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J. M. COFFIN ET AL

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SENSING DEVICE FOR TURNS COUNTING

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2 Sheets-Sheet 2

FIG-3

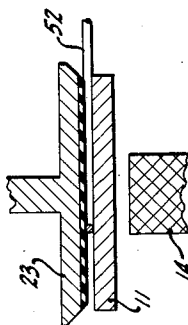
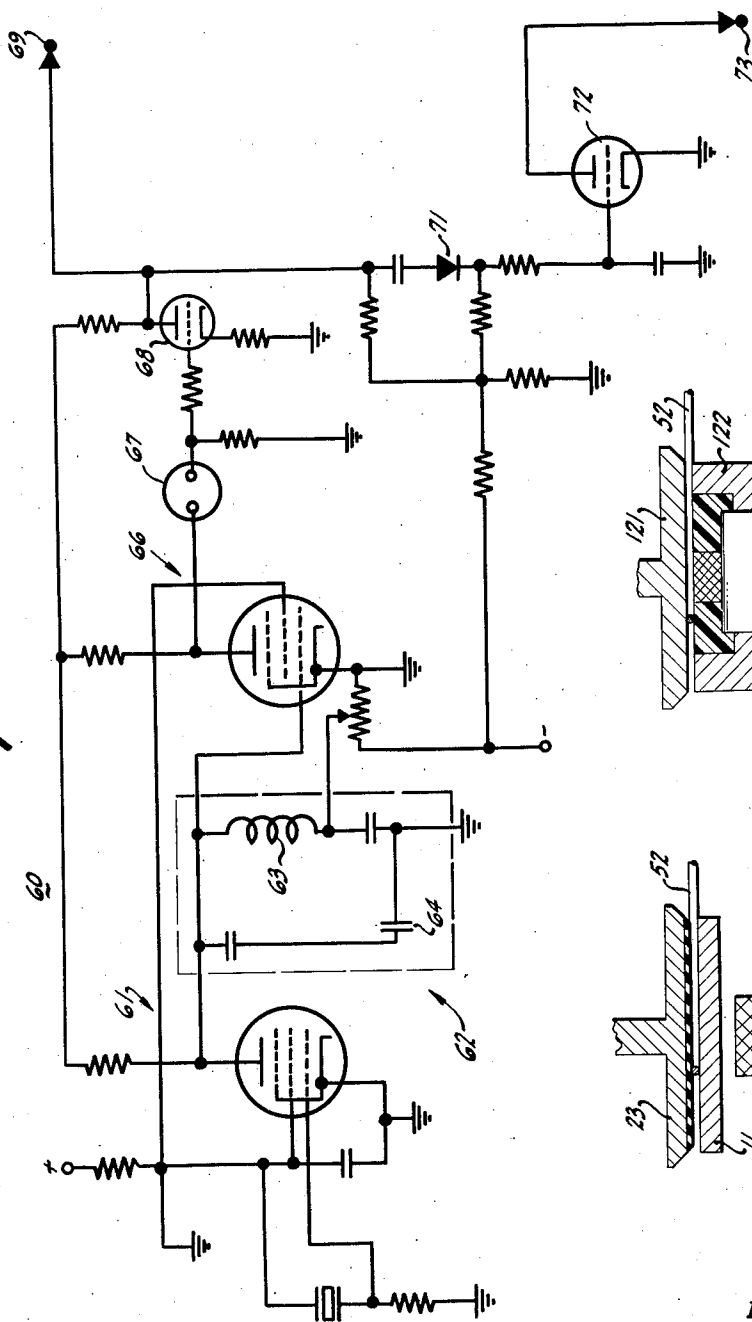


FIG-2

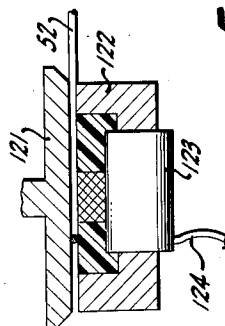


FIG-5

INVENTORS
JOHN M. COFFIN
BY ADAM G. EWING

Lippincott & Ralls
ATTORNEYS

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SENSING DEVICE FOR TURNS COUNTING

John M. Coffin, Menlo Park, and Adam G. Ewing, San Carlos, Calif., assignors to Lenkurt Electric Co., Inc., San Carlos, Calif., a corporation of Delaware
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The present invention relates to apparatus for sensing the number of turns of wire being wound upon a core and is particularly directed to the production of a measurable electrical phenomena upon the winding of each turn of wire upon a toroidal core in the manufacture of precision wound coils. Specifically, the invention is concerned with the production of a variation in the characteristics of an electrical circuit element for each turn of wire wound upon a core. While the invention is not limited to any particular type of coil, it is primarily advantageous in connection with winding toroidal coils and such coils are hereinafter referred to only as coils.

