

Dec. 21, 1954

C. H. SCARCE ET AL.

2,697,559

WINDING CONTROL MECHANISM

Filed May 29, 1951

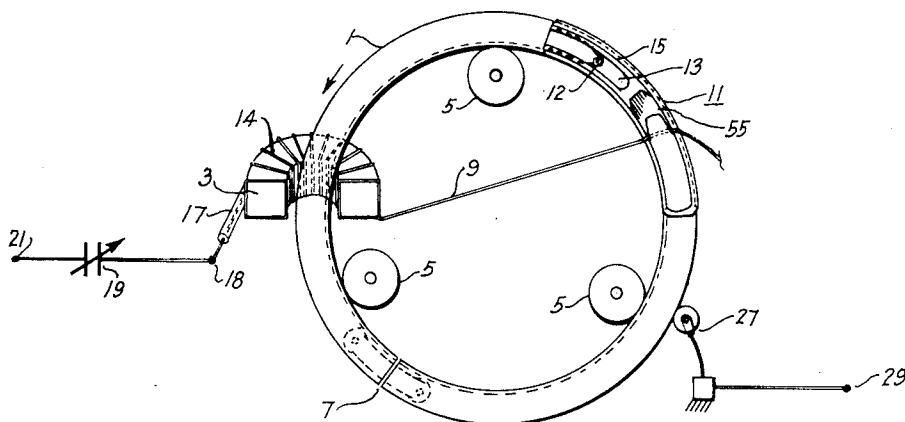


Fig. 1.

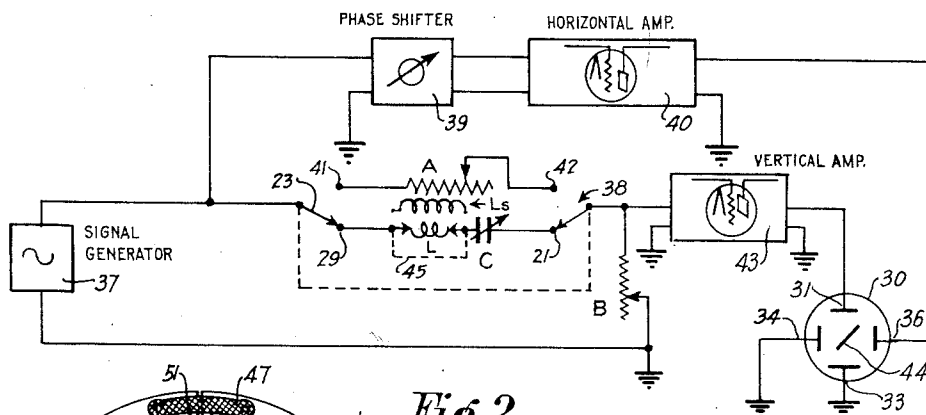


Fig. 2.

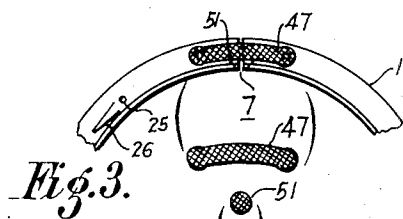


Fig. 3.

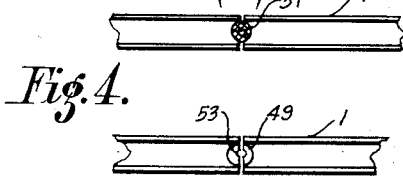


Fig. 4.

Fig. 5.

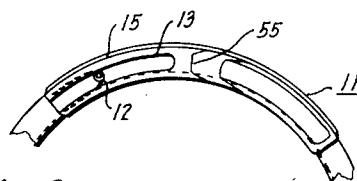


Fig. 6.

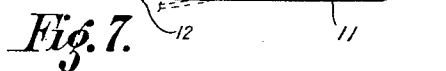


Fig. 7.

