April 24, 1962 W. H. ATTWOOD ET AL 3,031,153

COIL WINDING APPARATUS

Filed June 22, 1959 2 Sheets-Sheet 1

Fig.1.

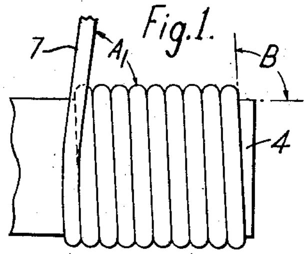


Fig. 2.

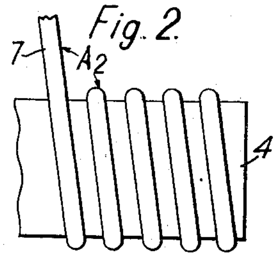
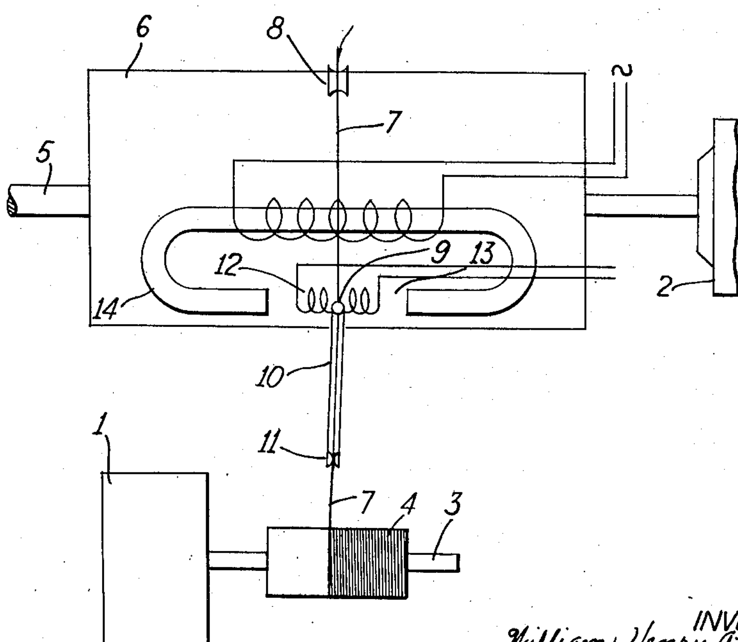


Fig. 3.