In the manufacture of precision-wound coils it is necessary to determine very accurately the number of turns of wire which must be wound upon any particular core to produce the desired coil characteristics and also to control accurately the number of turns of wire which are actually wound upon the core in order to provide an identity between the desired winding and the wound coil. For conventional solid-core coils, it is only necessary to employ shaft revolution indicators to determine the number of turns of wire wound about the core during winding operations, however, turns information for toroidal coils poses a much greater difficulty.

There are known in the art various devices and apparatus for evaluating cores, so that the number of turns of winding which should be provided thereabout to attain a desired inductance, may be determined. From such information it is then theoretically possible to count the number of turns of wire wound about a core to attain the desired coil characteristics, and it is in connection with this turns counting that the present invention provides a material advancement in the art. The manufacture of toroidal coils can only be economically carried out by high-speed operations wherein a very large number of turns of winding may be provided about cores in extremely short time intervals, so that it is necessary for turns counting to be very rapidly and accurately carried out. For toroidal coils there have been proposed a variety of means for counting the number of turns disposed thereabout during winding operations and in this respect there have been employed microswitches, or the like, which are physically tripped by the passage of wire about a core, and probes which are generally not contacted by the wire being wound. Particularly as regards high-speed coil winding, it has been found that prior art turns counting devices have serious limitations. Thus, for example, physically tripped devices are generally seriously limited in the speed of response and probe devices are found to produce a very low signal-to-noise ratio.

It will be appreciated that the counting of turns wound upon toroidal coils is complicated by the problem that a single revolution of the shuttle does not necessarily establish one full winding turn upon the core. The present invention is particularly directed to an improvement in the sensing of the number of turns formed about toroidal cores in coil winding operations. More particularly, the present invention provides a high-speed variable circuit element which is operable to produce a readily measurable electrical phenomena for each turn of the winding operation, substantially without limitation as to the speed of the operation. The present invention combines the advantages of various prior art electrical systems and physically movable switching systems without the disadvantages of

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either. It is contemplated herein that there shall be provided a variable circuit element such as a capacitor or inductor disposed in close proximity with a core being wound and in such position so that the wire being wound upon the core will pass through the sensing element. This passage of wire is herein employed to establish a very substantial change in the circuit element characteristics forming the sensing unit of the present invention. The present invention further provides for the elimination of difficulties normally arising from rapidly moving parts, for without special precautions, such parts normally tend to chatter or bounce upon rapid movement and such bounce would, of course, cause serious difficulties in precise counting apparatus. While it is possible to utilize the force of gravity in an attempt to overcome the bouncing of mechanical parts rapidly moved together and apart, it has been found that this expedient is unsatisfactory in the counting of winding turns inasmuch as the large weight necessary to achieve a desired gravitational effect is wholly unsuited to be moved by fine wires. Through the utilization in the present invention of a magnetic restoring force, which is known to decrease rapidly with distance, it is possible to prevent chatter of the mechanical parts of the sensing unit of the present invention without forming a substantial obstacle to the passage of wire therethrough.

It is an object of the present invention to provide a positive-acting high-speed sensing unit for turns counting applications in precision coil-winding operations.

It is another object of the present invention to provide for a turns counter, a circuit element having relatively movable portions adapted for physical displacement by engagement with wire passing therebetween to establish a substantial variation in the electrical characteristics thereof.

It is a further object of the present invention to provide a turns counter for winding coils including a circuit element having at least one movable portion operating under the influence of a permanent magnet for positive return to normal position after displacement by engagement with a wire passing through the circuit element.

It is yet another object of the present invention to provide a turns counter for coil-winding operations, including an oscillator circuit having a capacitor or inductor therein with elements thereof movable by physical engagement with wire passing therebetween for each turn of winding to establish electrical signals from each winding turn made.

Various other possible objects and advantages of the present invention will become apparent to those skilled in the art from the following description of a preferred embodiment of the present invention in connection with associated circuitry with which same is adapted to be used. It is not, however, intended to limit the present invention by the terms of the following description, but instead, reference is made to the appended claims for a precise delineation of the true scope of the present invention.

The invention is illustrated in the accompanying drawings, wherein:

FIG. 1 is a transverse sectional view taken in a vertical plane centrally through one preferred embodiment of the sensing device of the present invention;

FIG. 2 is a simplified schematic illustration of the capacitor plates of FIG. 1 encompassing a coil wire during one phase of operation of the invention;

FIG. 3 is a circuit diagram of a signal unit adapted for connection to the capacitor device hereof;

FIG. 4 is a block diagram of a turns count indicator and control unit, adapted to produce automatic winding controls;

FIG. 5 is a simplified schematic illustration of an inductor forming a sensing element in accordance with another embodiment of the invention.

