

Nov. 26, 1940.

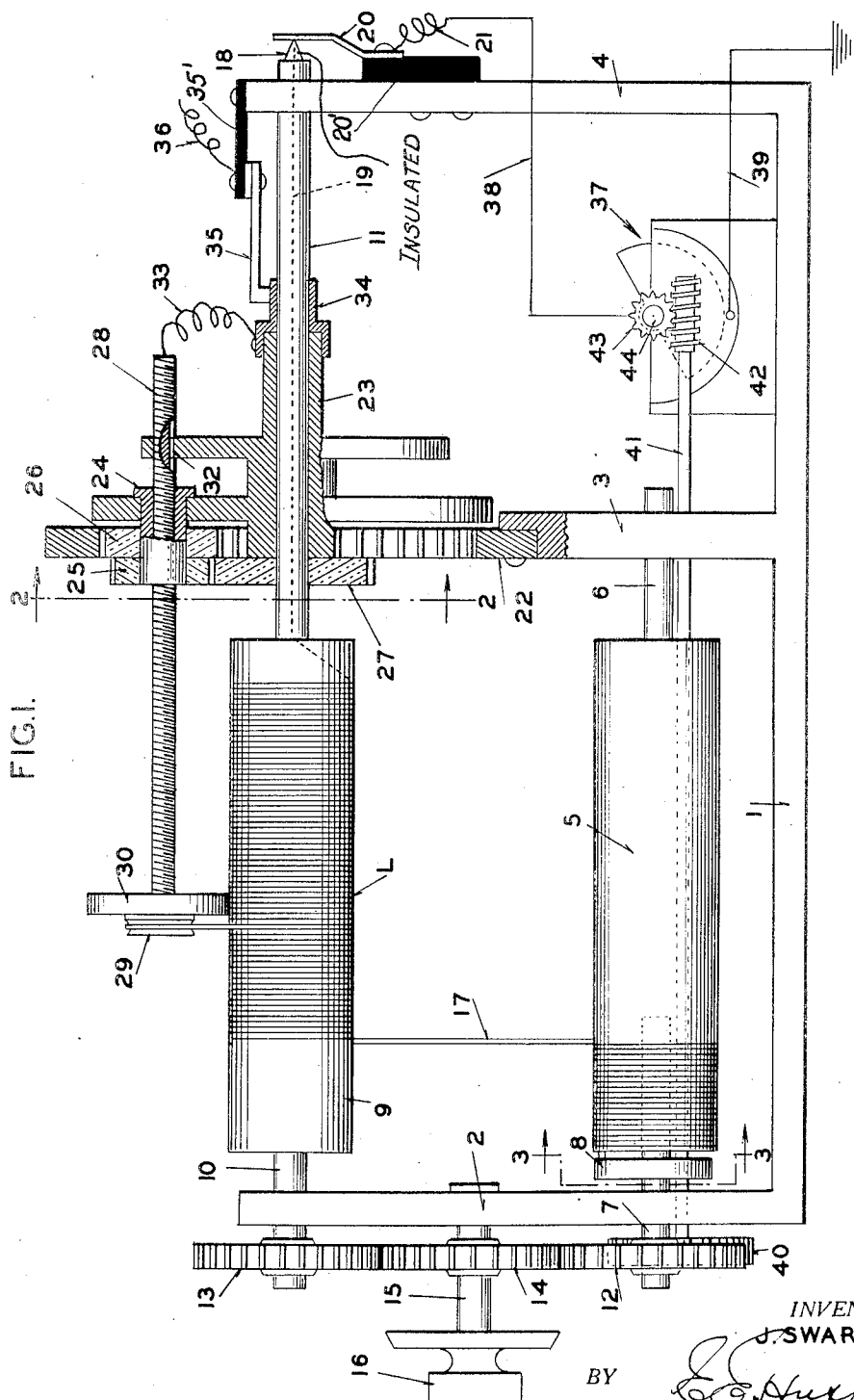
J. SWARBRICK

2,223,080

VARIABLE COIL

Filed Oct. 22, 1938

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

FIG. 2.

