanges 3 and 4 are reduced by grinding so that their outside diameter is about 0.002 inch less than the inside diameter of the sleeves 11 and 12. This enables the sleeves 11 and 12 to fit snugly over the end flanges 3 and 4 with minimal air gaps. Each sleeve has a length equal to the distance from the outside face of its respectively associated end flange 3 or 4 to the nearest side of the middle flange 5 as is represented in FIG. 1. Thus, when the sleeves 11 and 12 are mounted on the end flanges 3 and 4, the inductive device 1 will be substantially cylindrical in shape.

Before the sleeves 11 and 12 are placed on the end flanges 3 and 4, a number of slots are cut in the various parts by any suitable method, such as by grinding. These slots, which may conveniently all be of the same width, include a pair of slots 7 in the central flange 5, a pair of slots 6 in the upper end flange 3, a pair of slots 8 in the lower end flange 4, a slot 13 in the upper sleeve 11, and a slot 14 in the lower sleeve 12. The slots comprising each of the pairs 6, 7, and 8 are formed 180 degrees apart, as is illustrated in FIG. 2, and extend downward through their respective flanges 3, 4, and 5 until they approach the surface of the core 2. As can also be seen in FIG. 2, each of the sleeves 11 and 12 has only one slot 13 and 14, respectively. The depth of each of the slots 13 and 14 is about 0.013 inch greater than the width of the respectively associated flanges 13 and 14 in order to provide space for accommodating the end leads 15 and 16 as is shown in FIG. 1.

After the double bobbin core 2 has been fabricated, the two windings or coils 9 and 10 are formed on the double bobbin core 2 with each of the windings 9 and 10 being located between the central flange 5 and a respectively different one of the end flanges 3 and 4. These windings 9 and 10 may preferably be made from a single length of wire, such as 40 gauge wire, which is bent in the middle and doubled back upon itself by twisting for a length of about an inch, as is represented in the drawing, for the purpose of forming the center tap 17. The insulation on this looped section of wire is removed and the section is solder-tinned so as to make one solid lead or tap 17.

The center tap 17 is placed in one of the slots 7 in the central flange 5. This slot 7 accommodates the tap 17 with the end of the tap 17 protruding outwardly therefrom, as is best seen in FIG. 2. The opposite lengths of wire are then wound around the core 2 in a series-aiding manner. The winding operation proceeds from the central flange 5 outwardly around the core 2 toward the respective end flanges 3 and 4 until the desired lengths of the windings 9 and 10 have been formed. Thus, the

flange 5 constitutes spacing means at an intermediate point on the core 2 for separating the windings 9 and 10 into two coils, and also provides means for accommodating or receiving the center tap 17. The windings 9 and 10 are held in place on the core 2 by wrapping small pieces of a suitable tape around them. The ends of the wire are then brought out through the nearest ones of the respectively associated end slots 6 and 8 to form the end leads 15 and 16.

These end leads 15 and 16 are fed through the bores in the sleeves 11 and 12 which are then mounted upon their respectively associated end flanges 3 and 4. The sleeves 11 and 12 are pushed inward so as to abut against the sides of the central flange 5 thereby minimizing the air gaps between the sleeves 11 and 12 and the central flange 5. The sleeves 11 and 12 are temporarily held in these positions by means of small pieces of suitable tape. It should be noted that each of the sleeves 11 and 12 is so oriented that its respective slot 13 or 14 faces outward as is shown in the drawing.

The inductive device 1 is now connected to a suitable inductance measuring device, such as an inductance bridge, and its total inductance value is measured. The inductance value of the winding 9 in the upper section of the device 1 and the inductance value of the winding 10 in the lower section of the device 1 are separately measured. From these measurements, the coefficient of coupling can be readily calculated in a manner known to those skilled in the art.

If these measurements indicate that the inductance value of either the upper or lower section of the device 1 is too low or too high, the necessary corrective adjustments can be quickly and precisely accomplished by the following method. For example, let it be assumed that the inductance value for the upper section 9 is too low. The first step in the method of adjustment is to loosen the tape holding the upper sleeve 11 and then to rotate the sleeve 11 on the associated end flange 3 so as to align the sleeve slot 13 with that one of the diametrically opposed flange slots 6 which holds the upper end lead 15. The next step is to pull the end lead 15 upwardly out of the flange slot 6 and into the sleeve slot 13 so as to protrude therefrom. The sleeve 11 is then rotated in a positive direction with respect to the direction of the turns comprising the winding 9. During this rotation, the sleeve 11 carries with it the lead 15 thereby forcing a portion of the lead 15 to be wound on the core 2. This increases the total length of the winding 9 and consequently increases its inductance value.

The sleeve 11 is secured in this new position by means of the tape, and the inductance of the upper section 9 of the device 1 is again measured. If the inductance value is now too high, the sleeve 11 is rotated in a negative direction with respect to the direction of the turns of the winding 9. This movement causes the sleeve 11 to carry with it the lead 15 which is thus unwound from the core 2. Accordingly, the total length of the winding 9 is correspondingly reduced thereby producing a reduction in its inductance value.

This process is duplicated by rotating the sleeve 12 around the winding section 10 for adjusting its inductance value. Thus, by using this method, the lengths of the windings 9 and 10 can be adjusted to provide the desired inductance values. When this condition has been obtained, the sleeves 11 and 12 are again secured in place with small pieces of tape. If desired, the sleeves 11 and 12 can be permanently held in place by means of a suitable cement, which may be inserted into their slots 13 and 14, so that the finished product will be a fixed inductor.