INVENTORS
Chester H. Scarce
 BY *Robert G. Turnbull*
Lippincott & Smith.
 ATTORNEYS

1

2,697,559

WINDING CONTROL MECHANISM

Chester H. Scarce, Millbrae, and Robert G. Turnbull,
Redwood City, Calif., assignors to Lenkurt Electric
Co., Inc., San Carlos, Calif., a corporation of Delaware

Application May 29, 1951, Serial No. 228,876

19 Claims. (Cl. 242—5)

This invention relates to improvements in measuring circuits for winding machines and more particularly to the type machines employed for winding toroidal inductors.

Winding machines of this type usually comprise an annular shuttle, for carrying and dispensing the wire to be wound, which interlinks a toroidal core, the wire being transferred from the shuttle to the core by the revolving action of the shuttle. During this process the core is oscillated in its own plane either manually or by mechanism, thus effectuating an evenly distributed spiral winding on the core. By way of example only, and not by way of limitation, reference may be had to the Borgeson Patent, No. 1,827,186, issued October 13, 1931 for typical structure of a winding machine. Our invention hereinafter related could be easily adapted to perform in cooperation with such a machine.

Heretofore it was necessary to determine the number of turns wound upon the core manually or by use of a mechanical counter. This, of course, is a painstaking process which adds to the cost of manufacture. Further, this process is subject to error in that a pre-calculated number of turns does not always result in a given value of inductance because the permeabilities of the various cores differ slightly. This is especially true when cores of the powdered metal type are utilized, due to the fact that even under the tremendous pressures which are employed in compressing the powdered metal, irregularities in the various cores such as air holes or fissures result which are likely to receive unequal distributions of core material. Our invention compensates for such inequalities.

Briefly, our invention comprises means for continuously supervising the inductance of the coil as it is wound on the core in such manner that, as the final desired inductance is approached, the effect of the wire remaining on the shuttle is minimized and when the winding is complete, a substantially exact value of inductance is attained. Means are provided for eliminating the effect of the shuttle itself on the supervisory operation, and the device is so arranged that any residual errors in the supervisory measurement are always such that they can be finally corrected by the removal of one or two turns at most; a "negative" error, requiring additional turns, is never introduced. Coils of this type, when used in filter networks or as telephone loading coils or in many other applications, require exact values of inductance, particularly when two coils are wound on the same core to be used as mates in a filter network.

As our indicating device we employ a cathode ray oscilloscope connected through horizontal and vertical amplifiers respectively to an LC circuit and a voltage generating source. The inductance in the LC circuit, of course, is that of the coil which is being wound whereas the capacity consists of a known value which will cause a resonant condition when the coil has been sufficiently wound to produce an inductance of the desired value. Connections for the inductance are provided at one terminal by the end of the wire first wound on the core and at the other terminal by an electrical contactor which is spring biased to contact the periphery of the shuttle. The other end of the wire being electrically connected thereto. When the LC circuit is in resonance, the potentials from the generator and across the LC circuit are in phase, and the trace on the oscilloscope becomes a straight line; under other conditions it opens into an ellipse or circle.

2

In order that the shuttle will not appear as a short circuited turn linking the core, we provide a transverse joint or gap in the shuttle periphery with insulators extending across this joint or gap to provide the necessary rigidity for the shuttle. Furthermore, a relatively large shuttle is used so that one or two turns remaining thereon would supply many turns wound tightly around the core. The turns remaining on the shuttle therefore have a very small effect on the total inductance, which may either be ignored or readily compensated for.

The circuit is originally calibrated by inserting a resistor in place of the LC circuit including the inductance to be measured, and adjusting the phases of the potentials fed to the deflecting plates until the trace on the scope is a straight line. When this occurs, the sine waves from the signal generator to the horizontal and vertical deflecting plates of the scope will be in phase. Upon substituting the LC circuit, there will appear, on the set of deflecting plates connected across it, a 90° out-of-phase component (lagging when the number of turns on the coil is small) which opens the trace out into a wide ellipse or circle. As the toroidal core receives more and more turns, its inductance increases until finally a resonant condition is established between L and C. At resonance, it will be recalled, the impedance of an LC circuit appears as pure resistance, hence the scope will again indicate the diagonal line trace for which it was originally calibrated. Then the operator need only discontinue the winding operation to rest assured that the coil contains sufficient turns to yield the desired inductance, thus expediting the manufacture of coils.