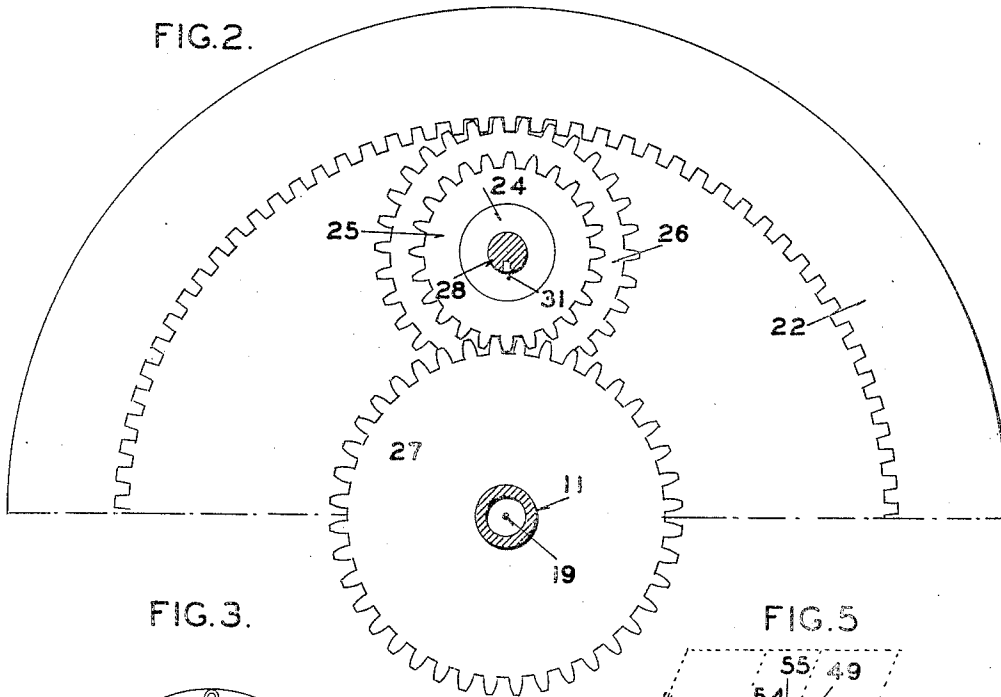


FIG. 3.

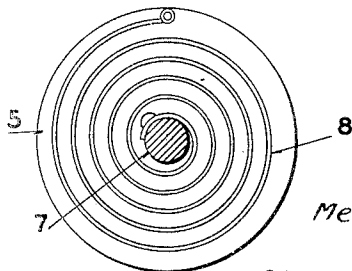
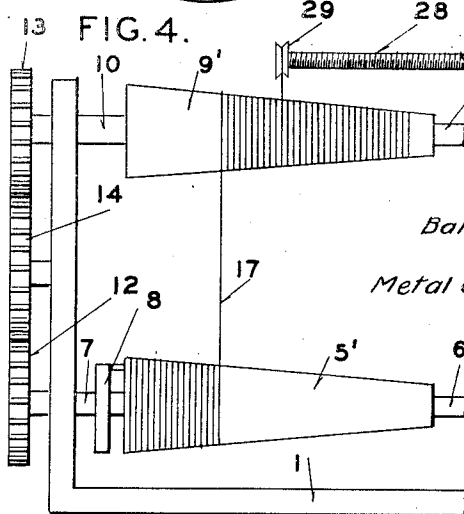
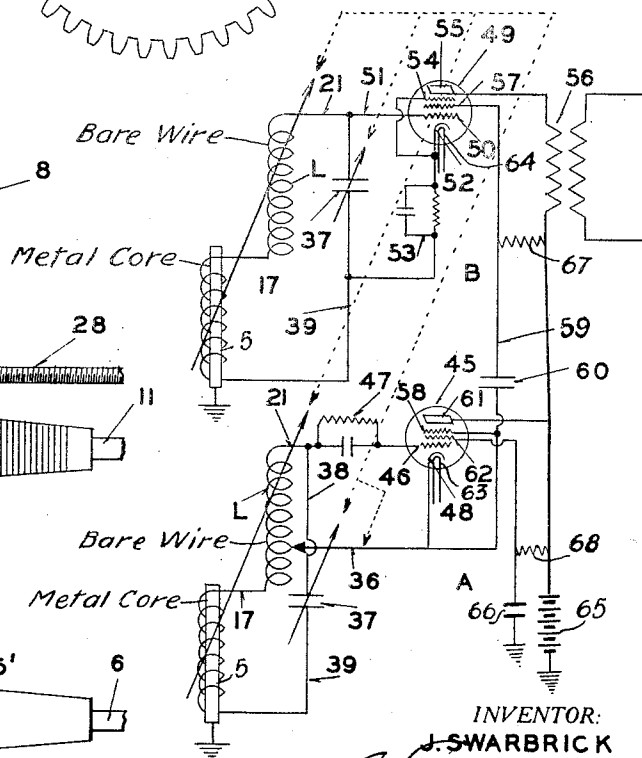


FIG. 5.