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COIL WINDING APPARATUS

Filed June 22, 1959 2 Sheets-Sheet 2

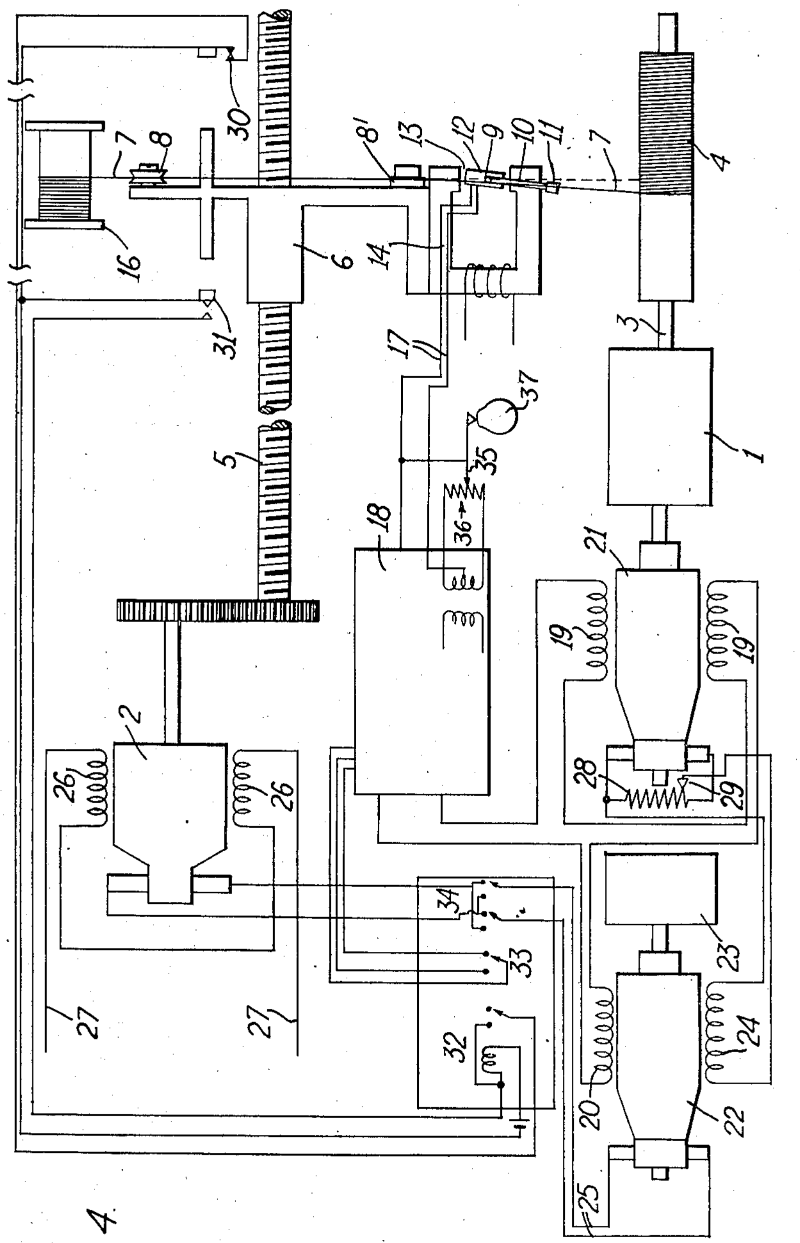

Fig. 4.

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United States Patent Office

3,031,153

Patented Apr. 24, 1962

3,031,153

COIL WINDING APPARATUS

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Filed June 22, 1959, Ser. No. 821,859

Claims priority, application Great Britain June 24, 1958

5 Claims. (Cl. 242—158)

The invention relates to the winding of a filar material such as wire, cotton yarn or the like (hereinafter referred to as "wire") on to a spool, bobbin or former or the like (hereinafter referred to as the "bobbin") or onto a batch of bobbins, so that it lays the wire on the bobbin or bobbins in some predetermined manner.

This winding action requires rotation of the bobbin and relative movement between a wire guide for the wire as it passes to the bobbins and the bobbin itself, this relative movement being in a direction parallel with the axis of the bobbin. It is usual to effect this relative movement by moving the wire guide by what is termed a traversing action: in what follows reference will for convenience be made to the usual arrangement it being understood however that the invention is no less applicable to the equivalent method in which the bobbin is traversed.

It is obvious that the relation between the rate of rotation of the bobbin and the rate of linear traverse will determine the lay of the wire along the bobbin. The speed of the motor or other mechanism driving the traverse mechanism must be directly related to the rotational speed of the bobbin by a factor dependent on the lay of the wire required along the bobbin in turns per unit length and on the rate of progression of the traverse.

The ratio that must be maintained between the rate of traverse and the rate of rotation of the bobbin depends, for close layer winding, on the diameter of the wire: this can vary as much as 50 or 100 to one so that for a winding machine to be universal the ratio of the two rates must be capable of being set to accommodate and maintain this wide variation of ratio for any given winding rate. Further, since it is a practical necessity to be able to vary the bobbin speed over wide limits, it is obvious that the desired speed ratio, dependent on wire diameter, must be maintained whatever the basic speed of the bobbin.

It is common practice in existing winding machines to obtain the traverse drive by a lead screw driven from the mandrel supporting the bobbin and to vary the rate of traverse by a gear train which is variable, either by manually replaceable gears or by some form of continuously variable gear box; this does enable the wide ratio of drives necessitated by the range of possible wire diameter to be dealt with but such arrangements are expensive and in the case of the continuously variable gear box it is mechanically very difficult of attainment if the full range of ratios is to be covered.

In the case of the manually changed gear trains, the system is cumbersome to the operator and, unless an infinitely large number of change gears is provided, precise agreement between the speed ratio and the wire gauge is not always obtained: moreover, variation does occur in the actual diameter of the wire along its length from its nominal diameter and a gear train is not able to compensate for such variations, with the result that the winding will either tend to bunch or to space along the layer.

It is the main object of the present invention to provide an improved apparatus which will enable the wire to be laid on a bobbin under a control which while being simple will be precise to ensure with accuracy any predetermined lay.

According to the present invention, the angle of "feed" of the wire to the bobbin is "measured" by moving a coil disposed in a magnetic field and moved in response to change in the angle of feed from the predetermined angle: change in position of the coil results in an electrical output which is used to vary the relation between the rate of rotation of the bobbin and the rate of traversing movement so as to compensate for the change detected by the coil. For layer winding provision would be made to effect a sudden reversal of the sense of the measured angle at the end of the traversing movement.

It has been found that in this simple way, a much improved result is obtained without the complicated and expensive mechanism which has so far been required: having estimated for any given nominal diameter of wire and manner of winding (i.e. open or close turns) the ideal angle of feed of the wire, any incipient change from that ideal angle can be measured and used in the course of the winding operation to adjust the angle of run of the wire to correct the change and to restore it to the proper angle of feed: such adjustment can be effected either by controlling the rate at which the bobbin is rotated, by controlling the rate of relative traverse, or by a combination of both controls.

