United States Patent

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[73] Assignee **Leesona Corporation**

[54] **COIL WINDER AUTOMATICALLY SEQUENCING MULTIPLE PRESET WINDING SELECTIONS**
10 Claims, 8 Drawing Figs.

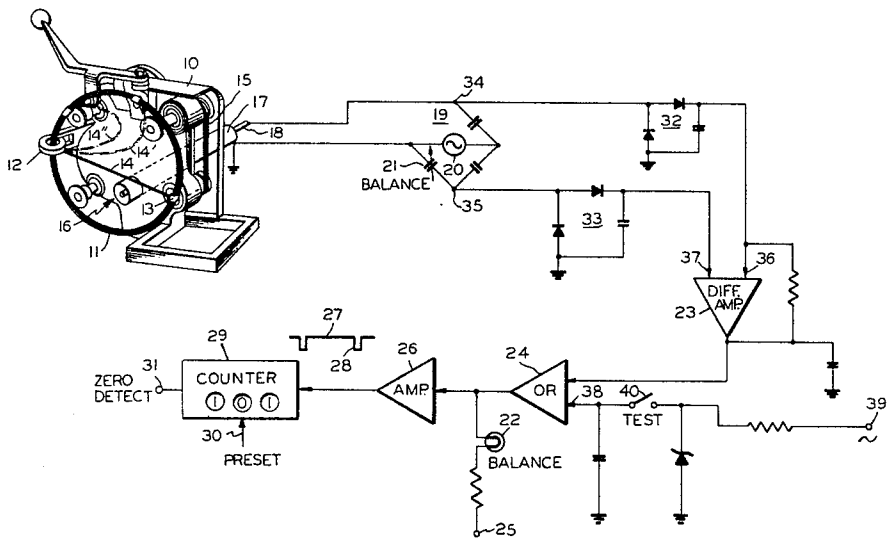
[52] **U.S. Cl.** **242/4,** 235/151.1
[51] **Int. Cl.** **H01f 41/08**
[50] **Field of Search** 242/3, 4, 5, 7.01, 7.02; 235/151.1

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ABSTRACT: A toroidal coil winder is disclosed with electronic turn counter equipment and preset turn count registers, including program control circuits for automatically stepping through an ordered array of turn count registers for successive windings on a single core.