In view of the above discussion, it can be understood that, through this method of adjustment, precise determination and adjustment of the inductance values about the center tap 17 may be obtained. In other words, close control of the inductance values of the two winding sections 9 and 10 may be obtained, both in relation-

ship to each other and to the total series-aiding inductance of the device 1.

It should be noted that the design of the inductive device 1 further facilitates other adjustments or changes in the coefficient of coupling. Specifically, the slots 7 in the central flange 5 readily permit cross-over of the winding turns from one section 9 to the other section 10 and vice versa. This enables different types of winding construction to be made which thereby provide various choices of coupling coefficients between the windings 9 and 10.

Finally, it should be further noted that the magnetic shielding of the device 1, such as that provided by the abutment of the sleeves 11 and 12 against the central flange 5, restricts the magnetic fields of the sections 9 and 10 to completely internal magnetic paths. This reduces the external field of the inductive device 1 to a minimum with the result that several of the devices 1 may be placed in an array with such close spacing as to be virtually touching each other, such as in an assembly for an electromagnetic delay line, without producing any objectionable magnetic field interaction between them.

What is claimed is:

1. A shielded inductive device comprising a core of magnetic material,
 - a length of wire wound around said core for forming at least one inductive winding thereon,
 - an end of said wire being disposed at one end of said core for forming at least one end lead to said winding,
 - shielding means for shielding said winding,
 - said shielding means including at least one sleeve of magnetic material enclosing said winding,
 - and adjusting means for adjusting the length of said winding,
 - said adjusting means including means formed of magnetic material at said end of said core for supporting said sleeve for rotation around said shielded winding,
 - and means for alternatively winding and unwinding said end lead with respect to said core,
 - said last-mentioned means including means in said sleeve for receiving said end lead and for carrying it during said rotation of said sleeve.
2. A shielded inductive device comprising a core of magnetic material,
 - wire wound on said core for forming inductive windings thereon,
 - at least two ends of said wire being disposed at opposite ends of said core for forming end leads,
 - spacing means of magnetic material formed at an intermediate point on said core for separating said windings into two coils,
 - shielding means for shielding said coils,
 - said shielding means including at least two sleeves of magnetic material each enclosing a respectively different one of said coils,
 - and adjusting means for adjusting the lengths of said coils,
 - said adjusting means including means for supporting said sleeves for rotation around said enclosed coils,
 - and means for alternatively winding and unwinding said end leads with respect to said core,
 - said last-mentioned means including means in each of said sleeves for receiving a respectively different one of said end leads therein and for carrying it during rotation of said sleeve.
3. A shielded inductive device comprising a core of magnetic material,
 - a single length of wire wound on said core for forming inductive windings thereon,
 - the ends of said wire being disposed at opposite ends of said core for forming end leads to said windings,

means for forming an intermediate tap to said windings,

accommodating means at an intermediate point on said core for accommodating said intermediate tap, and instrumentalities for varying the length of the windings on each side of said tap,

said instrumentalities including two sleeves of magnetic material each adapted for covering said windings on respectively different sides of said tap and for abutting against opposite sides of said accommodating means,

and means at each end of said core for rotatably supporting a respectively different one of said sleeves, each of said sleeves having means defining an opening therein for accommodating the outward protrusion therefrom of the respectively associated end lead, and each of said last-mentioned means being adapted for forcing the respectively associated end lead to be wound upon said core in response to the rotation of the respectively associated sleeve in one direction and for forcing said lead to be unwound from said core when said sleeve is rotated in the opposite direction.

4. A shielded inductive device comprising a core of magnetic material,
 - a single length of wire wound around said core for forming inductive windings thereon,
 - the ends of said wire being disposed at opposite ends of said core for forming end leads to said windings,
 - said wire being looped at an intermediate point along its length for forming an intermediate tap to said windings,
 - a member formed of magnetic material on said core for accommodating the protrusion of said intermediate tap therefrom,
 - shielding means for shielding said windings,
 - said shielding means including two sleeves of magnetic material surrounding the windings on said core with each sleeve being disposed between a respectively different end of said core and a respectively different side of said member,
 - and adjusting means for separately adjusting the length of each of said windings on opposite sides of said intermediate tap,
 - said adjusting means including means formed of magnetic material at each end of said core for supporting said sleeves for individual rotation around said windings,
 - each of said sleeves having means for receiving a respectively different one of said end leads and for carrying said respectively associated end lead with it during rotation of said sleeve whereby said respectively associated end lead is alternatively wound and unwound with respect to said core.
5. An adjustable shielded inductive device comprising a double bobbin of magnetic material having a flange at each end and also at its center,
 - said center flange having a larger diameter than any one of said end flanges,
 - each of said three flanges having means defining a slot therein,
 - two windings on said bobbin each located between said center flange and a respectively different one of said end flanges,
 - each of said windings having a lead extending into the slot in the respectively associated end flange and another lead extending into the slot in said center flange and protruding therefrom for forming a center tap,
 - and adjusting means for varying the inductance value of any one of said windings,
 - said adjusting means including two cylindrical sleeves of magnetic material each surrounding a respectively

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different one of said windings and each being rotatably mounted on a respectively different one of said end flanges while abutting against a respectively different side of said center flange,
and each of said sleeves having means defining a slot 5 in its outer end for receiving therein the lead in the slot in the respectively associated end flange whereby rotation of any one of said sleeves effects a change in the length of the respectively associated winding with a corresponding change in its induc- 10 tance.

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