May 18, 1954 W. F. SANDS 2,679,007

VARIABLE INDUCTANCE CIRCUITS

Filed July 15, 1949

Fig. 1

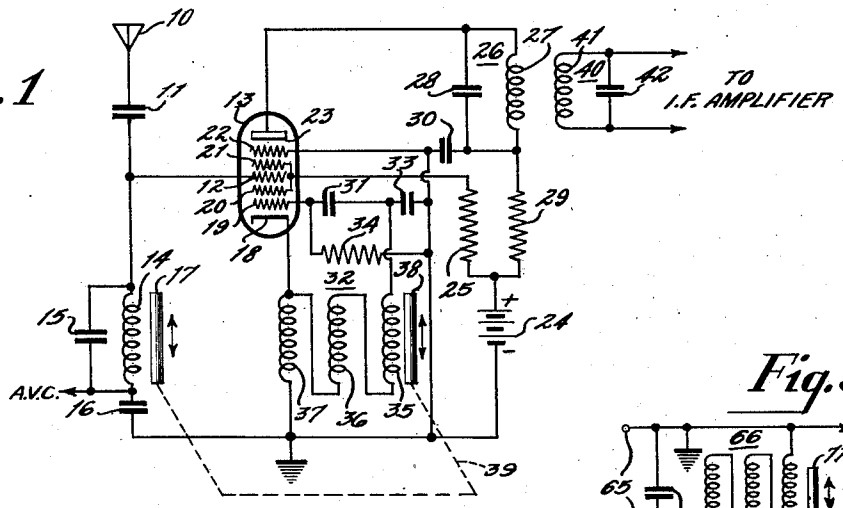
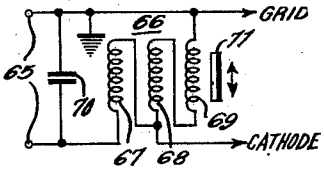


Fig. 5



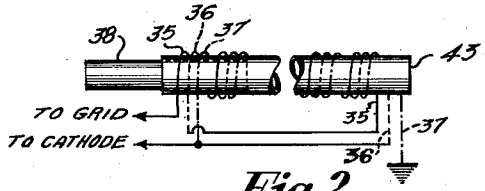


Fig. 2

Fig. 6

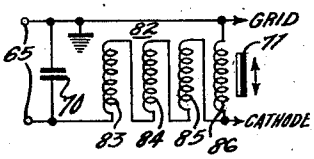


Fig. 3

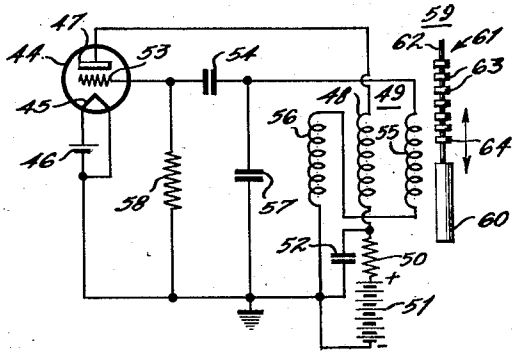
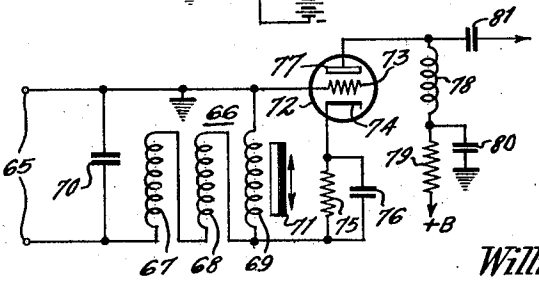


Fig. 4



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VARIABLE INDUCTANCE CIRCUITS

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14 Claims. (Cl. 250—36)

1

This invention relates to signaling circuits which are to be mutually coupled and which include inductances of different magnitudes having a predetermined ratio relative to one another, and particularly, to coil structures providing the inductance in the respective circuits which may be simultaneously varied by means of a movable core without varying substantially the predetermined inductance ratio of the two circuits.