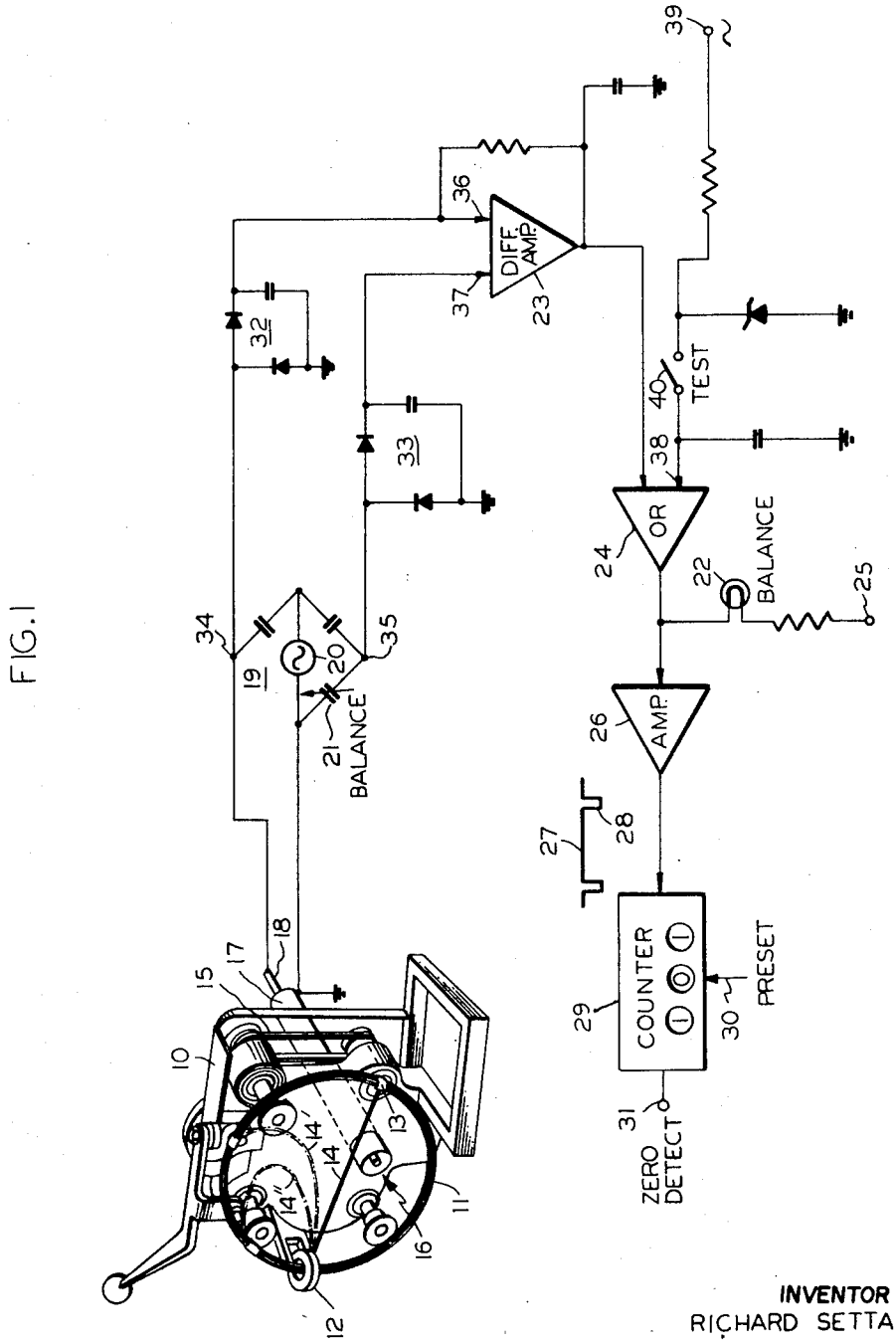


FIG. 1

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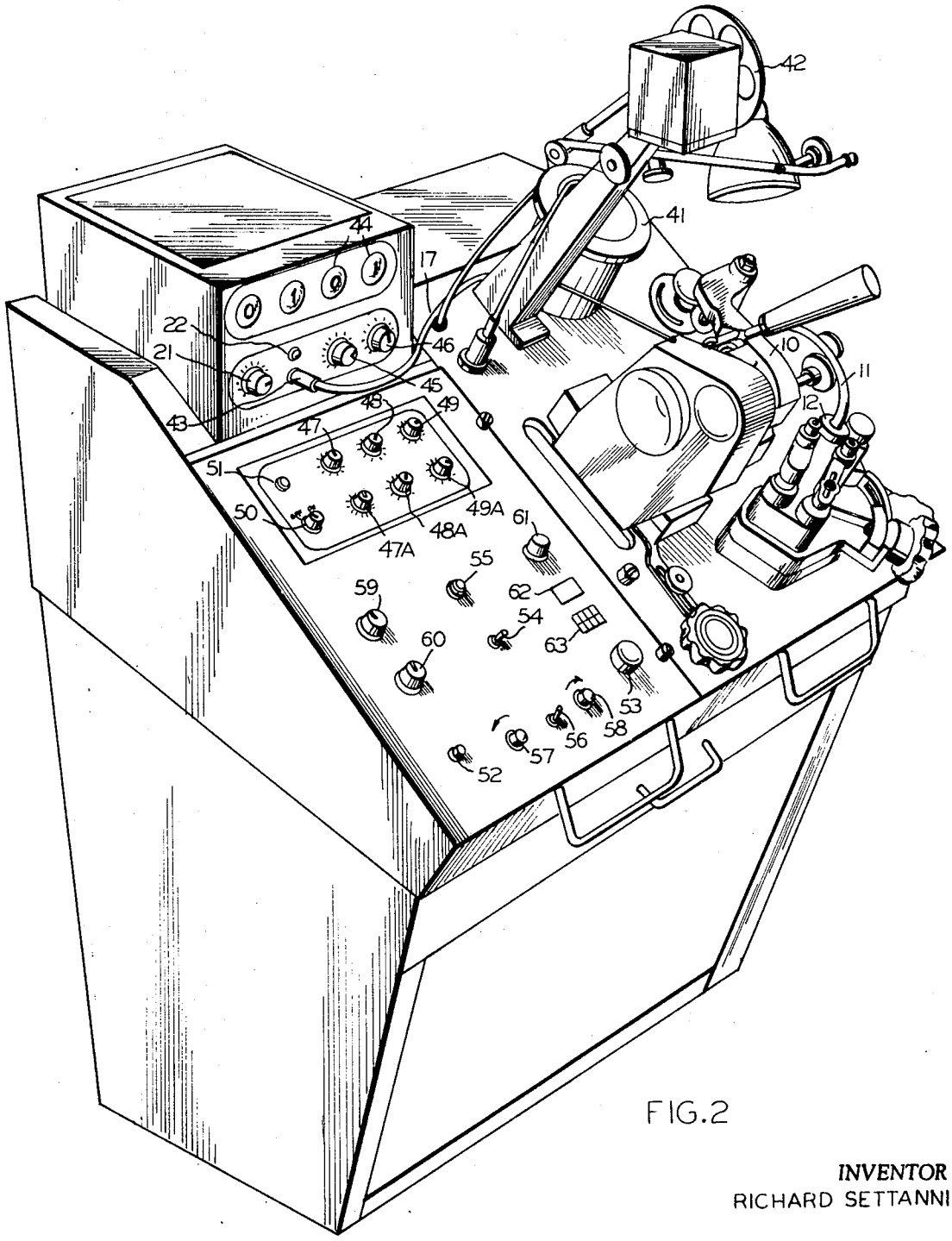


FIG.2

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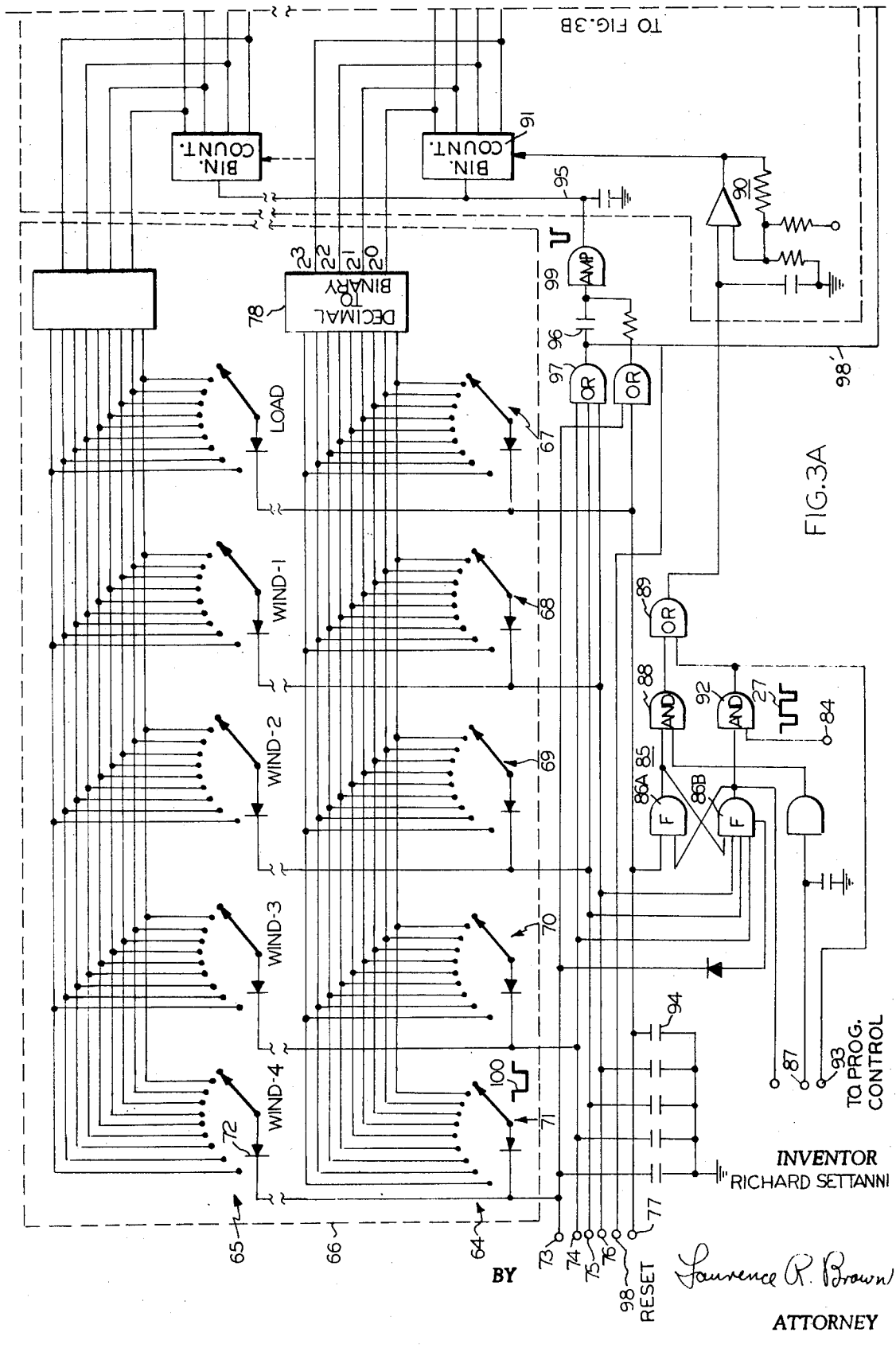