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VARIABLE COIL

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Application October 22, 1938, Serial No. 236,380

12 Claims. (Cl. 250—36)

My invention relates to electrical apparatus and more particularly to means for varying electrical inductance or resistance in an electrical circuit or circuits.

5 One of the objects of my invention is to provide a variable coil with an automatically-controlled intermediate tap which will always have a predetermined relationship with the coil.

10 Another object of my invention is to so control a variable coil and an intermediate tap therefor that the tapped turns of the coils will always have a fixed ratio with the total active turns of the coil.

15 Still another object of my invention is to provide improved means for electrically tapping a variable coil, the number of turns of which are varied by transferring the turns of a bare conductor from an insulated core to an adjacent conducting core.

20 A further object of my invention is to provide means in the type of variable coil above referred to which will prevent slack from developing in the portion of the conductor between the cores as the turns thereof are transferred from one 25 core to the other.

30 Still a further object of my invention is to provide means in a radio tuning circuit whereby the inductance and the capacity can both be so varied simultaneously that the proper ratio therebetween can be maintained for both the lower and higher frequencies, thus eliminating the use of fixed inductance coils and associated switches.

35 Another object of my invention is to provide means in a superheterodyne hookup for maintaining a predetermined ratio between the inductance of the electron coupled oscillator circuit and the inductance of the radio frequency circuit associated therewith whereby the proper intermediate frequency will at all times be secured.

40 Other objects will become apparent from the following description taken in connection with the accompanying drawings in which Figure 1 is a side view of my improved variable coil with an automatically operable intermediate tap embodying my invention; Figure 2 is a cross-sectional view taken on the line 2—2 of Figure 1, showing the gearing for controlling the intermediate tap; Figure 3 is a cross-sectional view taken on the 45 line 3—3 of Figure 1, showing the spiral spring for preventing slack in the conductor between the two rotatable cores; Figure 4 is a view showing the use of frusto-conical cores for the coils; and Figure 5 is a diagrammatic view of a portion of a tuning circuit showing my invention embodied 50 therein.

Referring to the drawings in detail, numeral 1 indicates a base having spaced apart upstanding supporting members 2, 3 and 4. A metallic core member 5 in the form of a cylinder is 5 mounted for rotation in the supporting members 2 and 3 by means of shafts 6 and 7, the former being secured to the core member and the latter being journaled in the core member but connected thereto by means of a spiral leaf spring 8, one end of which is secured to shaft 7 and the 10 other to the core member as shown in Figure 3. Above core member 5 is a second core member 9 made of non-conducting material such as rubber or Bakelite. One end of this core member carries a shaft 10 which is journaled in the 15 support 2 and the other end of the core member carries a hollow shaft 11 which is journaled in the support 4. In order that the core members 5 and 9 may be rotated simultaneously in the same direction, shaft 7 has secured thereto 20 a gear 12 and shaft 10 a similar gear 13, both gears meshing with a central gear 14 carried by a shaft 15 journaled in the support 2. The shaft 15 and gear 14 may be rotated by any suitable member on shaft 15 as, for example, the 25 knob 16.

A bare conducting wire 17 is wound upon the core member 9 and also on core member 5 in such a manner that when the two cores are 30 rotated in the same direction, the wire will be unwound from one core and wound on the other core and without overlapping any of the turns of the winding. One end of the wire is secured to core 9 and the other end of the wire is secured to core 5. It is thus seen that there is provided a variable inductance coil L upon core 9 which may be varied at will by the mere turning of knob 16. Thus if it is desired to add 35 turns to the inductance coil on core 9, it will be necessary to rotate the cores in a direction which will permit the conductor 17 to be unwound from core 5 and wound on core 9. The arrangement is such that all of the turns may be placed upon either of the core members. Thus the inductance coil on core 9 may be varied from 40 zero to the total number of turns that can be placed on the core. Since core 5 is made of a conducting material and conductor 17 is bare, the portion of the conductor which is wound on core 5 will be at a negative potential and thus ineffective. The end of conductor 17 which is secured 45 to core member 9 is electrically connected to a contact member 18 on the end of the shaft by means of a conductor 19 and extends through the hollow shaft 11. The contact member 18 is en- 55

gaged by a resilient contact member 20 on an insulating block 20' carried by support 4 and a conductor 21 is electrically connected to the contact member 20.