The present invention in brief comprises a circuit ele-

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ment having at least two portions mounted for movement relative to each other, and adapted to have wire passed between such portions to physically displace same for varying certain electrical characteristics of the element, such as the reactance thereof. More specifically, the invention may comprise either an inductor or a capacitor employed as a sensing element for counting the turns of wire wound about a toroidal core. In the instance wherein a capacitor is employed, the two plates of such element are mounted so that they are relatively movable whereby appropriate positioning of the sensing element causes wire being wound upon a core to pass between the plates to physically displace same and to thereby vary the capacitance of the sensing element. In the instance wherein an inductive sensing element is employed, the magnetic core thereof is formed in two parts with one of the parts being movable by the passage of wire between the two parts of the core to thereby materially vary the magnetic circuit of the inductance so as to provide a substantial variation in the inductance of the sensing element for each turn of wire passing through the element. The sensing element of the present invention will thus be seen to provide a substantial variation in electrical characteristics as is caused by physical displacement of one portion thereof with respect to the other, as produced by the passage of wire through the element. This variation in the electrical property of the sensing element may be employed in a variety of ways to produce substantial electrical signals that then may be further utilized in counting equipment or control circuitry. As an example of circuitry that may be associated with the sensing element of the present invention, there is illustrated an oscillator circuit of fixed frequency which varies from resonance upon a change in the electrical characteristic of the sensing element.

In order for the sensing element of the present invention to operate at very high repetition rates as is required in the high-speed winding toroidal coils, it is necessary for the physical portions of the element to move very rapidly and to maintain positions into which they are so moved. The present invention provides magnetic means which precludes any difficulty from mechanical bounce of the physical elements moved by wire therebetween. In the absence of such means, the chatter or bounce produced by rapid opening and closure of the physical portions of the sensing element might well give multiple signals for small displacements of the portions of the element.

Considering now one preferred embodiment of the invention in some detail, and referring to FIG. 1 of the drawings, there will be seen to be provided a first capacitor plate 11 formed of metal and inset into a lower face plate structure 12. This capacitor plate 11 is recessed into the upper surface of the face plate 12, and is maintained out of electrical contact therewith by means of an insulating layer 13, surrounding the edges and underside of the capacitor plate. The face plate 12 is formed somewhat as a truncated cone, having gradually tapering surfaces extending outwardly and downwardly from the lower capacitor plate, which is disposed generally horizontally at the cone truncation. Immediately beneath the lower capacitor plate 11, within the lower face plate 12, there is provided a permanent magnet 14, disposed within a central bore of the lower face plate 12 and insulated from the face plate and from the capacitor plate by a layer of high dielectric material 16. The magnet 14 is oriented with one pole thereof directed upwardly immediately beneath the lower capacitor plate 11, and is maintained in position by means of a plug 17 threaded into the bottom of the lower face plate 12 and insulated from the magnet by such as a washer 18. Immediately above the lower face plate 12 there is provided a mating upper face plate 21, having a concave conical undersurface 22. An upper capacitor plate 23 is disposed across the center of the surface 22, and is mounted for recipro-

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cal motion in the upper plate 21. This mounting may be achieved by the provision of an insulating cylinder 24 extending through a central bore in the upper plate 21, and itself having a central aperture accommodating a stem 26 extending upwardly from the upper capacitor plate 23. Rotation of the upper capacitor plate may be prevented by the provision of a vertically slotted boss 27 into which the capacitor plate stem 26 extends, and a cross spring or element secured to the stem by means of a bolt, or the like, 29. This cross piece 28 is formed of an electrically conducting material such as a metal spring, and is adapted to slide up and down in the slot of the boss 27 with reciprocal motion of the capacitor plate 23.

As regards the physical structure of the two capacitor plates 11 and 23, same are both preferably circular with planar facing surfaces, as illustrated. The upper planar surface 31 of the lower capacitor plate 11 is disposed in a generally horizontal plane in mating relationship with the upper conical surface 32 of the lower face plate 12. The upper capacitor plate 23 which is adapted to move vertically with the passage of a wire or the like between the capacitor plates, is formed with outwardly bevelled exterior edges 33, and is disposed in facing relation to the lower plate 11. A material having a high dielectric constant is disposed between the capacitor plates in a very thin layer upon at least one of the plates, as for example, the illustrated film 36 on plate 23. The film 36 contacts both plates in the lowered or depressed position of the upper capacitor plate 23 so as to thereby define with such plates a capacitor of known capacitance. The upper plate 23 is preferably formed of a ferrous material so as to be drawn toward the magnet disposed below same and in the illustrated embodiment the lower plate 11 is preferably formed of some other conducting material so as not to unduly divert the magnetic field of the magnet.