FIG. 3A

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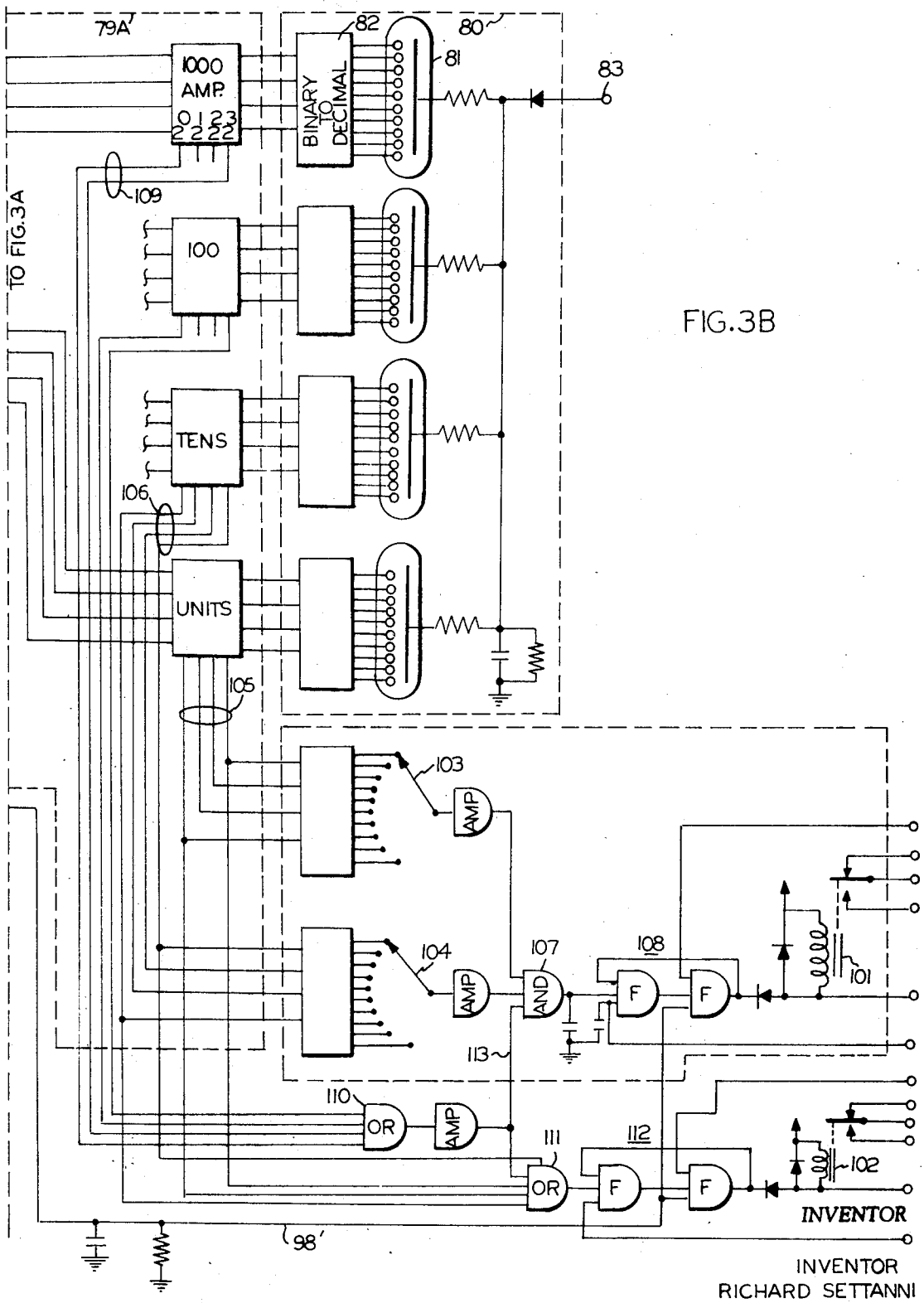