In signaling systems, such as those included in radio receivers and the like, there are many cases where two inductive circuits are to be mutually intercoupled and in which the magnitudes of the inductances included in the respective circuits are different and yet have a predetermined ratio with respect to one another and in which the inductance ratio must be maintained substantially constant. Where circuits of the character described are to be variably tuned, or at least are to be controlled in such a manner that corresponding variations in the respective inductances are to be effected without changing the ratio of the inductances in the respective circuits, it has previously been necessary to provide the inductive devices in the respective circuits with individual movable core elements. This has been necessary when using coil structures of conventional design by reason of the fact that in structures of this character a single movable core element necessarily affects one inductive device differently from the other.

There are various types of circuits which are to be coupled and variably adjusted in the manner described wherein it is desirable to effect the necessary corresponding variations in the inductances included in the respective circuits by means of a single movable core element. One type of circuit wherein such a facility may be advantageously employed is the coupling between the output and input circuits of an oscillator. Another such circuit is one in which an impedance transformation is desired. In oscillators, particularly, which operate by reason of an inductive coupling between the input and output circuits thereof, it generally is necessary, in order to effect the proper coupling, that a coil structure be provided in which one winding has a somewhat different inductance than another winding. For example, in the well known type of Hartley oscillator, there is employed a coil structure connected between the anode or equivalent output circuit electrode and the control grid with a tap provided for connection to the cathode at a point on the coil structure which is closer to one end thereof than the other. In other types of oscillators, also, there are provided separate inductively coupled windings included respectively in the anode and control grid circuits wherein the inductances of the two coils are materially different. In order that these oscillators operate in a satisfactory manner, it is necessary to maintain a substantially constant ratio between the inductance of the portion of the coil structure included in the anode or output circuit of the inductance and that portion of the coil structure included in the control grid or input circuit. When using coil structures of conventional design, it is not possible to employ a single movable core element for varying the frequency of the oscillator without effecting a greater change in the inductance of one of the coil structure portions than in the other. As a consequence, the ratio of the inductances in the respective circuits does not remain constant with the result that the operation of the oscillator is adversely affected.

2

Similarly, it is frequently desirable to employ an inductive device which is tapped at a point closer to one end than the other in a circuit wherein an impedance transformation is to be made. For example, where a relatively high impedance circuit is to be coupled to a relatively low impedance circuit, it is a common expedient to couple a coil structure having an inductance of a relatively large magnitude across the high impedance circuit, one terminal of which is common to a terminal of the low impedance circuit. By providing a tap on the coil structure at a point which is closer to that end thereof which is connected to the common terminal and by connecting this tap to the other terminal of the low impedance circuit, only a fractional part of the total inductance of the coil structure is effectively included in the low impedance circuit. However, where such a coupling device is to be variably tuned, a movable core element in conjunction with a conventional coil structure is unsatisfactory for the reason that a movement of the core element effects a substantially different change in the inductance of one portion of the coil structure from that effected in the other portion, with the result that the ratio of inductance of the two circuits is not maintained constant.

Accordingly, it is an object of the present invention to provide an improved variable inductance apparatus for coupling two inductive circuits having respectively different inductances in a predetermined ratio, whereby the respective inductances may be varied without varying the inductance ratio.

Another object of the invention is to provide an improved variable inductance coil structure for coupling two inductive circuits having respectively different inductances in a predetermined ratio, whereby a movable core element may be variably positioned within the coil structure to effect a variation in the inductances of the respective windings without substantially changing said inductance ratio.

Another object of the invention is to provide an improved coil structure for use with an oscillator as the coupling means between the output and input circuits thereof and which comprises portions having different inductances in the respective circuits in predetermined ratio, whereby a single movable core element may be variably positioned within the coil structure for effecting inductance variations in the respective coil portions in substantially the same proportion.

In accordance with the present invention, there is provided apparatus for coupling two inductive circuits having respectively different inductances in a predetermined ratio relative to one another which comprises a multi-filar coil structure having at least three windings arranged with adjacent corresponding turns. At least one of the windings is connected in one of the circuits and a different number of the windings is connected in the other of said circuits. A core element also is included and is mounted for movement within the coil structure so as to simultaneously vary the inductances of the respective windings, all in substantially the same proportion whereby the ratio of the inductances remains substantially constant.

