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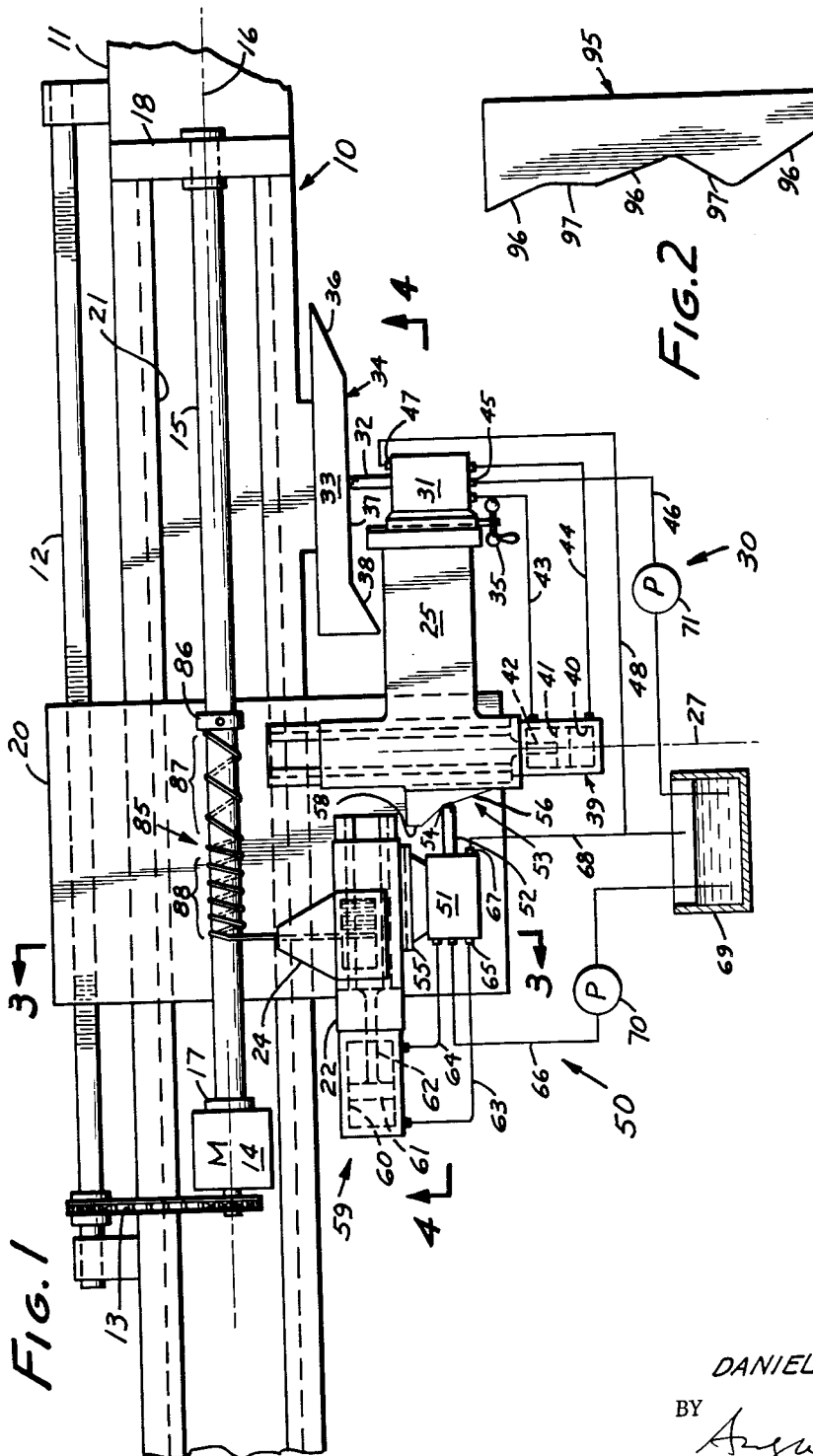
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VARIABLE PITCH COIL WINDING DEVICE