FIG.3B

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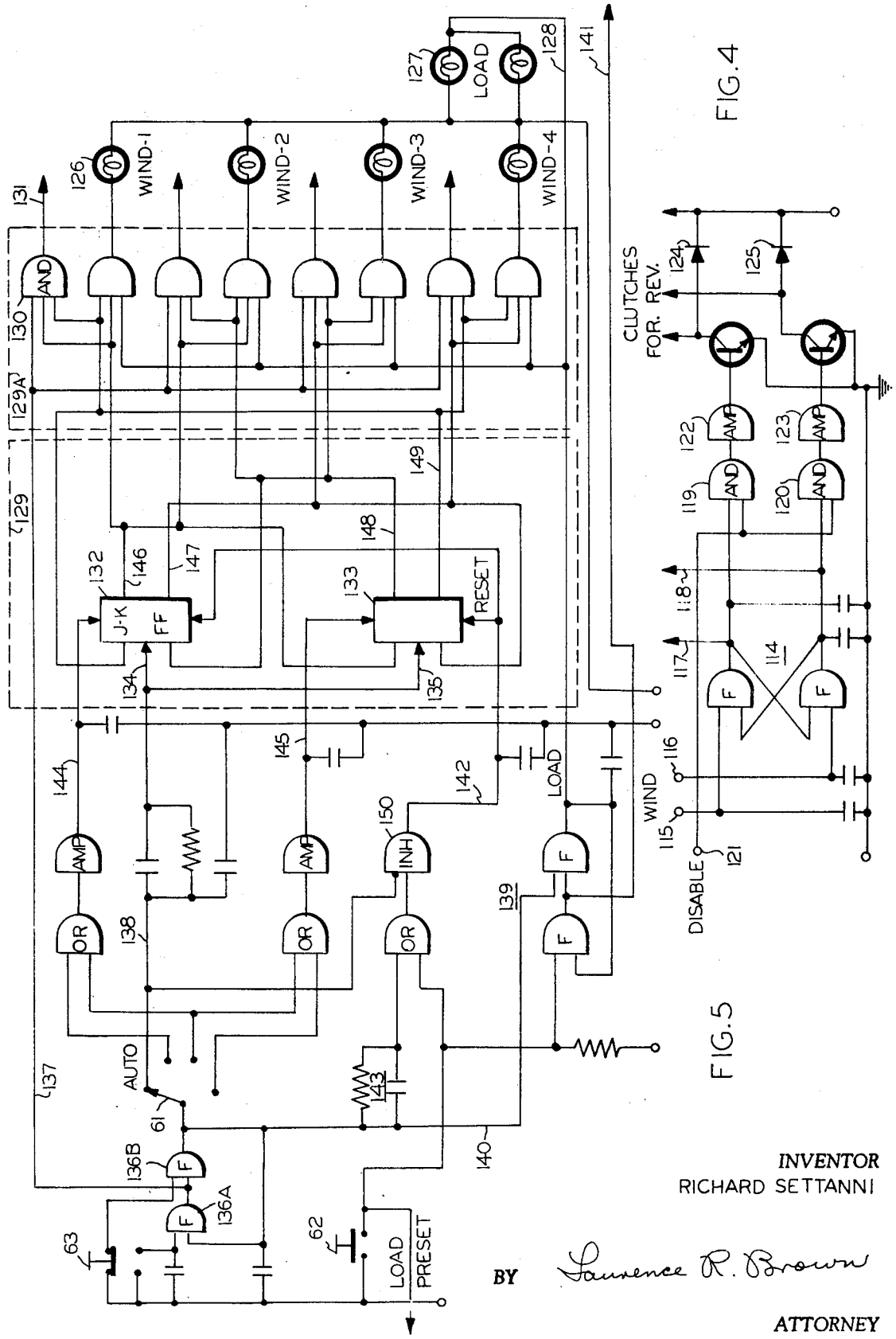


FIG. 4

FIG. 5

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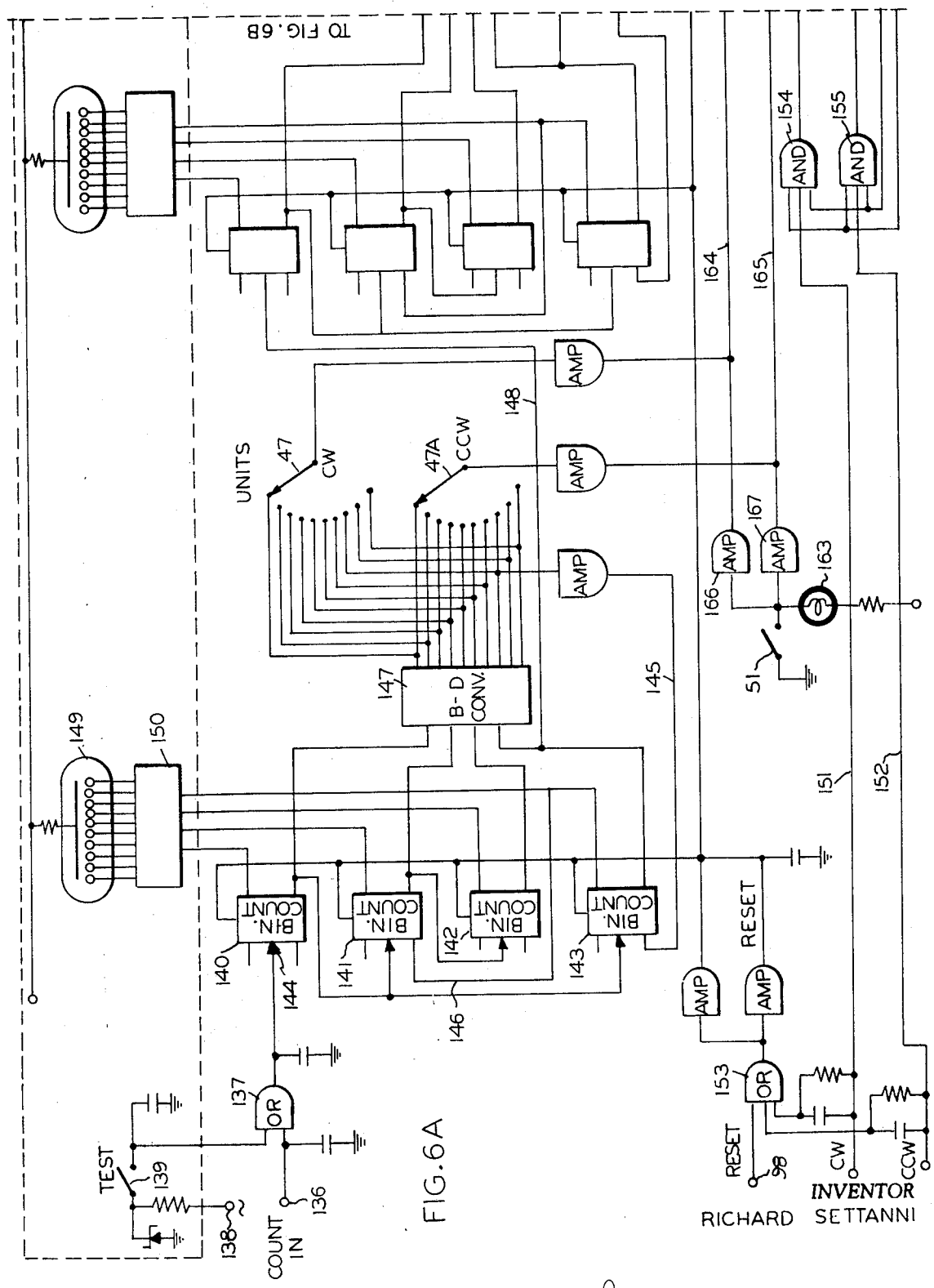