Electrical connections are made to the two capacitor plates 11 and 23 in order to connect these elements in a signal circuit such as that described below. Connection to the lower capacitor plate 11 may be provided through a bore 41 formed in the lower face plate 12 from a point adjacent the lower extremity thereof, and extending through the insulating layer 13, so that an insulated electrical conductor 42 may be extended through such bore and into electrical contact with the undersurface of the capacitor plate 11. Electrical contact to the upper capacitor plate 23 may be readily formed by connecting a conductor 43 to the cross member or spring 28, secured as above noted, to the stem 26 of this capacitor plate.

It is herein contemplated that the capacitor device described above may be preferably disposed within a shuttle of a coil-winding machine, and there is schematically illustrated in FIG. 1 such a shuttle 51 which will be seen to surround the upper and lower face plates 21 and 12, so that wire carried thereon and wound therefrom onto a core through which the shuttle extends, will thus be passed over the conical surface 32 of the lower face plate 12 of the present invention. This type of wire traverse has been found to be highly desirable in the winding of cores, and in accordance herewith the face plate surfaces 22 and 32 are disposed in parallelism and relatively close separation in order to accommodate the passage of a wire therebetween without binding between the face plates, and yet in minimum separation in accordance therewith. As above noted, the capacitor plates 11 and 23 with the dielectric 36 therebetween, form a capacitor of known capacitance with the upper plate 23 in a position illustrated in FIG. 1 wherein such dielectric film 36 rests upon the upper surface of the lower capacitor plate 11. Winding of wire upon a core by movement of the shuttle 51 about the invention hereof, serves to pass the wire over the upper surface 32 of the lower face plate 12, so that such wire then engages the upper capacitor plate 23. As set forth above, the outer periphery

of this upper capacitor plate is tapered outwardly so that no possible snagging or catching of the wire can result. The weight of the upper capacitor plate 23 must be relatively slight, inasmuch as quite fine coil wires must be capable of engaging the upper capacitor plate at the edge thereof when slid over the upper surface 32 of the lower face plate, so as to push the upper capacitor plate upwardly. The wire passes between the capacitor plates 11 and 23 in its traverse over the upper conical surface of the lower face plate 12, and in such traverse then provides a material separation of the capacitor plates. This variation in the distance between the capacitor plates serves herein to materially affect the capacitance of the capacitor formed of such plates and the dielectric 36. There is in effect interposed between the capacitor plates 11 and 23 a substantial thickness of air having a relatively poor dielectric constant, so that the capacitance of the unit is substantially reduced by the passage of a wire therebetween. The capacitance variation is herein employed in suitable circuitry to provide a control or counting signal whereby the number of wires passing through the capacitor are readily counted.

In order for coil-winding operations to proceed rapidly, it is necessary for the individual turns of the winding to be very quickly wrapped about the core and this then requires a high rate of repetition of wire passing through the plates of the capacitor hereof. In order for the capacitance to vary directly in accordance with the passage of wire between the plates thereof, it is necessary for the plates to rapidly return to normal or closed position wherein they are separated only by the dielectric film 36, following the passage of a wire between the plates. With high repetition rates, it is found that the available weight of the upper capacitor 23 is wholly inadequate to cause same to return to closed position before the wire is again passed between the plates. Rapid closure of the capacitor plates is herein accomplished by means of the permanent magnet 14, disposed beneath the lower capacitor plate 11 and thereby exerting an attractive force upon the upper capacitor plate 23. The upper capacitor plate 23 is formed of a ferrous material such as soft iron, or the like, so that a maximum attractive effect is attained by the utilization of a permanent magnet, as described. The relatively light weight of the upper capacitor plate 23 is herein necessary in order for the wire being passed between the capacitor plates to readily raise this upper plate without undue stress upon the wire, which might otherwise cause same to break. The magnet 14 serves to rapidly return the capacitor to normal or desired capacitance when no wire is actually interposed between the plates thereof. The magnet also provides an adjustable "weight" to prevent bouncing of the upper capacitor plate on the lower one at high rates of operation. As the magnetic field reduces much more rapidly than gravity with distance, the magnet provides an attraction between the plates when they are together that could only be equalled with such a large weight on the upper plate that wire damage would result. It is also possible to employ spring return means in this connection, however, a slower action is then dictated. Thus, for very high-speed operations, it is best suited to employ restoring means such as the permanent magnet illustrated, and it has been found that a repetition rate of wire passage through the capacitor plates of the order of 4,000 repetitions per minute can be readily accommodated by the capacitor indicator hereof, and yet accurately produce variations in capacitance in accordance with each passage of wire through the plates of the indicator.