5 In many instances it is desirable to provide the inductance coil on core member 9 with an intermediate tap for connecting a portion of the inductance coil in a secondary circuit. It is also desirable that the number of turns of the
10 inductance coil which are in the secondary circuit should bear a definite relationship to the total number of turns in the variable inductance coil. In order that this may be accomplished, I have provided an intermediate tap which is
15 automatically operable by the rotation of core member 9.

In accordance with this feature of my invention, the structure shown to accomplish this result comprises an internally toothed ring gear 22
20 secured to the support 3 and so positioned that the gear surrounds shaft 11 and has its center coinciding with the axis of the shaft. On shaft 11 is journaled a member 23 made of non-conducting material and rotatably mounted on this
25 member is a nut 24. This nut has secured thereto a pair of gears 25 and 26, the latter meshing with the annular gear 22 and the former meshing with a gear 27 secured to shaft 11. The axis of the nut is parallel to the axis of core member 9 and co-operates with a left-hand threaded
30 screw 28. The screw has rotatably mounted on its outer end a sheave 29 over which a turn of the bare conducting member 17 is looped. The screw member also has loosely mounted thereon
35 adjacent sheave 29, a wheel 30 engaging the surface of the core member 9 in order to support the end of the screw and maintain the portion of conductor 17 which is looped over the sheave in taut condition. The screw 28 is formed with
40 a keyway 31 which extends throughout the length of the screw and cooperating with this keyway to prevent rotation of the screw is a key 32 carried by the member 23. The rear end of the screw is electrically connected by a conductor 33 to a
45 slip ring 34 secured to member 23. A resilient brush 35 is carried by the support 4 on a member 35' of insulating material and cooperates with slip ring 34 in order to provide a connection between said slip ring and the conductor 36.

50 In the foregoing construction when core member 9 is rotated, gear 27 will rotate gears 25 and 26 and also nut 24. Since gear 26 meshes with the annular gear 22, screw 28, nut 24, and member 23 will all be caused to rotate around the axis of shaft 11 and core member 9. The rotation of nut 24 as member 23 moves about the axis of the core member 9 causes the screw 28 to have an axial movement only since rotative motion on its own axis is prevented by the key 32.
60 In the embodiment shown, the gears are so related to each other and the threads on the screw and nut have such a pitch that for each three rotations of core member 9, screw 28 will revolve once around the core member and will also have an axial movement which will be sufficient
65 to move the sheave to a position where it taps two more or two less turns of the coil depending, of course, upon the direction in which core member 9 is rotated. It is thus seen that
70 if core member 9 has one hundred and twenty turns of wire thereon and sheave 29 is so positioned that forty turns or one-third of the total turns are included in the secondary circuit, this ratio will always be maintained. If thirty turns
75 are removed from core 9, the sheave will assume

a position where ten less turns are tapped by the sheave and included in the secondary circuit. The ratio of tapped turns, that is, the turns in the secondary circuit or those from the sheave to end being unwound to the total number of
5 turns on the core member, of course, may be fixed as desired as the two-thirds ratio in the construction shown is only an example. If the ratio was desired to be one-fourth, all that
10 would be necessary would be to so change the ratio of the gears and the pitch of the threads between the nut and screw that three turns would be removed from the tapped portion of the coil each time four turns were removed from
15 core member 9.

For simplicity, core members 5 and 9 have been shown as plain cylindrical surfaces but if desired these surfaces may be provided with spiral grooves to receive the conducting member 17. It is also seen that since core member 5 is
20 rotatably biased by the helical leaf spring 3, the portion of the conductor between the two core members will always remain taut. The gears of the planetary gearing are shown as made of non-conducting material but these gears may be
25 made of a metal if so desired but when such is done, it will be necessary to properly insulate gears 25 and 26 from the metal screw 24.