FIG. 6A

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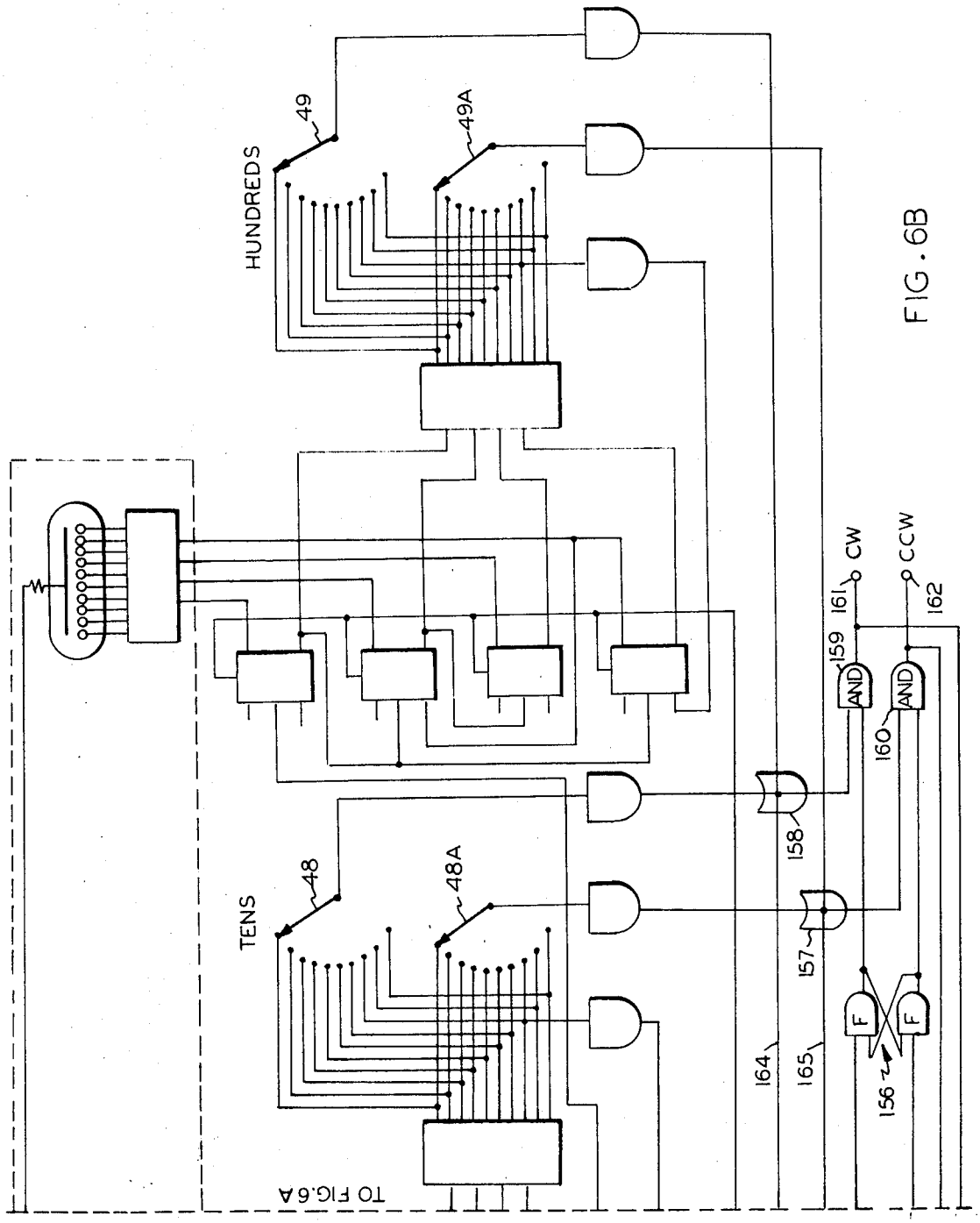


FIG. 6B

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COIL WINDER AUTOMATICALLY SEQUENCING MULTIPLE PRESET WINDING SELECTIONS

This invention relates to electronic controls for coil winding machines, and more particularly it relates to electronic controls operating a winding machine in response to a count of the number of turns put on an inductor core.

In the operation of a coil winding machine the prior art has afforded automatic turn count registers, which permit an operator to monitor the number of turns on a transformer core. However, the requirements for producing multiple turn transformers of varying specifications can result in operational control sequences that put a considerable burden on the operator to remember the status and to make adjustments of the numbers of turns on successive windings and the direction of winding etc. This not only takes operator time, reducing the output, but additionally and more important, introduces many opportunities for error.

It is accordingly an object of this invention to provide improved electronic control circuits for coil winding machines.

A more specific object of the invention is to provide electronic controls for coil winding machines which automatically provide for counting and assuring a preselected number of turns for each of a plurality of windings on a transformer.

Thus in accordance with this invention, preset conditions may be established in selectable count registers by an operator so that each of a plurality of successive windings can be controlled for the direction of winding, the number of turns and the sequence of application. Reliable turn counting is provided by a capacitance probe detector, and electronic counting and control circuits are provided for response to a turn count to decelerate and stop a motor at preselected turn counts, thus assuring efficient output with little chance for error.