As an alternate method of calibrating the circuit, we provide a standard coil of which type precise duplicates are desired. This coil may be placed in the LC circuit in making the preliminary adjustment for linear trace on the scope, and when linearity again appears the coil being wound will have the same value. Since the capacitor was pre-selected to have a value such that a resonant condition will be produced by the series combination of this capacitor and the standard inductance, the impedance of the combination will again appear as a pure resistance and the scope may be calibrated in the manner hereinbefore set forth. In the winding operation the shuttle, which carries the supply of wire to be utilized, the toroidal core and the shuttle contactor replace the standard inductance. Suitable switching means are provided for this purpose. Thus, when the toroid has received sufficient turns, resonance is again achieved and the scope pattern indicates to the operator that the winding operation may be terminated and that a coil having inductance comparable to that of the standard has been produced.

Accordingly, it is an object of this invention to provide an indicating circuit which will readily and efficiently enable the operator to determine when the correct number of turns has been wound on the core so as to provide a value of required inductance.

It is a further object of this invention to provide a method of winding which will enable the construction of a number of coils that will be identical to a given standard coil.

It is a further object of this invention to provide a means for visually indicating when the winding operation is complete.

A further object of this invention is the provision of a shuttle having a normally closed transverse insulating joint therein, which joint is secured against radial, tangential and transverse movement.

Further objects of the present invention will be apparent from a detailed description thereof when taken in conjunction with the accompanying drawings wherein:

Fig. 1 shows a side elevation of the winding shuttle interlinking the toroidal core to be wound;

Fig. 2 shows a block diagram of the indicating circuit embodied in our invention;

Fig. 3 is a view in side elevation of the transverse joint in the shuttle showing an elongated peripheral insulator thereacross;

Fig. 4 is a plan view of the periphery of the shuttle

showing the transverse joint therein having a spacing insulator located thereacross;

Fig. 5 is a view of Fig. 4 minus the spacing insulator;

Fig. 6 shows a view in side elevation of a wire guide and tension device; and

Fig. 7 is a plan view of the wire guide and tension device of Fig. 6.

Referring now to the drawings, Fig. 1 illustrates a side elevational view of the shuttle 1, which interlinks the toroidal core 3 to be wound. The shuttle is shown mounted on idlers 5 which employ a friction drive. In utilizing this invention, it must of course be realized that these idlers are necessarily electrically insulated so as not to interfere with the functions of the electrical measuring circuit; otherwise the driving portion of the machine may be any of the mechanisms known for this purpose and hence is not illustrated here. The shuttle has a normally closed transverse joint therein generally designated at 7 and shown closed as in normal operation with an insulator securing same. The wire 9, to be utilized in winding the core 3, is first wound upon the shuttle in a counter-clockwise direction and accordingly is therefore unwound from the shuttle onto the core in a clockwise direction.

Ordinarily the shuttle contains a length of wire which is slightly greater than that normally required to wind a complete coil, and sufficient to provide the required inductance on a core of the minimum permeability likely to be encountered in practice.

It might be noted at this point that two coils, each occupying a semi-peripheral portion of a core, may be wound on one core. Annular insulators may be attached to the core to adequately insulate the two coils. It has been found most desirable to oscillate the core 3 manually in its own plane so as to provide an even distribution of wire along the surface thereof. Of course, various types of mechanisms may be employed to do this mechanically. However, these mechanisms are deemed within the knowledge of one skilled in the art and accordingly the drawings were not complicated by showing such mechanisms.