The method of this invention can be carried into practical effect in various ways: the coil for "measuring" the angle of feed of the wire would be pre-set to a condition corresponding to the position the wire should have as it passes to the bobbin if the wire is in fact at the predetermined angle of feed.

The sensing device responds to any deviation of the wire from that predetermined angle and sets into action some means or the other operating to correct the angle of the wire so as to restore its angle of feed to the predetermined value.

The invention is illustrated in the accompanying drawings in which FIGURES 1 and 2 are diagrams illustrating the requirements for coil winding, FIGURE 3 is a diagrammatic view of one arrangement for sensing the angle of feed and FIGURE 4 is a diagram of a complete installation incorporating the sensing arrangement of FIGURE 3.

Referring firstly to FIGURES 1 and 2 a bobbin on which wire **7** is to be wound is shown at **4**, this bobbin being rotated during the winding operation: when the wire is required to be laid with its turns touching as shown in FIGURE 1, the wire has to be laid to the bobbin at an angle of feed denoted by the angle A_1 which angle lags the natural angle B: this angle A_1 of feed will depend on the nominal diameter of the particular wire being wound: if the turns of the wire are required to be spaced as is shown in FIGURE 2, the angle of feed will require to be increased to some angle A_2 which depends on the required spacing and again on the nominal diameter of the wire being used.

The present invention is based on the fact that the angle of feed can be predetermined for the different nominal wire diameters to suit the lay requirements: the invention proposes to sense any change in the actual angle of feed on the wire from the predetermined value for any particular case and to set up a control action to restore the angle to the predetermined value.

Referring to FIGURE 3, the wire **7** is taken over a guide **8** in a carriage **6** which is reciprocated by a screw **5** driven by a motor **2**. The bobbin **4** is mounted on a spindle **3** rotated by an electric motor **1**. On the carriage **6** is pivotally mounted at **9** a sensing coil **12** which is disposed in the air gap **13** of a magnet **14** energized from an alternating current supply: the coil **12** is carried by an arm **10** having pads **11** between which the wire **7** is trained in passing from the guide **8** to the bobbin **4**.

The parts of this sensing device would be set so that so long as the wire **7** moves to the bobbin **4** along a line at an angle which is the predetermined angle of feed, the electrical output of the coil **12** is constant and therefore exercises no control: as soon however as the wire deviates from that angle, the current output of the coil changes and this change is utilized to set up a correcting action which will cause the wire to return to the correct angle.

The initial setting of the parts of this sensing device can be varied to suit the requirements of any particular winding operation in various ways: for example, the angular relationships of the coil **12** of the arm **10** and of the magnet **14** could be adjustable: again the coil can be connected in circuit with a rheostat which can be adjusted to provide a variable neutral point corresponding to various predetermined feed angles.

It is obvious that, with practical limitations of size of the sensing arrangement described, the magnitude of the electrical signal output is small, but it can be amplified to produce or to control the production of an electrical power supply which varies in magnitude and direction with the change of wire feed angle referred to, from the predetermined angle.

This power is now available to achieve a control which will create an adjustment which will result in restoring the angle of feed to the predetermined value: this can be effected in various ways. In FIGURE 3 the amplified output is employed to energize the traversing motor **2**: so long as the measured angle of feed of the wire is set at the predetermined value, the motor **2** is driven continuously at the same speed relative to the speed of the motor **1**: any change however in the measured value of the angle of feed will cause the speed of this motor **2** to be varied so that, through the guide **8**, the wire feed angle will be shifted and restored to the predetermined angle.

In FIGURE 4 is shown in diagrammatic form a complete machine which incorporates the sensing arrangement shown in FIGURE 3 and in which provision is made for layer winding: in this FIGURE 4 the parts corresponding to those shown in FIGURE 3 are given the same reference numerals. This figure in addition shows at **16** the bobbin from which the wire **7** is drawn and passed via the roller **8** to the former **4** the wire passing between the pads **11** on the arm **10** carrying the coil **12**.

It is preferred, as is shown in this FIGURE 4, to pass the wire **7** as it moves from the guide **8** to the bobbin **4** over a reference component **8'** which replaces the function as described with reference to the guide **8**: this component **8'** is close to the point at which the wire **7** is laid on the bobbin **4** so that the response to the angle of feed is little likely to be affected by lateral flexing of the wire.

The current output of the coil **12** is taken via circuit connections **17** to the input of a phase-sensitive amplifier **18** the output of which is taken to the field coils **19**, **20** of two direct current generators **21**, **22**. The generator **21** is driven by the motor **1** which drives the mandrel **3** and the output of the generator **21** is applied across resistance **28** having an adjustable take off slider **29**.

The generator **22** is driven by a constant speed motor **23**.