In accordance with another feature of the invention, there is provided a coil structure substantially of the character described for use in coupling the output and input circuits of an oscillator. At least one of the windings is included in the output circuit of the oscillator and a greater number of windings is included in the input circuit of the oscillator. In a particular form of oscillator all of the windings are connected in series relationship. In another form of oscillator the windings associated respectively with the input and output circuits are not conductively coupled and the output circuit winding is centrally disposed relative to the input circuit windings.

The novel features that are considered characteristic of this invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and method of operation as well as additional objects and advantages thereof will best be understood from the following description taken in connection with the accompanying drawing.

In the drawing:

Figure 1 is a circuit diagram of that portion of a superheterodyne radio receiver embodying the present invention wherein a Hartley oscillator is employed as the local frequency generator in a frequency converter stage, whereby the received radio frequency signals may be changed into intermediate frequency signals;

Figure 2 is a diagrammatic representation of a tri-filar winding together with its associated magnetic core element by which it may be tuned in accordance with the invention;

Figure 3 is another circuit diagram of a reaction type of oscillator embodying the invention in conjunction with a triode electronic tube;

Figure 4 is a further embodiment of the invention as it may be used in an impedance transformation circuit; and

Figures 5 and 6 show alternative embodiments of the invention.

Having reference now to Figure 1, there is shown the radiant energy receiving and frequency converting portion of a superheterodyne radio receiver. An antenna 10 is coupled by a capacitor 11 to the signal input grid 12 of an

electronic tube 13 which as illustrated may be a pentagrid tube such as an RCA type 6SA7. The antenna circuit is resonated by an inductor 14 and a shunt-connected capacitor 15. The low potential terminal of the inductor 14 is bypassed to ground by a capacitor 16 so that a connection of this terminal may be made to a conventional AVC circuit as indicated. Tuning of the antenna circuit is effected by varying the inductance of the inductor 14 by means of an associated movable core element 17 which, it will be understood by those skilled in the art, preferably is positioned within the convolutions of the inductor and is axially movable relative thereto as indicated by the double-headed arrow.

The frequency converter tube 13 also is provided with a cathode 18, an oscillator grid 19, a pair of space charge grids 20 and 21, a suppressor grid 22 and an anode 23. Space current and the necessary operating potentials for the tube 13 are derived from a unidirectional power supply such as indicated by the battery 24. The two space charge grids 20 and 21 are connected together as shown and are supplied with suitable voltage of positive polarity by means of a connection including a resistor 25 to the positive terminal of the battery 24. The anode 23 of the converter tube is coupled through a parallel resonant circuit 26 comprising an inductor 27 and a resonating capacitor 28 and through a resistor 29 to the positive terminal of the battery 24, whereby space current is furnished to the tube 13 and also whereby signal-modulated intermediate frequency energy is developed in the circuit 26 which is tuned for resonance at the intermediate frequency. A capacitor 30 provides a bypass to ground from the resonant circuit 26 for radio frequency currents. The suppressor grid 22 of the tube 13 is connected directly to ground as shown.

The oscillator grid 19 of the tube 13 is coupled by a capacitor 31 to one terminal of a multifilar coil structure 32, which is resonated by a capacitor 33. A resistor 34 provides a leak to ground for the coupling capacitor 31. The multifilar coil 32 as shown comprises three substantially similar windings 35, 36 and 37 connected in series aiding relationship to ground. The ungrounded terminal of the winding 37 is connected directly to the cathode 18 of the frequency converter tube 14. The multi-filar coil 32 is provided with a movable core element 38 which, as will be more fully described hereinafter, is intimately and substantially equally associated with each of the windings 35, 36 and 37. Also the core 38 is arranged to be axially movable as indicated by the double-headed arrow, whereby to effect the desired variation in the inductance of the coil 32 to suitably alter the operating frequency of the oscillator for tuning purposes. The tuning cores 17 and 38 preferably are arranged for concurrent movement and, accordingly, are suitably linked mechanically as indicated by the dash line 39.

The intermediate frequency output signal is derived from the frequency converted by means of a secondary resonant circuit 40 comprising the parallel arrangement of an inductor 41 coupled to the primary inductor 27 and a resonating capacitor 42 by means of which the circuit 40 is tuned for resonance at the intermediate frequency. The terminals of the resonant circuit 40 may be suitably coupled to an intermediate frequency signal amplifier as indicated.