The wire guide and tension device shown at 11 is employed in this invention to guide the wire 9 from the shuttle, a portion of the wire carried by the shuttle adjacent to the guide and tension being shown in dotted outline in Fig. 1, onto the core as well as govern the tension in this wire. A spring 12 located in the slot 13 is adapted to be slidably movable along the slot by the operator of the mechanism. This spring biases resilient arms 15 so as to control the tension applied to the shuttle periphery. When the spring is moved toward the open end of the slot, it will be readily apparent that less tension is employed between the device and the shuttle flange upon which it rides, thereby facilitating peripheral movement of this device around the shuttle, this being due to the fact that the arms are biased further apart and accordingly less pressure is applied in the overall contact between the arms and the flanged periphery.

The adjustment of the spring is determined by the operator in accordance with the wire size being wound on any given core. The tension required to adequately reel out but yet prevent undue slack when using a No. 22 wire would probably be so great as to cause breakage in a No. 30 wire. This spring may be readily moved by employing a suitable pointed implement to slide it along the slot.

At 14 there is represented a few turns which have already been wound on the toroid. The end of the wire which is first applied to the toroid is scraped so as to provide an uninsulated end. This end may then be placed in a rubber sheath or insulator of such a nature as shown at 17 and the insulator 17 may extend along a portion of the periphery of the core so that it will be secured thereto by a few turns being wound on the core, thus providing a terminal 18 for the coil which will be readily accessible after the winding operation has been completed.

From this terminal the wire is connected to a standard capacity 19 (which may be an accurately calibrated variable) and then to a junction point 21 for providing contact with a switch blade 38 shown in Fig. 2. The opposite end of the wire to be wound on the core is also stripped of insulation and then attached to the shuttle ring by being inserted through the hole 25 in Fig. 3 and under the tab 26 on the flange of the shuttle, thus estab-

lishing a good electrical contact with the shuttle. The circuit further extends from the shuttle via spring bias contactor 27 to junction point 29, thus establishing a complete electrical circuit from junction 29 to junction 21 through the wire wound upon the shuttle as well as the wire wound upon the core and the standard capacity.

In Fig. 2 there is shown a diagram of the indicating circuit embodied in our invention on which an indicating device 30, preferably of the cathode ray oscilloscope type, is employed. The vertical and horizontal deflecting plates of this scope are indicated respectively at 31, 33, and 34, 36. Plates 33 and 34 are grounded, whereas plates 31 and 36 are connected to the remainder of the circuit. A voltage wave source or signal generator 37 is shown connected through a phase shifter 39 and a horizontal amplifier 40 to horizontal deflecting plate 36. A further connection from the signal generator 37 places the switch blades 23 and 38 (which are ganged together) in series with the vertical amplifier 43 which is connected to vertical deflecting plate 31. One adjustable calibrating resistor B is in series with the ganged switch and the signal generator whereas a further adjustable calibrating resistor A is adapted to be contacted by switch blades 23 and 38 at terminals 41 and 42 respectively. The LC combination shown in this figure represents the electrical circuit of Fig. 1 located between junctions 29 and 21.

It will be apparent to those skilled in the art that various types of indicating devices may be employed in place of the cathode ray tube. It will further be apparent that the connections for the deflecting plates may be made in various manners. The potential developed across the LC circuit may be compared to that of the signal generator or to the potential developed across the adjustable resistor B, in either of which case the phase difference will be present to yield a suitable pattern on the tube. The foregoing is readily apparent when it is realized that the vector diagram of the various potentials in the circuit defines a semi-circle for all cases except when resonance occurs, in which case the supply voltage is merely the sum of the in-phase voltages appearing across the LC circuit and the adjustable resistor B, and hence a diagonal line trace results. It also should be noted that the phase shifter, horizontal amplifier and vertical amplifier may be omitted without substantially injuring the performance of our circuit when a sensitive indicating device is employed.

This circuit may be calibrated in one of two ways, each of which has been described in the brief introduction to this specification. Accordingly, it will suffice now to say that in the first calibrating method the gang switch is merely thrown so that blades 23 and 38 contact terminals 41 and 42 respectively, thus forming, for all practical purposes, a purely resistive circuit. Accordingly, the sine waves produced by signal generator 37 are conducted to the indicating device shown at 30 in phase, thus resulting in a test pattern of diagonal line shape as shown at 44 on the face of the scope. The phase shifter shown at 39 may now be operated to compensate for any phase shift due to the amplifiers or any stray inductances or capacities present in the circuit, or to enable a standard capacity to be used which is not exactly resonant with the desired inductance, thus yielding a sharp diagonal line pattern on the scope which is free of disturbances.