A more detailed description of the invention together with the presentation of further features, objectives and advantages of the invention follows from the presentation of an embodiment illustrated in the accompanying drawing, wherein:

FIG. **1** is a schematic drawing of an automatic turn count detector and counter;

FIG. **2** is a perspective sketch of a coil winder cabinet array incorporating features of the invention;

FIGS. **3A** and **3B** are a schematic diagram for control circuits operable to control deceleration and stopping of the winding operation automatically in response to a preset turn count;

FIG. **4** is a schematic diagram of winding direction control circuits;

FIG. **5** is a schematic diagram of a program sequencing unit afforded by the invention; and

FIGS. **6A** and **6B** are schematic diagrams of a control circuit for selecting winding direction under automatic control of a preset turn count.

Referring now to FIG. **1** of the drawing, there is shown the shuttle mechanism **10** of a conventional toroidal winding machine which winds a wire from loop **11** through a toroidal core **12** by means of a movable shuttle mechanism **13** which passes a strand of wire **14** in a path across the coiled loop **11** for each periodic turn wound on the core **12** when taken from bobbin coil **11** as the driving means **15** rotates it.

By placing the capacitive probe **16** having a grounded casing electrode **17** and a signal electrode **18** in a position for sensing the wire **14** in the scanning path a reliable count of the turns passed onto toroidal core **12** is produced. Even when the wire is very fine, a good noise free signal is produced without mechanical contact, and the capacitive probe is not responsive to distant movements such as shadows nor is it affected by smoke, dust and other extraneous signals such as encountered by very sensitive photodetectors that could give a reasonable response to passing of a fine wire at high speed. Also the capacitive probe permits very high-speed response without any sleeping effect or change of characteristics presented by photodetectors.

The capacitive probe **16** is connected as one arm of the capacitance bridge circuit **19** having a common ground connection with probe terminal **17**. A high frequency oscillator **20** drives the bridge with a signal frequency such as 5 or 10 megahertz. Variable capacitor **21** in the bridge is adjustable under static conditions to compensate for environmental capacitive conditions surrounding the position at which probe **16** is placed. This adjustment is desirable, for example, if certain jigs or variations are made in the vicinity of the shuttle mechanism **10** after the probe is installed, and therefore preferably comprises a front panel adjustment having an indicator lamp **22** showing when the bridge is in balance and ready for a winding count operation.

The balance indicator lamp is operable by the static output signal coming from differential amplifier **23**, which is adjustable by balance capacitor **21**. Thus the lamp **22** can be caused to glow at balance condition with DC excitation potential at lamp terminal **25**.

Amplifier **26** provides an output signal train **27** having impulses **28** representing each turn that can serve to operate preset counter **29**. By presetting counter **29** to the desired turn count at preset input **30**, the preset count may be counted down until a zero count appears as detectable at output terminal **31**. This can produce a feedback signal for controlling winding means **15** if desired to automatically shut down the periodic winding mechanism.

In addition to the desirability of the differential amplifier **23** for use in the calibration of the bridge circuit, the bridge circuit arrangement is advantageous in producing a DC signal little affected by extraneous noise interference and not requiring critical RF amplifiers. For example, the band width requirements of an RF amplifier for passing detected RF pulses of different widths or durations as represented by changes of winding speeds and wire sizes presents a formidable problem and a sophisticated RF amplifier would be necessary. However in accordance with this invention DC signals are taken at the bridge circuit level by means of rectifiers **32, 33** respectively connected to bridge terminals **34, 35** and each providing a signal potential referenced to ground terminal **17**.

Rectifier **32** detects the dynamic signal change effected by capacitance probe **16**. Rectifier **33** neutralizes changes due to amplitude variations of oscillations from source **20**. Thus input leads **36, 37** for differential amplifier **23** indicate the balance condition of the bridge circuit. The variable balance adjusting capacitance **21** may be adjusted proportional to the capacitance of probe **16** to balance the bridge.

For further calibration and testing purposes the OR circuit **24** may have introduced at input terminal **38** a test signal derived from an AC source coupled to terminal **39** which may comprise a 60 cycle power line for example. Thus test switch **40** is used selectively to count down counter **29** or to assure that the counter circuit is operating properly.

In FIG. **2** is shown a typical toroidal core winding machine embodying the foregoing capacitive bridge counter arrangement with like reference characters referring to similar components throughout the respective views. The wire winding machine is adapted in accordance with this invention to semiautomatic control of windings placed on core **12** by the coil-shuttle arrangement **10—11** by means of a preset counter system generally indicated in FIG. **1**.

In operation the winding machine takes wire from a spool **41** over counter reel **42** from which it is preloaded onto coil **11** for winding about toroidal core **12**. The capacitor probe is coupled by cable **17** to a proximity detector circuit input jack **43**. This input circuit is similar to that shown in FIG. **1**, with access at the front panel of the balancing capacitor **21** and the lamp **22** showing that balance is obtained. The preset count on the counter may be read at indicators **44** at all times and these indicators continuously indicate the status of turns on the core **12** as the preset count is diminished by each turn through the hereinbefore described operation.

Knobs **45, 46** provide for presetting a number at which a signal is obtained from the counter to start decelerating the

driving motor (not shown). The winder has a motor running at both high1speed and low speed modes. Thus, during winding the motor runs at high speeds. However when the count on the counter as displayed at 44 reaches the preset count of knobs 45, 46 such as 12, an output signal is taken from the counter to reduce the winding speed until a stop signal is reached at zero count (31, FIG. 1). Thus the invention provides for deceleration control.

Further the preset controls for the counter 29 (FIG. 1) may be located within the cabinet lid for example. Further preset conditions are settable by knobs 47, 48, 49, which may appear in two banks with switches 47A, 48A and 49A controlling counterclockwise operation and the former switches controlling clockwise operation. As shown the reversible preset operation may be selectively introduced by means of switch 50, which has an associated position indicator lamp 51. Typically the preset switches 47, 48, 49 may set in a desired number of turns in the clockwise direction of rotation of the shuttle-coil mechanism 11—12 and the alternate set 47A, 48A, 49A may be used for counterclockwise control. The number of preset registers can vary to provide for the number of turns put on a succession of windings wound on the same core, either in the same winding direction, or the opposite, and further registers exist inside the machine panels having similar preset switches.