In some situations it may be desirable to vary the diameter of the inductance coil which is
30 wound on the non-conducting core. In Figure 4 I have illustrated how this may be accomplished. The conducting core 9' which is made of non-conducting material is frusto-conical in shape instead of cylindrical. Similarly, core 5'
35 which is made of conducting material is also frusto-conical in shape instead of cylindrical. The cores are so positioned that the wire 17, when unwound from a portion of the core having a certain circumference will be wound onto
40 a portion of the other core having the same circumference, thus preventing any slack from developing in the wire. The cores 5' and 9' are mounted and rotated in the same manner as
45 cores 5 and 9 previously described. The sheave 29, rotatably carried on the end of screw 28, is adapted to have looped thereover one turn of the wire on core 9'. The screw is supported solely by the planetary gearing since the construction does not permit the use of the supporting
50 wheel 30. By having core 9' of a frusto-conical shape the diameter of the coil decreases as the length of the coil decreases.

When my variable coil is employed in receiving systems for radio waves as a variable inductance coil, a variable condenser will be shunted
55 across the coil. In such a circuit it is desirable that there be a predetermined relation between the inductance of the coil and the capacity of the condenser. Referring again to Figure 1, I have shown how this may be accomplished. One part of a variable condenser 37 is connected by a conductor 38 to the conductor 21 which as
60 previously described is electrically connected to one end of the inductance coil on the core member 9 and the other part of the variable condenser is connected to ground by a conductor 39, thus shunting the condenser across the coil. In order that the capacity of the condenser may be varied simultaneously with the inductance
65 of the coil on the core 9, the condenser is driven from the gearing which rotates the two cores. In the embodiment shown, a gear 40 meshes with gear 12 and drives a shaft 41 which has a worm 42 on its end for driving a worm gear 43 secured
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to the shaft 44 of the movable element of the condenser. The ratio of the worm and worm gear and the size of the gear 40 is such that the capacity of the condenser will be so changed as the cores 5 and 9 are rotated that there will be maintained a predetermined relation between the capacity of the condenser and the inductance of the coil.

My improved variable coil with the means for maintaining a predetermined relation between the inductance of the coil and the capacity of the variable condenser has been found to be very useful in radio tuning systems, especially one employing a superheterodyne receiving circuit. By its use it is possible to maintain the proper ratio between the inductance and capacity of the different circuits, as for example, the electron coupled oscillator circuit and the radio frequency circuit associated therewith and by the use of the intermediate tap for the cathode of the electron tube of the electron coupled oscillator circuit it is also possible to maintain the proper relation between the inductance in the cathode circuit and the inductance in the control grid circuit.

In Figure 5 I have diagrammatically shown how the structure shown in Figure 1 may be embodied in a superheterodyne receiving circuit. The electron coupled oscillator circuit is shown at "A" and the radio frequency circuit embodying the detector or mixer tube is shown at "B." The electron coupled oscillator circuit has its control grid 46 connected to the conductor 21 of the variable inductance coil "L" shown in Figure 1, there being provided the usual grid leak and condenser 47 in this circuit. The cathode 48 of the tube is connected to the conductor 36 which leads to the sheave 29 of the tap shown in Figure 1. A filament 63 is associated with the cathode and is connected to a suitable source of power (not shown) such as a 6 volt battery. The variable condenser 37 is shown as shunted across the inductance coil in a manner already described.

The electron tube 49 in the radio frequency circuit "B" has its control grid 50 connected by a conductor 51 to the conductor 21 of the variable coil "L" which is the same as that shown in Figure 1, except that the intermediate tap is eliminated. The variable condenser 37 is shunted across the inductance coil. The cathode 52 of the tube having associated therewith the filament 64 is connected to the conductor 39 of the condenser through a cathode bias 53. The cathode is also connected to the suppressor grid 54 in a well-known manner. The plate 55 is also connected to the intermediate frequency transformer 56 which in turn is connected to the intermediate amplifier circuit. The source of power for the plate is a grounded battery 65 connected as shown. The screen grid 57 of the tube 49 is connected to the suppressor grid 58 of tube 45 by a conductor 59 through a condenser 60, the grid 58 also being connected to the cathode 48 of tube 45. The plate 61 and the screen grid 62 of the electron tube 45 are connected respectively to the power supply 65 and to ground through a condenser 66 in a well-known manner. Voltage dropping resistors 67 and 68 are also shown for the screen grids of the tubes. In the circuit "A" with the connections shown all the current flowing between the plate and the cathode inside the tube 45 must flow through the cathode section of coil "L." Thus a portion of this current is induced into the grid section of the

coil to produce a feed back thereby creating oscillations.