Having reference now to Figure 2 of the drawing, there is indicated diagrammatically the manner in which a multi-filar coil structure may be formed in accordance with the invention. In the illustrative example, the multi-filar coil comprises three windings which may be supported upon a coil form consisting of a hollow tube **43**, preferably of insulating material. Since there are to be three windings forming the particular tri-filar coil shown for illustrative purposes, there are three conductors represented herein by the solid line **35**, the dash line **36** and the dot-dash line **37** in order that they may be individually distinguished. It may be seen from an inspection of Figure 2 that the three conductors **35, 36** and **37** are interwound upon the tube **43** in such a manner that each turn or convolution of each winding is adjacent to the corresponding convolutions of the other windings. The magnetic core element **38** is inserted within the hollow tube **43** substantially as indicated. It may be readily seen from this figure that, irrespective of in what position the core **38** may be placed within the tube 43, substantially the same number of turns of each of the windings **35, 36** and **37** are magnetically linked thereby. Consequently, whatever change in the value of the inductance of one of the windings may be effected by varying the position of the core **38** within the tube 43, substantially a proportional change in the inductance of the other windings will be effected.

Bearing in mind the structural arrangement of the multi-filar coil 32 and its cooperating tuning core 38 as shown in Figure 2, consideration should now be given with reference to Figure 1 of the operation of the embodiment of the invention in conjunction with the oscillator stage of a superheterodyne radio receiver. As is well known by those skilled in the art, the pentagrid frequency converter tube 13 includes an oscillator comprising the cathode 18, the oscillator grid 19 and effectively the space charge grids 20 and 21 serving as the oscillator anode or output electrode. As in a conventional Hartley oscillator, the cathode 18 is connected to the feedback inductor such as the tri-filar coil **32** at a point located approximately at one-third of the distance from the grounded terminal. Accordingly, a tri-filar coil such as the coil **32** serves effectively in an oscillator of this type by reason of the fact that the cathode 18 may be connected to one of the junction points between the windings of the coil. It may readily be seen that, when the magnetic core elements 17 and 38 are adjusted in position relative to their associated coils 14 and 32 to vary the tuning of the receiver, not only is the overall inductance of the coil **32** changed in the manner desired but also the inductance of the winding 37 connected to the oscillator cathode 18 is changed in substantially the same proportion. Therefore, the inter-relationship between the energy developed in the output circuit of the oscillator and the energy fed back to the input circuit for producing sustained oscillations is substantially unaltered when the feedback coil 32 is a tri-filar one in accordance with the invention and the inductance thereof is varied for tuning purposes. The oscillator, as a result, performs with substantially equal facility irrespective of the frequency at which it is tuned.

Referring now to Figure 3 of the drawing, there is shown another form of oscillator which may advantageously employ an embodiment of the invention. In this case, the electronic tube **44** is a triode having a directly heated or filamentary cathode **45** which may be suitably energized by a relatively low voltage unidirectional power supply such as indicated by the battery **46**. The anode **47** of the oscillator tube **44** is coupled through a centrally disposed winding **48** of a tri-filar coil structure **49** and thence, through a load resistor **50** to the positive terminal of a source of unidirectional space current such as a battery **51**. The resistor **50** and the battery **51** may be bypassed to ground by a capacitor **52**.

The grid **53** of the oscillator tube **44** is coupled by a capacitor **54** to one terminal of one end winding **55** of the tri-filar coil structure **49**, the other terminal of which is coupled in series aiding relationship to one terminal of the other end winding **56** of the coil structure. The other terminal of the winding **56** is connected to ground and the two windings **55** and **56** are resonated by a capacitor **57**. A resistor **58** provides a leak circuit to ground from the grid **53** of the oscillator tube. The tri-filar coil structure is provided with a movable core element **59** which, as indicated by the double-headed arrow, may be axially moved relative to the coil windings for tuning purposes.

The windings **48, 55** and **56** may be formed upon a suitable hollow tube in a manner substantially similar to that shown in Figure 2. Inasmuch as each convolution of each of the windings is wound upon the supporting form in such a manner that it is adjacent to corresponding convolutions of each of the other windings, the position of the core **59** within the supporting tube will produce substantially proportional inductance changes in each of the windings.