The winder may be restarted by button 52 after being stopped by button 53 without losing the count in the selected register. Normally when the winder is turned on only button 62 or 63 can be used to start the winding which stops at the end of the preset count until the next operation of button 62 or 63 occurs. Power is turned on by switch 54 as indicated on lamp 55. Core rotation for progressively wound cores may be manually selected by switch 56 as shown by pilot lamps 57, 58. Speed of loading coil bobbin 11 is controlled by knob 59 and the winding speed of bobbin 11 is controlled by knob 60. Various preset registers may be selected by switch 61. These controls are conventional when used in the manual sense.

In accordance with this invention however, the preset registers are automated so that switch 62 controls the load operation, and switch 63 automatically steps from one preset register to another as the switch is depressed after each previous winding is completed, and displays in its various sections an indication of the register in use. Thus, an operator need only pushbutton 62 to load bobbin coil 11 with a preset number of turns, and then pushbutton 63 successively for control of a series of windings each having the number of turns identified in a preset register.

The preset control system is set forth schematically in FIGS. 3A and 3B, which show two of a plurality of preset banks of selector switches 64, 65 within preset switch block 66 representing units and thousands of digit positions respectively with the intermediate positions removed to simplify the drawing. As shown, the columns of switches 67, 68, 69, 70 and 71 respectively provide for control of the number of windings for the load reel and four separate windings upon the core.

Each selector switch is isolated by a diode 72 from other switches in the same column, and each switch column has a separate energizing conductor 73, 74, 75, 76 or 77. The switches are in decimal notation, so that each switch bank has a diode decimal to binary encoding matrix 78 to permit communication with a binary counter within block 79. Block 79A includes buffer amplifier circuits providing two isolated sets of binary output leads. In block 80 are decimal indicator lamps 81 with the corresponding binary to decimal converter-driver devices 82 and DC energizing terminal 83.

The input waveform 27 representing the count of the number of turns put on the winding, as described with operation of the capacitive detector probe of FIG. 1, is provided at terminal 84. The input selector circuit 85 provides for processing signals in accordance with the conditions of the preset signal pulses received at terminals 73 to 77. Thus, in a manual mode of selection when switch 61 (FIG. 2) is in a selected register position, a momentary load pulse at terminal 77 from switch 62 (FIG. 2) will select switch column 67 to preset the load count of column 65 in counter 79 and set flip-flop section 86A to gate a footage count pickup at lead 87 through AND gate 88 to the OR amplifier 89 thereby energizing a Schmidt trigger circuit 90 to produce a pulse at the units stage counter 91 serving to count down the preset count to zero. Actually the counter has its indicator lamps connected so that the counter always counts up but the indication and preset takeoff leads correspond to the indicated counts. That is, a preset of nine would set the counter stage to zero which by the indicator lamp shows nine, and as the counter counts up to nine, the indicator lamp shows a count down to zero.

Further in the manual mode of operation, if a preset number in column 70 is chosen, then the switch 61 (FIG. 2) indicates this register and pushing wind switch 63 will produce a momentary pulse at lead 74. This (or a similar pulse at leads 73, 75 or 76) will set flip-flop section 86B and actuate and gate 92 serving to pass the turn count input signals at lead 84 into the counter after presetting to the count signified by the switches in column 70. For automatic selection of a progressive sequence to be later discussed, a signal at lead 93 will be taken from the flip-flop gate input selector 85 at AND circuit 92 through which the continuing count signal from terminal 84 is passed. This also operates counter 91.

The preset pulse at leads 73—77 is a longer duration pulse sustained as long as the input switch 69 (FIG. 5) is depressed. The reset amplifier 99 may provide from the input switch depression a short initial pulse at lead 95 resetting all counter stages to zero. This pulse may be 10 microseconds in duration as effected by differentiating capacitor 96, when an input signal is received at OR circuits 97 to operate the counter reset gates 91. Therefore the counters are reset by shorter pulse 99 and then preset to the desired count by the longer duration preset pulse 100. An external reset pulse is carried by way of terminal 98 to reset the reversing control counter (FIG. 6A) for each start button 63 depression. Lead 98′ also serves to put the relays 101, 102 (FIG. 3B) in operating position.

The drive motor (not shown) for the coil winder has two operational speeds as well as a start and stop control circuit. Thus relay 101 provides for slowing the motor down in a deceleration mode as the winding nears the desired count, and relay 102 provides for stopping the motor at the terminal count of zero. For the purpose of choosing the deceleration count, the pair of preset switches 103, 104 is provided and since not more than 99 turns are usually necessary for a deceleration point, only the units and tens digits are processed by means of cable connections 105, 106.

Thus when all three inputs at AND circuit 107 are coincident (at the preset count position), deceleration coincidence is indicated to set flip-flop 108 to a position operating relay 101 to select the slower motor speed.

To stop the motor all digits are at nine (reading zero on the indicator lamps 81) as indicated by signals on the 2^0=1 plus 2^3=8 leads at cable 109 of the thousands counter output terminals. Thus OR circuits 110, 111 respond to set flip-flop 112 into the condition actuating relay 102 to stop the motor. The third condition to AND circuit 107 requires that the hundreds and thousands counter stages are reset to zero (9) as provided at lead 113.

Shown in FIG. 4 is a reversing control circuit for the direction of the winding. The winding direction is controlled by a conventional solenoid operated clutch arrangement (not shown). The respective clutch solenoids are operated for forward and reverse winding by the direction control flip-flop 114, which is set for the two directions at input lead terminals 115 and 116. The flip-flop output condition represented at terminals 117, 118 is used also for control purposes in the automatic mode of operation. For clutch control purposes, the respective flip-flop output signals are passed through AND gates 119, 120, so that the clutches may be disabled by signals at clutch control terminal 121. Each clutch has an independent amplifier and transistor driver circuit 122, 123 with output leads clamped by diodes 124, 125 to avoid damage by any inductive kick produced in the clutch control solenoids.