The complete calibration process for the resistive method of calibration may comprise the following: first, adjust calibrating resistors A and B, each to the approximate value of the resistance of the LC circuit at resonance (the reason being to form a diagonal line pattern on the scope having a 45° inclination, as this is the most sensitive condition for the scope). Secondly, adjust the scope amplifiers for equal horizontal and vertical deflection, and thirdly, adjust the phase shifter circuit to balance out any phase shift which is still present in the test circuit.

The second method of calibrating our circuit may be set forth in some detail, reference being had to Figure 2. At Ls there is indicated a standard coil having a given value of inductance, of which type it is desired to produce several duplicates. Accordingly, this standard inductance may be readily employed to calibrate the circuit. This may be done by throwing switch 45 so as to place Ls in series with C (which is the variable capacity standard 19 of Fig. 1) and at the same time disconnect L from the circuit. As the value of C has been pre-selected so that

5

a resonant condition will occur when C and Ls are placed in series, a diagonal line trace will appear on the face of the cathode ray tube. At this time the phase shifter 39 may also be employed to balance out any phase shift which may be present in the test circuit. After the calibration has been achieved in this manner, switch 45 may be thrown to the position shown in Fig. 2, thus placing the toroidal core and shuttle circuit back in series with the adjustable condenser and disconnecting the standard coil Ls from the circuit.

The operator may now commence the winding operation and allow the shuttle to place turns upon the toroid until the inductance L attains a value of inductance equal to Ls, at which time the diagonal line trace again appears on the scope and indicates to the operator that the winding operation may be terminated. There will then usually remain two or three turns upon the shuttle, which are substantially as effective inductively as the same number of turns wound directly upon the core, but since they are wound in the opposite direction they produce a subtractive effect. When the wire is clipped and the coil winding alone is connected to the indicating circuit, the inductance will be slightly too great but the removal of one or two turns will correct this. In past practice it has been necessary to wind on each core the number of turns required for a minimum permeability core, requiring that in the average case twenty to thirty turns would have to be unwound. With a toroidal coil this is a tedious process, which becomes more time-consuming very rapidly as the number of turns to be removed is increased. We have found that the practical elimination of this process through the use of this invention has decreased the cost of winding such coils by as much as 25%.

By way of example only and not by way of limitation, we employ a signal generator capable of supplying voltage in the range of from $\frac{1}{2}$ to 16 kilocycles. A variable capacity standard engrossing .1 to .5 microfarad may be utilized to resonate with coils having from .05-1,000 millihenries. Frequency forms the standard for our winding circuit, and we have chosen this particular range because the distributed capacities present in the coils range between 30-70 micro-microfarads, which values produce less than .1% error in total circuit capacity. The standard commercial variable capacities are only guaranteed to be accurate within .1%, therefore distributed capacities may be disregarded.

In Fig. 3 there is shown a side elevational view of a portion of the periphery of the shuttle 1. This portion contains the transverse joint 7 which is provided to permit lateral movement of the two ends of the shuttle ring so that the toroidal core may be interlinked therewith. As has hereinbefore been pointed out, this joint must provide an electrical gap in the shuttle ring so that it will not appear as a short circuited turn to the toroid. Accordingly, we have devised a means of insulating this gap as well as providing rigidity in the ring. In this figure an insulator 47, generally conforming to the curvature of the shuttle but having lobes at each end, is fitted into a conforming recess in the flanged periphery of the shuttle. In Fig. 5 there is illustrated a substantially circular recess 49 in the abutting ends of the shuttle, which is adapted to receive a disc insulator 51, shown in place in Fig. 4. A hole 53 is formed in the bottom of the recess (see Fig. 5) for facilitating the removal of the disc insulator. Holes for the same purpose are provided in the flanged periphery of the shuttle in connection with the insulator 47. These insulators may be comprised of various materials such as Bakelite, Armite, Fiberglass or any other suitable material. It should be pointed out that the cooperative action of these two insulators guards against radial, tangential or transverse movement of the ring in the vicinity of said joint.