The physical mounting of the upper and lower face plates wherein the capacitor elements of the present invention are mounted, may be determined by the individual applications of the invention. Thus, for example, the lower face plate 12 may be mounted within a block or the like, which is fixed to a stand upon which coil-winding apparatus is likewise mounted. The upper face

plate 21 may, in turn, be adjustably hinged or otherwise secured to upright or frame members in rigid connection to such base member as noted above. This type of mounting allows for the separation of the face plates in order to inspect the capacitor elements, and also for the adjustment for the spacing between the adjacent surfaces 22 and 32 thereof. It will be appreciated that insofar as the physical structure of the capacitor hereof is concerned, a minimum thickness of the dielectric film 36 is highly desirable in order to attain a maximum capacitance between the plates 11 and 23 of the capacitors. The dielectric material from which the film 36 is formed may be chosen from a wide variety of known dielectric materials. However, it is herein preferable that such materials shall have a substantial wear strength in order not to be unduly eroded or worn by the passage of wire thereover. Additionally, it is desirable that such material shall have a relatively slick surface in order not to provide any unnecessary drag upon wire passing thereover. In this respect it has been found that material such as Teflon and nylon are highly suited for the dielectric film 36 of the capacitor hereof.

There is illustrated in FIG. 2 the relative disposition of the upper and lower capacitor plates of the present invention when same are separated by a wire 52 in the process of passing between these plates. Passage of the wire 52 is accomplished by winding mechanism forming no part of the present invention and including, for example, such elements as the shuttle, schematically illustrated in FIG. 1. It may be readily appreciated from the illustration of FIG. 2, that the capacitance existing between the plates 11 and 23 is materially decreased by the passage of wire therebetween inasmuch as the plates are then separated by an additional layer of air.

Translation of the capacitor plate relative motions into counting or control signals may be accomplished by the provision of an electrical circuit including the capacitor as an element thereof, whereby variations in capacitance of such element produce, for example, frequency modulations of a signal. Appropriate detection means may then be driven by such frequency-modulated signal to produce count signals or control signals by means of which a register, or the like, may be energized or winding operations may be controlled. In this respect reference is made to FIG. 3 of the drawing, wherein there is illustrated a circuit suitable to produce both counting and control signals from the capacitor illustrated in FIG. 1 of the drawing. The circuit of FIG. 3 will be seen to include a crystal oscillator 61 producing a fixed frequency output and connected to a resonant output circuit 62. This output circuit includes an inductance 63 and capacitance 64, which is formed by the capacitor plates 11 and 23, described above. The output circuit 62 is tuned to resonance for the capacitance of the capacitor 64 with the plates 11 and 23 thereof closed, i.e., separated only by the dielectric film 36 of the capacitance. Variations of the value of the capacitance 64 will thus be seen to de-tune the resonant circuit 62, and there is provided a detector tube 66 connected to this output circuit 62 of the crystal oscillator 61. The detector tube 66 serves to produce signals responsive to de-tuning of the resonant circuit 62, so as to thereby cause a neon tube 67 to light, and to thereby pass a control signal to an output tube 68. This output tube 68 serves to produce output voltage pulses, which are applied to a counting output terminal 69. This output voltage is also applied through a rectifier 71 to maintain a vacuum tube 72 conducting. Continued conduction of the tube 72 is indicative of continued counting by the above-described circuit, as is caused by the continued passage of wire through the capacitor thereof, and thus this tube 72 may be employed to control winding operations. Failure of the circuit to receive or generate signals in accordance with variations in the capacitance of the capacitor 64 may be indicative of a break in the wire being wound upon a core, and thus the tube 72 may serve to operate as a wire break signal indicator,

with the output of this tube being connected to an output terminal 73 for control purposes.

The counting and control signals which are provided by circuitry such as illustrated in FIG. 3, and described above, may be further employed in the automation of coil winding, for example in the manner illustrated in FIG. 4 of the drawings. The signal generator circuit 69 of FIG. 3 is illustrated in FIG. 4 with the output terminal 73 thereof being connected to a winding of a wire break relay 81; the contacts of such relay being adapted for connection in control circuitry of a winding motor operating mechanism winding wire about a core. Cessation of counting signals will cause the tube 72 to cut off, so as to remove the output voltage from the terminal 73, whereby the wire break relay 81 will release the contact of such relay so as to de-energize a winding motor and, consequently, stop winding operations as a result of wire breakage. The counting terminal 69 of the signal generator is illustrated in FIG. 4 as being connected to a count circuit 82, with such connection being accomplished through a coupling capacitor 83 to such as the cathode of a drive tube 84 in the count circuit. The count signal applied to the output terminal 69 of the signal generator is differentiated by the coupling capacitor 83 and a cathode resistor 86 of the drive tube 84, so as to thereby operate the drive tube 84 for actuation of one of a series of counting tubes 87. The circuit of the counting circuit 82 may be quite conventional in including a plurality of counting or registering tubes 87 with output connections therefrom extending to a plurality of decade switches in a switch unit 88. The signals applied to each of the ten electrodes of each of the registering tubes 87 are also applied through output connections 89 of the counting circuit to separate decade switches within the switch unit 88. These decade switches are herein preset to particular positions, in response to a switch control circuit 91 mechanically ganged to the decade switches. A receiver 92 receives winding information from such as a permeameter and associated circuitry illustrated by the box 93 in FIG. 4. Precision-winding of coils is accomplished by pre-testing of each of the cores to be wound upon such as a permeameter and producing from such test control signals indicative of the number of turns of winding which must be provided about such core in order to achieve a desired inductance of the coil wound therefrom. A permeameter suitable for this use is disclosed in the copending application of John M. Coffin et al., Serial No. 801,874, filed in the U.S. Patent Office on March 25, 1959, entitled "Core Testing Device," and now Patent No. 2,970,255, and control signals may be produced from such a device by circuitry such as that disclosed in the copending application of Jay R. Semelman entitled "Permeability Evaluator," and filed in the U.S. Patent Office on September 21, 1959, with Serial No. 841,281.