The variable inductance coil "L", the variable condenser and intermediate tap of the cathode in the electron coupled oscillator circuit "A" are all operated simultaneously in a manner disclosed in Figure 1. The variable inductance coil "L" and the variable condenser 37 in the circuit "B" are simultaneously operated in the same manner as shown in Figure 1. Gear 14 will be employed to drive the rotatable members of both inductance coils "L," these coils being positioned adjacent each other. In order to indicate that the variable inductance, variable condenser, and the intermediate tap of circuit "A" and the variable inductance and variable condenser of the circuit "B" are all operated simultaneously, these members have been connected together by the dashed lines in Figure 5.

In the receiving circuit shown in Figure 5 it is readily seen that the inductance of the variable inductance coil and the capacity of the variable condenser in the circuit "A" will always have a predetermined relation. Also the inductance in the cathode circuit will have a predetermined ratio with respect to the inductance of the control grid circuit. It is also apparent that the variable inductance and variable capacity in the circuit "B" will have definite relationship to each other. By so coordinating the inductances and the capacities of the two circuits and simultaneously controlling them from a single member as the gear 14, it is possible to secure the desired intermediate frequency from the tube 49 and to maintain this at all times. Such a receiving circuit as shown in Figure 5 eliminates the use of padder condensers to secure the desired intermediate frequency and also eliminates the use of several coils and band switches and inefficient short-circuiting devices. It provides a receiver system which has continuous tuning over a much wider range than as heretofore attained.

Being aware of the many uses of the structure described and the possibility of modifications therein without departing from the fundamental principles of my invention, I do not intend that its scope be limited except as set forth in the appended claims.

Having fully described my invention, what I claim as new and desire to secure by Letters Patent of the United States is:

1. In electrical apparatus of the class described, a primary circuit, a secondary circuit, an inductance coil or bare wire connected in the primary circuit, means for varying the active turns thereof, an intermediate tap for said coil for placing a portion of the active turns in the secondary circuit and comprising a rotatable member having a turn of said coil looped thereover, and automatically operable means controlled by the varying means for so moving the member both circumferentially of the coil and longitudinally of the axis of the coil as the active turns of the coil are varied that a predetermined relationship will be present between the tapped turns and the total active turns of the coil.

2. In electrical apparatus of the class described, a primary circuit, a secondary circuit, a coil connected in the primary circuit and comprising a rotatable member having a plurality of turns of the bare wire thereon wound in one direction, means for varying the number of active turns of said coil, means for making an electrical tap at an intermediate point of the active turns of said coil for placing a portion of the active turns in

the secondary circuit, and means automatically operable by the rotation of the rotatable member for so moving the connection of said tap with respect to the active turns of the coil that there will be a predetermined fixed ratio between the number of tapped turns and the total active turns.

3. In electrical apparatus of the class described, a primary circuit, a secondary circuit, a coil connected in the primary circuit and comprising a rotatable member having a plurality of turns of bare wire thereon wound in one direction, means for varying the number of active turns of said coil, means for making an electrical tap at an intermediate point of the active turns of said coil for placing a portion of the active turns in the secondary circuit, and means controlled by the rotation of the rotatable member for so moving the connection of said tap with respect to the active turns of said coil that there will be a predetermined fixed ratio between the number of tapped turns and the total active turns.

4. In electrical apparatus of the class described, a primary circuit, a secondary circuit, two simultaneously rotatable members, one of which is made of a conducting material and the other of a non-conducting material, a plurality of turns of bare wire connected in the primary circuit, said wire being wound in a single direction on each of the members and so associated with said members that the wire may be wound onto one of the members and unwound from the other member, means for making an electrical tap at an intermediate point of the turns on the insulated rotatable member for placing a portion of the active turns in the secondary circuit, and means operable by the rotation of one of the members for so moving the connection of said intermediate tap with respect to the turns on said insulated rotatable member that there will be a predetermined ratio between the tapped turns and the total turns on the insulated rotatable member.