In Figs. 6 and 7 there are shown, respectively, a view in side elevation and a plan view of the wire guide and tension 11. This tension is arcuate in shape and contains flanges on one side thereof which are adapted to grip the flanged periphery of the shuttle ring. This tension may be placed on the flange of the shuttle by sliding it thereon when the transverse joint is moved in a lateral direction. The tension should preferably be constructed of a resilient material such as spring steel so that the spring 12, which is slidably mounted in open-ended slot 13, may bias the arm 15 so as to obtain the tension required for the different sized wires utilized. The operator may slide the spring towards the open end of the slot to balance a greater portion of the spring pressure

6

exerted by the arms on the shuttle periphery, thus permitting easier movement of the tension along the shuttle.

The groove 55, transversely located in the tension, is of such shape so as to guide the wire from the shuttle to the core. This groove should be deep enough and set at such an angle so as to prevent the wire from slipping out of it. Hinges or slidable flaps may be provided to maintain the wire in the groove in case it tends to come out.

This tension, though simple in construction, has readily made it possible to manufacture successively, coils comprising different wire sizes. A complete set of coils for a filter network requiring anywhere from four to eight or more different sized coils may be wound successively in much less time than heretofore realized. In changing wire sizes the operator need only slide the spring backwards or forwards in the slot, thus providing the correct tension for the different sized wires. By providing the correct tension requirements the tension acts to unwind the supply of wire on the shuttle and to guide it to the core being wound, thus expediting the manufacture of toroidal coils and thereby decreasing manufacturing costs.

Further, it might be mentioned that the wire tension and guide shorts the shuttle each time it slides across the gap. This produces a flicker on the scope but since one turn of wire on the shuttle will provide numerous turns on the core, the tension only shorts the shuttle for a small portion of the winding time. Thus the flicker does not substantially affect the scope indication.

Various modifications of our invention will be readily apparent to those skilled in the art and therefore we do not wish this invention to be confined to the embodiments represented by the drawings.

What is claimed is:

1. In combination with a toroidal core winder which includes means for rotating an annular shuttle which interlinks the core to be wound, supervisory means for controlling the inductance of a coil to be wound comprising a conducting wire-carrying shuttle adapted to be rotated by said winder and thereby to transfer said wire to a core to be wound, said shuttle having a gap in the periphery thereof, means for connecting to said shuttle the end of the wire wound thereon, a circuit including a condenser adapted for connection through said coil, shuttle and the wire thereon, a source of electrical current of known frequency connected to supply said circuit and means for indicating the relative phase of the potential developed across said condenser, coil and wire with respect to the current in said circuit.

2. The combination of claim 1 having insulating means for locking the ends of the shuttle, defining said gap, against relative motion.

3. The combination as recited in claim 1 wherein said relative phase indicating means comprises a resistance connected in series with said circuit, connections across said entire circuit including said resistor and between said resistor and the remainder of the circuit, and means connected thereto for indicating the relative phases of the potentials across any two pairs of said connections.

4. In a toroidal core winding machine of the type employing an annular wire-carrying shuttle which interlinks the core to be wound, an electrical conducting shuttle having a transverse gap therein, at least one insulator in the periphery of said shuttle extending across said gap to secure rigidity in said shuttle, a condenser in electric series connection with said shuttle and the wire thereon, including any which has been transferred to said core, to form an LC circuit, a signal generator connected to said LC circuit for supplying energy thereto and means connected to said circuit and said generator for indicating the relative phase of the potential developed across said condenser and wire with respect to the current in said generator.

5. The combination in accordance with claim 4 including a first adjustable resistor adapted to be connected to replace said LC circuit and a second adjustable resistor in series with said generator and said LC circuit, and said second resistor being in series with said first resistor and said generator when said LC circuit is replaced.