The movable core structure **59**, as used in this form of the invention, may consist of a ferromagnetic portion **60** and a substantially non-magnetic portion **61**. The non-magnetic portion may be formed by mounting upon an insulating rod **62** a series of finitely spaced non-metallic rings **63** which, for example, may be made of copper. Not only are the rings **63** finitely spaced with respect to one another, but there also is provided a finite spacing between the end ring **64** and the adjacent end of the ferromagnetic portion **60**. The purpose of such a movable core element is to extend the range over which the tri-filar coil structure **49** may be tuned.

Briefly, the operation of the oscillator shown in Figure 3 consists of the development in the winding **48** of output circuit energy which is inductively coupled in suitable proportion into the windings **55** and **56** so that there is impressed upon the input circuit of the oscillator tube **44**, by means of the capacitor **54**, energy in suitable magnitude and phase to effect the generation of sustained oscillations. The magnetic core element **59** may be varied in its position relative to the number of convolutions of the windings **48, 55** and **56** which it links so as to suitably vary the frequency at which the oscillator operates.

During that portion of the movement of the core **59** wherein the ferromagnetic portion **60** only is associated with the windings of the tri-filar coil structure **49**, the non-magnetic portion **61** of the core has no effect upon the coil structure. As the ferromagnetic portion **60** is withdrawn from the coil structure in a downward direction, as viewed in the drawing, there is effected a continuous decrease in the value of the inductances of the respective windings **48, 55** and **56**. As the downward movement of the

core 59 is continued the copper rings 63 of the non-magnetic portion 61 become associated with the windings of the coil structure 49 so that the respective inductances of the windings 43, 55 and 56 are still further decreased as a result of the production of eddy current losses in the spaced non-magnetic rings 63. In other words, maximum inductance of the coil windings is achieved by maximum penetration of the coil structure by the ferromagnetic portion alone and minimum inductance of the coil windings is achieved when only the non-magnetic portion 61 is entirely within structure. Thus, it may be seen that the additional decrease in the inductances of the respective windings, effected by means of the non-magnetic rings 63 after the ferromagnetic portion 69 has been entirely withdrawn from the coil structure, enables the tuning of the coil structure over a much wider range than would otherwise be possible.

By virtue of the separation of corresponding turns of the input circuit windings 55 and 56 of the tri-filar coil structure 49, the capacitive coupling between the two portions of the input circuit windings is decreased thereby enabling more efficient performance of the oscillator.

Having reference now to Figure 4 of the drawing, there is shown an embodiment of the invention for use in effecting an impedance transformation between two circuits which it is desired to couple together and which it is desired to variably tune. The terminals 65 are connected to a circuit having a relatively high impedance. There is provided a multi-filar coil structure 66 having in this instance three windings 67, 68 and 69. The multi-filar winding 66 is formed substantially in the manner as that indicated in Figure 2. The individual windings are connected in series aiding relationship, as shown, for coupling across the terminals 65 and are resonated by a capacitor 70, also, coupled across the terminals 65. The multi-filar coil structure 66 is provided with a movable core element 71 by which to correspondingly vary the inductances of all of the respective windings thereof. The low impedance circuit which is to be coupled to the terminals 65 comprises the cathode circuit of an electronic tube 72, the control grid 73 of which is grounded. The circuit connected to the cathode 74 includes a relatively low impedance resistor 75 which is bypassed by a capacitor 76. The output circuit of the tube 72 includes an anode 77 which is supplied with space current from a suitable source indicated at +B through a circuit which includes an inductor 78 and a load resistor 79 which is bypassed to ground by a capacitor 80. The output circuit may be coupled to any suitable utilization circuit by means such as a capacitor 81.