The variable output of the generator **21** is applied to a field winding **24** of the generator **22** and the output of this generator **22** is taken by lines **25** to the armature of the motor **2** for driving the traversing screw **5**: the motor is of the variable-speed shunt-wound type, having its field coils **26** excited by a constant voltage through lines **27**.

Thus, the direction of the traversing motor **2** will be a function of the auxiliary power supply from the generator **22** and its speed will be due to a combination of the effect of the signal from the sensing coil **12** and the signal from the auxiliary generator **21**: in other words the signal due to any change in the measured angle of feed of the wire will act to vary the speed of the motor **2** above or below the speed set by the generator **21** and by the setting of the slide **29**. Thus this set speed can be varied to suit the different winding requirements by variably exciting the field coil **24** of the generator **22**.

For the purpose of adapting the invention to multilayer winding a switching mechanism is provided to effect a quick reversal of the control action given by the sensing device. Thus stops can be fitted on the traverse mechanism, to operate switches **30**, **31** operating through a relay **32** and phase-change contacts **33** and motor direction contacts **34** to cause the direction of the sensing output to be reversed, the stop being set in conformity with any desired winding length so that after the wire **7** has traversed a layer on the bobbin **4** of this desired length, the direction of the motor **2** and hence of the traverse and the sensing of the wire feed angle will be reversed: the conditions of the constant feed angle will now be held for the reverse direction of traverse.

In this FIGURE 4 is also shown an electrical arrangement for setting the sensing coil device at an initial or datum position corresponding to the predetermined angle of feed in any particular case: in this electrical arrangement, the lines **17** from the coil **12** are shunted across a potentiometer arrangement **36** having an adjustable component **35** which imposes a variable potential on the coil **12** to create an adjustable null point chosen to suit the predetermined angle of feed of any particular case.

The sensing coil can be automatically adjusted, as by a cam **37** as shown in FIGURE 4, during a winding operation so as to vary the angle of feed to produce close layer winding, or spaced winding of predetermined spacing and any combination of the two during the process of the winding operation.

Although reference has been made principally to controlling the angle of feed by control of the rate of the traversing action, the mandrel speed being predetermined, it is to be understood that the invention is equally applicable to the condition where the traverse speed is predetermined and the automatic control from the sensing device is applied to the rotational speed of the bobbin. Further, the automatic control derived from the sensing device can be caused to control neither the mandrel nor the traverse directly, but to control a system which splits the control action between the mandrel traverse drive so that the ultimate speeds are related in the manner required to maintain the angle of feed at the constant value.

It will be clear that the invention has the following advantages:

(*a*) The precise ratio between winding mandrel and traverse drive for accurate layer winding of a very wide range of wire diameters may be accurately and easily predetermined, and automatically and constantly held for a given wire diameter irrespective of random variations of spindle speed and load and automatically corrected for random variations in wire diameter.

(*b*) The conditions set out in (*a*) are automatically maintained over any desired range of mandrel speeds.

(*c*) The conditions set out in (*a*) and (*b*) are capable of being simply set for spaced winding with predetermined spaces as well as winding with adjacent turns touching.

(*d*) The apparatus is capable of being simply and automatically varied during the winding process, so that a predetermined variation of spacing can be accommodated during one layer of winding.

(*e*) The apparatus provides a means of compensation for the error produced when the distance between the inner faces of the cheeks of a bobbin is not a precise multiple of the diameter of the wire to be layer wound thereon.

We claim:

1. In a coil winding apparatus, a rotatable bobbin; means for rotating said bobbin; a wire guide for guiding a wire to the bobbin at a predetermined angle of feed to the bobbin axis of rotation; means for effecting relative traversing movement of said bobbin and guide parallel with the axis of rotation of said bobbin; means providing a magnetic field, means for detecting a departure in the

angle of feed from said predetermined angle of feed and including a coil mounted to move in said field in response to such a departure in the angle of feed; and means in electrical circuit with said coil and being controlled by changes in current in said circuit caused by movement of said coil in said field for varying the relation of the rate of rotation of said bobbin to the rate of said relative traversing movement to restore the angle of feed to said predetermined angle of feed.

2. Coil winding apparatus as claimed in claim 1 and having means to adjust the detecting means to correspond to selected predetermined angles of feed required by different winding requirements.

3. Coil winding apparatus as claimed in claim 1 and wherein the detecting means comprises a mechanical feeler connected to said coil and being displaceable by change in the angle of feed of the wire from the predetermined angle.

4. Coil winding apparatus as claimed in claim 1 and wherein the coil circuit includes means to vary its electrical datum to correspond to different predetermined angles of feed.

5. Coil winding apparatus as claimed in claim 1 and wherein the detecting means operates to effect control by varying the speed of the traversing means.

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