6. The combination in accordance with claim 1 including a calibrating circuit comprising a standard impedance and switching means operative to interchange said calibrating circuit and at least the portion of said first-mentioned circuit including said coil and wire.

7. A mechanism for use in a machine for winding toroidal coils comprising an electrically conducting winding ring having a transverse gap therein, the periphery of said ring having a circular and an elongated recess each extending inwardly of the ends of the winding ring defining said gap, and a circular and an elongated insulator respectively spanning the gap and adapted to fit into the circular and elongated recesses.

8. The winding ring of claim 7 wherein the elongated insulator has lobes on the ends thereof.

9. A mechanism for use in a machine for winding toroidal coils comprising a one-piece winding ring having a transverse gap therein, said ring having flanges on both edges thereof, the periphery of said ring having a circular recess disposed inwardly in the ends of the winding ring forming said gap and a circular insulator adapted to span the gap and to fit into said recess, one of said flanges having a peripheral recess also disposed inwardly in the ends of the winding ring forming said gap and an insulator adapted to span the gap and to fit into said recess, and a spring-biased wire guide and tension slidably mounted on the other of said flanges.

10. A mechanism for use in a machine for winding toroidal coils comprising a one-piece winding ring having flanges on the edges thereof, said ring having a transverse gap therein adapted to be opened to receive toroidal cores to be wound, one of said flanges having an elongated recess in the end portions of the ring defining said gap, an insulator adapted to fit in said recess, the periphery of said ring having a circular recess also located in the end portions of the ring defining said gap and an insulator adapted to fit into said recess whereby the ring is prevented from longitudinal, radial and transverse movement by the cooperative action of said insulators.

11. A mechanism for use in a machine for winding toroidal cores of the type employing an annular wire-carrying shuttle which interlinks a core to be wound comprising an electrical conducting shuttle having a transverse gap therein, insulators spanning said gap for securing rigidity in said shuttle, a capacitor in electrical series connection with the core, shuttle and wire thereon for forming an LC circuit, a signal generator connected to supply energy to said circuit and a resistor in series with said generator and circuit, a cathode ray tube having horizontal and vertical deflecting plates, horizontal and vertical amplifiers connected to said plates, a phase shifter connected to one of said amplifiers and a plurality of connections across said generator and said circuit for supplying energy to said amplifiers and tube whereby said tube indicates the relative phases across any two pairs of said connections.

12. In combination with a toroidal core winder which includes means for rotating an annular shuttle which interlinks the core to be wound, supervisory means for controlling the inductance of a coil to be wound comprising a conducting wire-carrying shuttle adapted to be rotated by said winder and thereby to transfer said wire to a core to be wound, said shuttle having a gap in the periphery thereof, means for connecting to said shuttle the end of the wire wound thereon, a circuit including an impedance element adapted for connection through said coil, shuttle and the wire thereon, terminal points adapted for the connection thereto of a source of electrical current of known frequency connected to supply said circuit and means for indicating the relative phase of the potential developed across said impedance, coil and wire with respect to the current in said circuit.

13. The combination claimed in claim 12 wherein the impedance element is a condenser.

14. In a toroidal core winding machine of the type employing an annular wire-carrying shuttle which interlinks the core to be wound, an electrical conducting shuttle having a transverse gap therein, at least one insulator in the periphery of said shuttle extending across said gap to secure rigidity in said shuttle, a condenser in electric series connection with said shuttle and the wire thereon, including any which has been transferred to said core, to form an LC circuit, terminal points to which an electric current of known and stable frequency is adapted to be connected to said LC circuit for supplying energy thereto and means connected to said circuit for indicating the relative phase of the potential developed across said condenser and wire with re-

spect to the stable frequency current supplied at the terminals.