Considering now the manner in which the multi-filar coil structure 66 functions to effect a satisfactory impedance transformation between the relatively high impedance circuit coupled to the terminals 65 and the relatively low impedance cathode input circuit of the tube 72 terminating between the grounded grid 73 and the ungrounded terminal of the coil 69, it should be taken into account that these impedances remain substantially constant. Also, it will be appreciated that, as the core 71 is variably positioned relative to the windings 67, 68 and 69, the inductance, and therefore the impedance of the respective windings necessarily varies which, of course effects a variation of the total impedance of the multi-filar coil structure. Consequently, in the present case, a compromise is necessary, whereby the impedances of the windings of the multi-filar coil structure are chosen so that, at a predetermined intermediate point of the range of adjustment of the core 71, a substantially exact impedance transformation is effected. For example, the center point of the range, in most cases, will produce optimum performance. Obviously, for all other points of the range the impedance transformation will not be exact, but ordinarily is satisfactory. However, for all points in the range of adjusment of the core 71, the impedance ratio of the two portions of the multi-filar coil structure 66 which are coupled respectively to the high and low impedance circuits remains substantially constant and substantially equal to the impedance ratio of the circuits. Accordingly, in this description and in the appended claims, it will be understood that the values given are those pertaining to the previously described intermediate point of the range of adjustment of the core 71.

The total impedance of the serially connected windings 67, 68 and 69 is substantially equal to the impedance of the circuit connected to the terminals 65. The impedance of the winding 69 is substantially equal to the impedance of the cathode input circuit of the tube 72. In the embodiment of the invention illustrated in Figure 4, it is assumed that the impedance of the circuit connected to the terminals 65 is substantially nine times the impedance of the cathode input circuit of the tube 72. Since all of the windings 67, 68 and 69 of the multi-filar coil structure 66 are substantially identical and are substantially unity-coupled by virtue of the described manner in which the coil structure 66 is made, it is seen that the total impedance of the serially connected windings is substantially nine times the individual impedance of any one of the windings such as the winding 69. Obviously, if the ratio of the relatively high impedance circuit to the relatively low impedance circuit is greater or less than nine, a different number of windings and/or different circuit connections thereto may be made within the scope of the present invention.

For example, in the event that the impedance of the circuit connected to the terminals 65 bears a relationship to the cathode input impedance of the tube 72 such as substantially 9:4, three windings may be employed in the multi-filar coil structure 66 connected substantially as shown in Figure 5 across the terminals 65. In this case, it will be noted that the cathode-connected resistor 75 is connected to the junction point between windings 67 and 68.

In the event that the impedance of the circuit connected to the terminals 65 is substantially sixteen times the impedance of the cathode input circuit of the tube 72, Figure 6 illustrates an embodiment of the invention for coupling two such circuits. In this case, a multi-filar coil structure 82 is provided consisting of four substantially identical windings 83, 84, 85 and 86, all of which are wound upon a supporting form in a manner similar to that shown in Figure 2. The windings are connected in series aiding relationship, the entire series arrangement being connected across the relatively high impedance terminals 65. The cathode resistor (not shown) is connected to the junction point between windings 85 and 86. It may be seen, therefore, that by reason of the substantial identity of the individual windings, the 16:1 impedance ratio may

be readily effected by coil structure substantially as shown in Figure 6.

It is to be understood that coil structures in accordance with the present invention are not necessarily limited for use as impedance transformation devices wherein a relatively high impedance output circuit is to be coupled to a relatively low impedance input circuit as shown in Figures 4, 5 and 6. Alternatively, it obviously is within the scope of this invention to employ coil structures of the character described herein for effecting impedance transformations between a relatively low impedance output circuit and a relatively high impedance input circuit. In order to effect this type of impedance transformation, it merely is necessary to reverse the connections of the coil terminals to their respective circuits. For example, in either of Figures 4, 5 and 6, the terminals **65** would be connected to the relatively high impedance input circuit, while the terminals shown in these figures as connected to the input circuit of an electronic tube would be coupled instead to the output circuit of an electronic tube, for example, the impedance of which would be less than the impedance of the input circuit of the following stage.

It should be clear from a consideration of the several illustrative embodiments of the invention disclosed herein, that the inductance or impedance ratios between the two circuits which are to be coupled by means of the improved coil structures determines the minimum number of individual windings comprising the coil structure, and also the respective number of windings included in the two circuits. For example, where the impedance ratio is 9:1 or its reciprocal 1:9, three windings or any multiple thereof are required in the coil structure as shown in Figure 4. In such a case, two windings or a multiple thereof are included in one circuit and one winding or a multiple thereof is included in the other circuit. Also, where the impedance ratio is 9:4 or the reciprocal thereof, the coil structure may comprise three windings or a multiple thereof connected as shown in Figure 5. Also, as one further example where the impedance ratio is 16:1, 16:9 or the reciprocals thereof, four windings or a multiple thereof are required in the coil structure. Typical circuit connections for a 16:1 impedance ratio are indicated in Figure 6. Further extensions of the principles underlying the present invention are considered to be obvious in view of the foregoing illustrative examples whereby coil structures in accordance with this invention may be provided for coupling two circuits having substantially any inductance ratio other than unity.