The turns information from the permeameter and associated circuitry 93 is herein transmitted to a receiver 92 which, in turn, operates the switch control means 91 for presetting the decade switches of the switch unit 88. By the application of the turns count from the counter 82 to the preset decade switch unit 88, it will be appreciated that a coincidence between the required number of turns and the actual number of turns accomplished will occur in the switch unit. This coincidence may be readily employed to produce output signals for controlling the winding operation. In accordance herewith, the decade switching unit is conventionally wired to produce an output signal at the coincidence of turns counts and preset turns information at a terminal 94. An additional output terminal 96 is herein energized at a preselected number of turns prior to the coincidence of desired turns and turns actually made by the presetting of the decade switches, preferably a separate deck thereof appropriately prewired. The output terminal 96 may be connected to a relay 97, so as to maintain the contacts thereof closed until the application of a signal thereto, whereupon such

contacts open to operate winding control mechanism for reducing the speed of winding prior to actual termination of a winding operation. The output terminal 94 may be connected to another relay 98, so that the production of a signal at the output terminal 94 will produce an energization or actuation of this relay to open the contacts thereof and de-energize apparatus performing the winding operation. In the instance wherein it is desired to visually compare the number of counts desired with the number of counts made during winding operations, there may be additionally provided a register 99, connected to the switch control 91 and serving to visually indicate the number of turns to be wound upon each particular coil as such information is obtained at the receiver 92 from the permeameter and associated circuitry 93.

Operation of the control and indicating circuit of FIG. 4 follows directly from the generalized description thereof. Assuming a winding operation to be performed by a suitable coil-winding apparatus adapted for control by electrical signals, precision winding is preceded by appropriate testing of the core in a permeameter 93. From such permeameter there is produced turns information indicative of the number of turns of winding to be disposed about such tested core to produce a required inductance thereof. This information is transmitted to a receiver 92 which, in turn, is connected to and operates switch control means 91 to physically move elements thereof which are mechanically ganged to a plurality of decade switches within the switch unit 88. This turns information is thus employed to preset the contacts of decade switches with the stationary contacts of said switches being wired through contacts 89 to a counting unit 82, which is adapted to receive count signals in response to turns being wound upon the core. With the commencement of the actual winding operation, each turn of wire wound about a core passes over the conical surface 32 of the lower face plate 12 of the device illustrative in FIG. 1 and consequently operates to displace the capacitor plates 23 and 11 from each other so as to thereby vary the capacitance of the output circuit 62 of the crystal oscillator 61. Each turn of the windings serves to raise the upper capacitor plate 23 and consequently to vary the capacitance of the capacitor 64, and a very rapid return of this upper capacitor plate is herein accomplished by the restoring force of the permanent magnet 14. De-tuning of the output circuit 62 of the oscillator 61 is detected by the detector tube 66 of the circuit of FIG. 3 and serves to produce an output pulse at the count terminal 69 of this circuit. As long as the turns counter continues to produce de-tuning of the oscillator output circuit, the positive going portion of the output pulse of the tube 68 is rectified and serves to maintain the tube 72 conducting. Continued conduction of this tube 72 thereby applies a continuous signal to the output terminal 73, whereupon the wire break relay 81 is maintained energized so that winding operations may continue. Should a wire break during a winding operation, no further counts will pass through the tube 68, and consequently after a predetermined time delay the output signal will disappear from the wire break relay so as to cause such relay contacts to open and thereby immediately stop the winding operation. Continuation of winding, as normally occurs in the absence of faults such as breakage of the wire, causes continued signals to be applied to the counting circuit 82 from the signal generator 69, and such signals are therein visually indicated upon the register 87 and also applied through the conductors 89 to the switch unit 88. As the count of turns wound reaches a preselected number less than the required number of turns for the coil being wound, certain decade switch contacts are energized which are contacted by the movable contact of the switch deck and there is produced a signal at terminal 96 to slow down winding operations. A coincidence between the number of turns wound and the number desired energizes switch

contacts engaged by other movable contacts to produce a signal at terminal 94 as stop winding operations.