15. The method of winding insulated wire upon a closed ferromagnetic core to an accurate inductance value which comprises stripping one end of such wire from a wire supply, leading said one stripped end to contact an electrically conducting part of a split ring shuttle forming part of a machine for winding wire upon a closed core, winding a quantity of such wire from said wire supply upon said shuttle, providing another stripped and severed end for said shuttle wound wire, leading said other stripped and severed wire end through the core and connecting said other wire end to a terminal of an inductance measuring device, establishing an electrical connection between said shuttle conducting part and a second terminal of said measuring device, revolving said shuttle in interlinked relation to said core as a winding operation, and stopping said machine and terminating the core winding when said measuring device indicates a desired inductance value whereby a core may be wound accurately to a desired inductance value without inductance tests prior to or subsequent to said winding.

16. In combination, a machine for winding wire upon a closed ferromagnetic core, said machine including a split ring shuttle having at least part thereof of electrically conducting material, said shuttle being adapted to have a predetermined amount of wire thereon prior to winding and, from which the wire is wound upon said core, a device for measuring inductance, said device having two terminals, means for connecting one terminal of said device to said shuttle ring conducting part, said connecting means including a wiping contact, the outer end of said shuttle wound wire being adapted to be threaded through said core at the start of a winding operation and thereafter connected to the other terminal of said inductance measuring device, said core being of the ferromagnetic type and said device measuring inductance values of the order usual in a closed ferromagnetic core type of winding, the entire length of wire initially upon said shuttle ring being connected throughout the entire winding operation to said inductance measuring device, the wire upon said shuttle ring having such few turns relative to the finished winding upon said core and the shuttle ring having such low effective permeability compared to said core that the inductance of wire when on said shuttle ring is negligible compared to the inductance of the winding upon said core.

17. The method of winding insulation covered wire to a desired inductance value upon a closed path ferromagnetic core which comprises wrapping upon a conducting shuttle member a length of wire at least equal to that required to produce a desired value of inductance when wrapped upon the core, stripping one end of the wire of insulation covering and electrically connecting the stripped wire end to the shuttle, interlinking the shuttle forming part of a machine for winding wire with the ferromagnetic core, stripping the insulation from the end of the wire leading from the shuttle to wind on the core and connecting the so-stripped end to a terminal of an inductance determining device, establishing an electrical connection between the conducting shuttle and a second terminal of the inductance determining device, revolving the shuttle in interlinked relation to the core as a core winding operation and terminating the core winding operation when the inductance determining device indicates the desired inductance value whereby a core may be wound accurately to a desired inductance value without inductance tests prior to or subsequent to said core winding.

18. In combination with a core winder which includes means for rotating an annular shuttle, means for determining the inductance of a coil to be wound upon the core including a conducting wire-carrying shuttle adapted to be rotated by said rotating means thereby to transfer wire carried upon the shuttle to the core to be wound, means for connecting the end of the wire wound upon the shuttle to establish an electrical connection between the wire and the shuttle, an indicating circuit adapted for connection through the coil, the shuttle and the wire wound thereon, terminal points adapted for the connection thereto of a source of alternating current to supply the indicating circuit and means for indicating concurrently with the coil winding operation the relative inductance of the coil being wound to a desired value of inductance.

19. In combination with a mechanism for winding wire from an annular shuttle member upon a ferromagnetic

9

core having a closed magnetic path and which mechanism includes means for rotating the annular shuttle relative to the core, means for determining the inductance of a coil to be wound upon the core including a conducting wire-carrying shuttle adapted to be rotated by said rotating means thereby to transfer wire carried upon the shuttle to the core to be wound, said shuttle having a peripheral joint to permit shuttle opening prior to the winding operation to link therewith the core and to provide thereafter the closed annular shuttle, means for connecting the end of the wire wound upon the shuttle to establish an electrical connection between the wire and the shuttle, an indicating circuit adapted for connection through the coil,

10

the shuttle and the wire wound thereon, terminal points adapted for the connection thereto of a source of alternating current to supply the indicating circuit and means for indicating concurrently with the coil winding operation the relative inductance of the coil being wound to a desired value of inductance.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
1,921,869	Ewald	Aug. 8, 1933