It will be seen from the foregoing disclosure of several illustrative embodiments of the invention that there is provided an improved coil structure for coupling substantially any two inductive circuits having different inductances in predetermined ratios relative to one another, both of which inductances are to be correspondingly varied by means of a core element movable relative thereto without substantially changing the inductance ratio. Consequently, coil structures of the type embodying this invention make it possible to simultaneously vary the inductance by a movable core means of numerous circuits which heretofore have required individual separately movable core means.

It, therefore, will be apparent to those skilled in the art that the invention may be embodied in various forms other than those specifically disclosed herein for illustrative purposes. Accordingly, the scope of the invention is to be determined particularly by reference to the appended claims.

What is claimed is:

1. Apparatus for coupling two inductive circuits having different inductances in a predetermined ratio relative to one another, said apparatus comprising a multi-filar coil structure having at least three windings arranged with adjacent corresponding turns, at least one of said windings being connected in one of said circuits, a different number of said windings being included in the other of said circuits, and a core element adjustably positionable within said coil structure, whereby to simultaneously vary the inductances of said respective windings all in substantially the same proportion so as to correspondingly vary the inductances in said circuits while maintaining said predetermined ratio substantially constant.

2. Apparatus for coupling two inductive circuits as defined in claim 1, wherein said multi-filar coil structure comprises three windings, two of which are included in one of said circuits and the third of which is included in the other of said circuits.

3. Apparatus for coupling two inductive circuits as defined in claim 1, wherein all of said windings are interconnected in series aiding relationship.

4. Apparatus for coupling two inductive circuits as defined in claim 3, wherein a tap is provided at the junction point between two of said windings so as to locate said tap at a point which is unsymmetrical relative to the series connection of said windings.

5. Apparatus for coupling two inductive circuits as defined in claim 1, wherein said multi-filar coil structure comprises an odd number of windings.

6. Apparatus for coupling two inductive circuits as defined in claim 5, wherein a centrally disposed one of said windings is included in one of said circuits and the remainder of said windings are connected in series aiding relationship and are included in the other of said circuits.

7. Apparatus for coupling two inductive circuits as defined in claim 6, wherein said multi-filar coil structure comprises three windings.

8. In an oscillator including an electronic tube having an input circuit electrode, an output circuit electrode and a third electrode common to both input and output circuits, a circuit coupling said input and output circuits, comprising a multi-filar coil structure having at least three mutually closely coupled windings in which each of the turns of each winding is adjacent to corresponding turns of each of the other windings, circuit means connecting at least one of said windings to said output circuit electrode and a different number of said windings to said input circuit electrode, capacitance means coupled to said coil structure for resonating certain ones of said windings at an oscillator frequency determined by the values of said capacitance and the inductances of said respective windings, and a core element adjustably positionable within said coil structure to vary the inductances of all of said windings substantially in the same proportion, whereby to vary said oscillator frequency.

9. An oscillator as defined in claim 8, in which at least two of said windings are connected to one another in series aiding relationship.

10. An oscillator as defined in claim 9, in which two of said interconnected windings are coupled between said input circuit electrode and said common electrode.

11. An oscillator as defined in claim 10, in which a third one of said windings is coupled between said output circuit electrode and said common electrode.

12. An oscillator as defined in claim 8, in which at least one of said windings is coupled in one circuit between said output circuit and said common electrodes, and the others of said windings are connected in series aiding relationship and are coupled in another circuit magnetically associated only with said one circuit between said input circuit and said common electrodes.

13. An oscillator as defined in claim 12, in which said multi-filar coil structure comprises three windings of which two are connected in series.

14. An oscillator as defined in claim 8, in which said multi-filar coil structure comprises three windings of which the central one is coupled between said output circuit and said common electrodes, and the two end ones of said windings are connected in series aiding relationship and are coupled between said input circuit and said common electrodes.

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