As noted above, numerous variations are possible in the present invention without departing from the true spirit and scope thereof. In this respect the circuitry for producing electrical signals in response to variations in electrical characteristics of the sensing element of the invention may be alternatively comprised. For example, instead of the fixed frequency oscillator illustrated in FIG. 3 of the drawings, there may be employed other types of oscillating circuits or, alternatively, there may be employed such as balanced bridge circuits. It is not necessary for the signal generating circuitry hereof to be composed of vacuum tube circuitry and instead there may be utilized fully electromechanical devices in this respect. Additionally, the sensing element of the present invention may be comprised of an inductor rather than the capacitor element illustrated in FIGS. 1 and 2 of the drawings.

As regards the physical structure of the sensing element of the present invention wherein same is alternatively embodied as an inductor, reference is made to FIG. 5 of the drawings. There is schematically illustrated in FIG. 5 a simplified sensing element formed of an inductor. As shown in FIG. 5, the sensing element, which is adapted to fit into the structure of FIG. 1 in the same manner as the capacitive sensing element of FIG. 2, includes a movable upper portion 121 and a lower stationary core member 122. The members 121 and 122 in combination form a magnetic core for an inductance and are thus preferably formed of a ferromagnetic material. A winding 123 is disposed about the lower core portion 122 in convention fashion and electrical connections 124 extend from the opposite ends of this winding 123. The lower core portion 122 may have a U-shape, as illustrated, with the upper core portion 121 comprising only a flat plate adapted to extend between the terminal ends of the U to thereby provide a closed magnetic loop through the winding 123 in the lowered position of the upper core member 121.

Operation of this embodiment of the present invention directly follows the above-described operation of FIGS. 1 and 2 of the drawing. Thus, a wire 52, which may be passed between the structural elements of the sensing device, is adapted to pass between the upper and lower core members 121 and 122 respectively as wire is wound about a toroidal core. With the wire 52 passing through the inductive sensing element, it will be seen that the wire physically separates the core portions by raising the upper core portion 121 so as to consequently produce a substantial variation in the reluctance of the magnetic path through the inductance core formed of the elements 121 and 122. This substantial variation in the magnetic core properties is reflected by a substantial variation in the inductive reactance of the winding 123 so that by the connection of appropriate circuitry to this winding it is possible to produce electrical signals responsive to the change in electrical characteristics of the sensing element as is brought about by the passage of wire there-through. In this embodiment of the present invention there is also employed a magnetic attractive force upon the upper core element 121 so as to urge same into direct contact with the lower core portion 122. The magnetic force may be herein produced by the flux passing through the core parts 121 and 122 or, in those instances wherein such is insufficient, a permanent magnet 14 may be employed. In the same manner as discussed above, this magnetic restoring force serves to rapidly return the core portions into physical contact and also to prevent bouncing of the upper core portion upon the lower core portion during high speed winding operations. By the provision of a suitable number of turns of winding 123, it is possible with this embodiment illustrated in FIG. 5, to achieve a maximized variation in electrical characteristics of the sensing element and for certain applica-

tions the inductive sensing element is preferable to the capacitive sensing element disclosed above and illustrated in FIGS. 1 and 2 of the drawings.

The turns count indicator hereof serves to produce count information for very rapid coil-winding operations, and furthermore, serves to produce a very high signal-to-noise ratio, inasmuch as a very substantial capacitance variation is produced by the counting device, so that a minimization of circuit complexity is herein obtained. Furthermore, the complexity of the actual capacitor unit employed to produce capacity variations in accordance with turns accomplished will also be seen to be minimized, so that the end result is a highly practical and advantageous unit, which is not only suited to the provision of turns count indications, but also to the more comprehensive application of full coil-winding automation, as generally indicated in the above description.

What is claimed is:

1. A sensing element for turns count indication comprising a circuit element divided into two parts, said element having electrical characteristics with two parts thereof together which are different from such characteristics with the two parts separated, means mounting said circuit element with one part thereof movable with respect to the other, guide means adjacent said element and leading to the junction of the parts thereof to direct wire between said parts during coil winding for physically separating the parts of said element during wire passage, a magnet urging said parts together, and electrical circuitry connected to the circuit element and producing electrical signals responsive to variations in electrical characteristics thereof.

2. A turns count indicator comprising a reactive sensing element including two separable portions and having a different reactance when separated than when together, a magnet urging the portions of said sensing element together into normally contacting relation, means mounting said sensing element in position to intercept successive turns of wire being wound upon a core and mounting one of said portions in movable relation to the other whereby each turn of wire separates the portions of said sensing element to vary the reactance thereof, and an electrical circuit connected to said sensing element and producing electrical signals in response to reactance variations.