5. In electrical apparatus of the class described, a coil comprising a rotatable member having a plurality of turns of bare wire thereon, means for varying the number of active turns of said coil, means for making an electrical tap at an intermediate point of the active turns of said coil, said means comprising a sheave mounted for rotation on a rod extending parallel to the coil and having a turn of said coil looped thereover, and means for so controlling said rod that the sheave will be rotated about the axis of the coil and simultaneously moved longitudinally.

6. In electrical apparatus of the class described, a primary circuit, a secondary circuit, an inductance coil of bare wire connected in the primary circuit, means for varying the active turns thereof, an intermediate tap for said coil for placing a portion of the active turns in the secondary circuit and comprising a rotatable member having a turn of said coil looped thereover, and automatically operable means controlled by the varying means for so moving the member as the active turns of the coil are varied that a predetermined relationship will be present between the tapped turns and the total active turns of the coil, said means comprising a screw and nut for moving the rotatable member longitudinally and planetary gearing for rotating the nut and also the rotatable member around the axis of the coil.

7. In electrical apparatus of the class described,

two simultaneously rotatable members, one of which is made of a conducting material and the other of a non-conducting material, a plurality of turns of bare wire so associated with said members that the wire may be wound onto one of the members and unwound from the other member, means for making an electrical tap at an intermediate point of the turns on the insulated rotatable member and comprising a sheave having a turn of the coil looped thereover, and automatically operable means controlled by the rotation of one of the members for so moving the sheave both around and axially of the insulated member that there will be a predetermined fixed ratio maintained between the turns on the insulated member from the tap to the end of the coil which is connected to the other member and the total turns thereon.

8. In electrical apparatus of the class described, two simultaneously rotatable members, one of which is made of a conducting material and the other of a non-conducting material, a plurality of turns of bare wire so associated with said members that the wire may be wound onto one of the members and unwound from the other member, means for making an electrical tap at an intermediate point of the turns on the insulated rotatable member and comprising a sheave having a turn of the coil looped thereover, a screw for carrying the sheave, a nut cooperating with the screw, means for mounting said nut for rotation on its own axis and also about the axis of the insulated rotatable member, and gearing operable by the rotation of the insulated member for rotating the nut about both axes, the threads on the nut and screw and the teeth on the gearing being so related to each other that the sheave will be maintained in such a position that there will be a predetermined ratio maintained between the turns on the insulated member from the tap to the end of the coil which is connected to the other member and the total turns thereon.

9. In electrical apparatus of the class described, a coil comprising a rotatable member having a plurality of turns of bare wire thereon, means for varying the number of active turns of said coil, means for making an electrical tap at an intermediate point of the active turns of said coil, said means comprising a sheave mounted for rotation on a rod extending parallel to the coil and having a turn of said coil looped thereover, means for controlling said rod that the sheave will be rotated about the axis of the coil and simultaneously moved longitudinally, and a wheel rotatably mounted on the rod adjacent the sheave and engaging the rotatable member for supporting the axis of the rod and sheave at a fixed radial distance from the axis of the rotatable member.

10. In combination, an inductance coil having two end terminals and a movable intermediate tap terminal, a circuit connected to the ends of the coil, a circuit connected to an end terminal and the tap terminal, means to vary said inductance, and means responsive to operation of said first means to so move said tap terminal that a fixed ratio exists between the inductance of the entire coil and the inductance of the tapped portion.

11. The invention according to claim 10, wherein said combination includes a vacuum tube having input and output terminals, the input terminals being coupled to one of said circuits,

and the output terminals being coupled to the other of said circuits.

5 12. In electrical apparatus of the class described, two simultaneously rotatable frusto-conical members having their axes parallel, one of said members being made of a conducting material and the other of a non-conducting material, an electrical circuit comprising a plurality of turns of bare wire so associated with said
10 members that the wire may be wound onto a given diameter of one of the members and un-

wound from the same diameter of the other member, means for making an electrical tap at an intermediate point of the turns on the insulated member for placing a portion of the turns in a secondary circuit, and means operable by 5 the rotation of one of the members for so changing said intermediate tap that there will be a predetermined ratio between the tapped turns and the total active turns on the insulated member.

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