In the automatic mode of selection as determined by an automatic position of switch **61** (FIG. **2**) a preset scanning circuit is used as shown in FIG. **5**. This serves to progressively and automatically step from one preset counter to the next through a sequence that will provide multiple windings of different turns upon the toroid core. This the wind switch **63** need only be pushed to institute each new winding after the completion of the preceding winding without requiring the operator to select a special preset register or to think about or remember the winding next needed or its number of turns. The sectioning of switch **63** (FIG. **2**) indicates that a lamp may be lit to show which preset register is selected in each step, as shown at **126**. A load lamp circuit **127** can also be actuated from terminal **128** or an external relay circuit.

The block **129** comprises a shift counter circuit which scans the output and gates **130** of gating block **129A** to provide signals for winding circuit progressive control at terminals **131**, etc. corresponding to terminals **73—77** of FIG. **3**.

In the winding mode actuated by switch **63**, the counter **129** is preset in manual positions of switch **61** to operate the respective wind gates **130**. The counter itself comprises two *j—k* flip-flops **132**, **133** which have clock pulses introduced for sequencing at leads **134**, **135** in the automatic mode of operation to step progressively from wind **1** through wind **4** output positions as each successive closure of switch **63** occurs. Any other conventional sort of shift register that may be preset may be used in place of counter **129** if desired. Wind switch **63** when pressed and released sets and resets flip-flop stages **136A** and **136B**, where lead **137** serves as a gating lead for and gates **130**. Lead **138** serves to produce a pulse at both flip-flops **132**, **133** for the shifting operation.

Flip-flop **136A** and **136B** also serves the purpose of preventing misoperation due to switch control bounce generally encountered in manually operated switches. The flip-flop section **136A** is set and switch bounces do not effect it. The operation is terminated when flip-flop section **136B** is set upon release of switch **63** where similarly bouncing effects are eliminated.

Flip-flop **139** serves as a memory gate for the wind lamps **126**. The load lamp control signals may be taken from lead **128**. Terminal **141** may be used for other optional control signals. The counter is reset by a short signal produced on lead **142** as a result of differentiating circuit **143**. This permits longer pulses to be applied at set inputs **144**, **145** of the counter stages. Thus the position of switch **61** serves to set the flip-flops **132** and **133** into the desired positions in the manual mode to operate output AND gates **130** through output leads **146**, **147**, **148** and **149**.

In the automatic mode inhibit gate **150** prevents clearing of the flip-flops as the input pulses are applied at the clock pulse terminals **134**, **135** of the counter causing it to sequence.

The remainder of the control circuitry coupled together in this system is the reversing control portion of FIGS. **6A** and **6B**. For this mode of operation the count in pulses are applied at terminal **136** and OR circuit **137** permits alternatively test signals derived from AC source terminal **138** when switch **139** is operated.

Binary counter stages **140**, **141**, **142**, **143** are connected by way of input terminal **44** to count up to ten and reset from a feedback circuit supplied through leads **145** and **146**. The count is taken through binary to decimal converter circuit **147** to terminals of the preset switch banks **47**, **48**, **49** for clockwise rotation and **47A**, **48A**, **49A** for counterclockwise rotation. Each of the units, tens and hundreds stages operate similarly with a 10 count transfer lead **148** communicating between stages. For each stage a numerical indication tube may be supplied with a binary to decimal driver circuit **150**.

Leads **151** and **152** receive signals respectively that direct clockwise and counterclockwise control modes. These signals are fed through OR circuit **153** to reset the counters. They are then controlled by AND gates **154**, **155** to prevent destroying the memory position of flip-flop **156** receiving a coincident count signal through coincidence circuits **157**, **158** as gated through gates **159**, **160**. Clockwise and counterclockwise output indications are available at terminals **161**, **162**.

Lamp **163** is actuated to indicate that the coincidence circuits are in operation. Leads **164**, **165** by way of amplifiers **166**, **167** are put into operation by switch **51**.

The various elements of the system have been described with their interconnecting leads so that they may be housed separately and added as control units where desired by the appropriate interconnections to produce an electronically controlled coil winder with semiautomatic capabilities of winding coils having multiple windings of different winding direction and turns. The various elements of the system are well known and may comprise integrated circuit packages, for example, used in a conventional manner to perform the functions herein described. Accordingly versatile and improved control circuits are provided herein for coil winding machinery.

I claim:

1. Automated coil winding apparatus, comprising in combination means for winding wire upon a coil, a set of presettable electronic numerical counter registers, means detecting a signal for each turn wound on a coil by said apparatus, means selecting a first one of said registers and coupling said detecting means thereto to register a change of count thereon, means in said apparatus responsive to a signal received at a designated count on said selected register to effect a winding control operation, and scanning means automatically selecting in a sequence different ones of said registers for replacing said first one of the register for counting and controlling in response to said turns wound on the coil.

2. Apparatus as defined in claim **1** including means responsive to a predetermined count on the said selected register to reduce the winding speed, and responsive to a further count to stop the winding operation.

3. Apparatus as defined in claim **1** including means selecting the direction of winding wire upon said coil.

4. Apparatus as defined in claim **1** having means to override manually the automatic sequence and select predetermined ones of said registers for counting by said turns signals.

5. Apparatus as defined in claim **1** wherein said scanning means is provided with a manually operable selector switch, and each selection in said sequence is effected manually by operation of this switch.

6. Apparatus as defined in claim **1** wherein the coil winding apparatus is a toroidal winder having a movable shuttle mechanism.

7. Apparatus as defined in claim **7** wherein the winding apparatus has a loading reel, a presettable counter register is provided for indicating the quantity of wire to be wound thereon, and means is provided for selecting a load mode of operation for automatically providing the preset quantity of wire on the loading reel.

8. Apparatus as defined in claim **1** having numerical indicators and means coupling the indicators to the preselected circuit in use to indicate the resident count therein.

9. Apparatus as defined in claim **8** wherein the electronic counting means operates in an upward counting sequence such as 1, 2, 3 etc. and the numerical indicators are coupled to indicate a downward counting sequence 9, 8, 7, etc.

10. Apparatus as defined in claim **5** wherein the manually operable selector switch is of the momentary contact-type, and a flip-flop circuit is set by said switch when depressed and is reset by said switch when released.