3. A turns count indicator comprising a capacitor having a pair of plates having a thin dielectric film therebetween, means mounting one plate of said capacitor for reciprocal movement normal to the other plate in contacting relation thereto, means directing successive turns of wire between said plates to briefly separate same by the passage of winding turns therebetween, and restoring means rapidly returning said plates together.

4. A turns count indicator comprising a conical member having a truncated upper portion forming a stationary capacitor plate, a movable capacitor plate disposed in spaced relation to said stationary plate and separated therefrom by a dielectric film, means mounting said movable capacitor plate for reciprocation normal to the stationary plate as forced by the passage of wire between said plates, and a magnet disposed to urge said capacitor plates together for rapidly restoring said movable plate to a position adjacent said stationary plate following passage of a wire therebetween whereby the capacitance of the indicator is rapidly varied with each turn of wire passing between the plates.

5. A turns count indicator as claimed in claim 4, further comprising an oscillator having an output circuit including said capacitor plates and tuned to resonance at the capacitance of said plates together, and detecting means producing count signals for each de-tuning of said oscillator output circuit.

6. A turns counter comprising a capacitor including a pair of relatively movable plates and magnet means urging said plates together, a dielectric film disposed upon

the surface of at least one of said plates whereby said plates provide a maximum capacitance at minimum plate separation, a tuned circuit including said capacitor plates, an oscillator feeding said tuned circuit, detecting means connecting to said tuned circuit and producing output signals responsive to de-tuning of said circuit as results from the separation of said capacitor plates produced by the passage of wire turns therebetween, and registry means connected to said detection means for visually indicating the number of plate separations as a count of the number of turns of wire wound upon a coil by the passage of each turn between said plates.

7. A turns count indicator comprising a pair of elements disposed adjacent coil-winding apparatus in position to intercept wire wound upon a core whereby each turn of wire passes over the surface of one of said elements and between said elements, a capacitor formed of a first plate disposed in inset relation upon the surface of the lower of said elements and the second plate mounted for reciprocation upon the upper of said elements to move into and out of capacitive relationship with the first of said capacitor plates, magnet means urging the second of said capacitor plates into capacitive relationship with the first of said capacitor plates, and electrical connections extending from each of said capacitor plates together with means insulating said plates from said elements whereby the passage of wire over the lower of said elements engages said second capacitor plate to move same away from the first capacitor plate whereby the capacitance between said electrical conductors is decreased for each wire passage, so as to produce an electrical phenomenon of measurable amplitude indicative of each turn of wire wound upon a core.

8. Indicating apparatus for coil winding, comprising means defining a conical slot adapted for disposition in juxtaposition to coil-winding apparatus whereby wire passes through said slot for each turn of wire wound, a capacitor including a pair of insulated plates respectively disposed within said members on opposite sides of slot and having a layer of high dielectric material between said plates, one of said plates being formed of a ferrous material and being mounted for reciprocation normal to the other plate for opening and closing said slot, a permanent magnet mounted to urge said plates together, and electrical connections extending from said plates for connection in a signal circuit to vary the capacitance of same for each passage of wire through said slot.

9. Indicating apparatus as claimed in claim 8 further defined by said movable capacitor plate having a stem extending therefrom into a bore for reciprocal plate mounting and further having the plate periphery inclined upwardly and outwardly for engagement by wire passing through said slot without snagging of the wire.

10. Capacitive indicating means comprising upper and lower elements having extended mating parallel conical surfaces disposed in separated facing relation for defining a slot, said elements being adapted for disposition adjacent coil-winding apparatus to intercept wire wound upon a core whereby each turn of wire passes through said slot, a first planar capacitive plate inset in the upper face of said lower element of truncating same, insulating means about said capacitor plate and insulating same from said element, a ferrous planar second capacitor plate mounted for free reciprocation in insulated relation within a bore in said upper element and facing said first capacitor plate, a layer of dielectric material between said capacitor plates to form a capacitance thereof whereby wire passing through the slot defined between said elements raises said second capacitor plate in passage between the plates to materially reduce the capacitance of said capacitor, electrical leads connected to said first and second plates, and a permanent magnet mounted in one of said elements and urging said second capacitor plate toward said first capacitor plate for minimizing return time of said upper plate following passage of wire between the plates.

11. A turns count indicator producing a signal for each turn of wire wound upon a core and comprising an inductor having a core with a winding about a portion thereof, said inductor core having two separable parts having a first position in physical proximity and a second position in physical separation, wire guide means leading to the juncture of said two inductor parts and disposed in position to intercept wire as same is wound on a toroidal core whereby each turn of wire physically separates the core parts, a magnet urging said core parts together, and means responsive to variations in the inductance of said inductor for counting turns of wire wound upon a toroidal core.

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