Filed July 25, 1963

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

FIG. 3

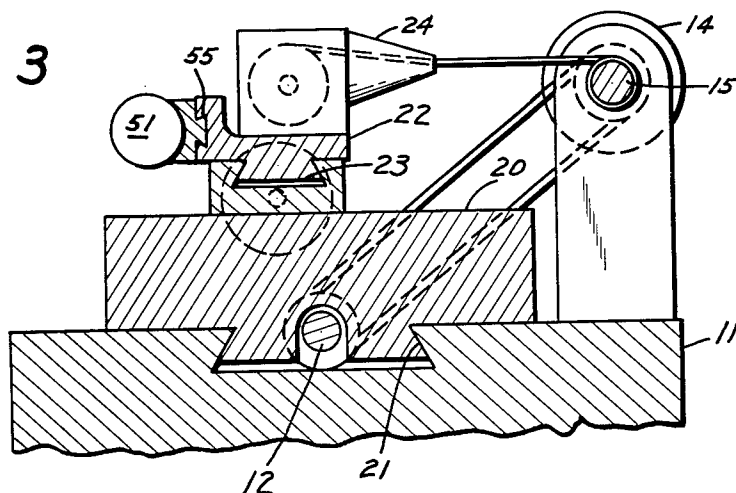


FIG. 4

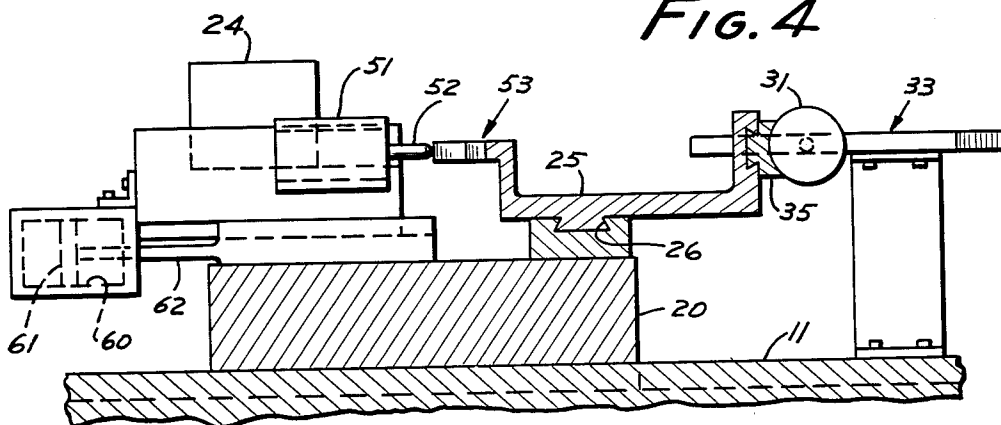
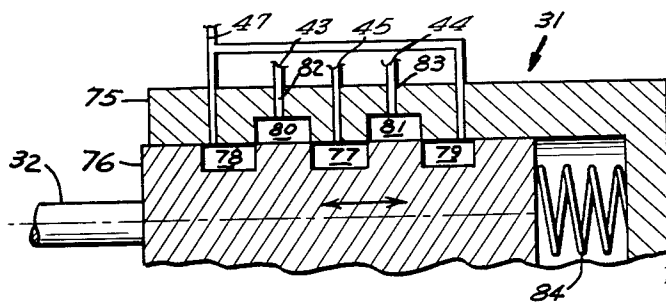


FIG. 5



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1

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VARIABLE PITCH COIL WINDING DEVICE
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This invention relates to coil winding machines.

In the winding of helical coils such as filaments, springs and the like, it is often desired to wind different axial portions of the coil with different pitches. The pitch may be uniform for a distance and then may change to a different uniform pitch or may, over another region, have a continuously changing pitch. Heretofore, it has been largely a matter of trial-and-error to wind coils of varying pitch, and the scrap rate has been very high. It is an object of this invention to provide a coil winding machine in which the axial length of the spring and its pitch at a given location can readily be determined in advance and constructed.

A coil winding machine according to this invention has a bed and a mandrel. The coil is wound on the mandrel. The mandrel is mounted to the bed for rotation around its axis. A first carriage is axially movably mounted to the bed, and a second carriage is axially movably mounted to the first carriage. A wire-paying means is mounted to the second carriage whereby constant relative motion between the mandrel and the first carriage without relative motion between the first and second carriages results in winding of a coil of constant pitch on the mandrel. Control means is interposed between the bed and the second carriage adapted to move the second carriage relative to the first carriage in order to vary the pitch of the coil wound on the mandrel.

According to a preferred but optional feature of this invention, the control means includes a third carriage mounted to the first carriage which is adapted to move laterally relative to the first carriage. Contour-responsive means is provided for moving the third carriage relative to the first carriage, and other contour-responsive means is provided for moving the second carriage relative to the third carriage.

According to still another preferred but optional feature of the invention, the control means comprises a first template-tracer valve system interposed between the third carriage and the bed, and a second template-tracer valve system interposed between the second carriage and the third carriage.

The above and other features of this invention will be fully understood from the following detailed description and the accompanying drawings in which:

FIG. 1 is a plan view of the presently preferred embodiment of the invention;

FIG. 2 is a plan view of a template for use in FIG. 1 in making different coils;

FIGS. 3 and 4 are cross-sections taken at lines 3—3 and 4—4, respectively, of FIG. 1; and

FIG. 5 is a fragmentary cross-section view of a portion of a tracer valve suitable for use in this invention.

FIG. 1 shows a coil winding machine 10 according to the invention. This machine includes a bed 11 to which there is rotatably mounted a conventional lead screw 12 which is driven through chain or gearing 13 from a first motor 14, which is also attached to the bed. The motor also drives the mandrel 15. The mandrel has an axis 16 which coincides with the axis of the machine. The mandrel is supported by the bed through bearings 17, 18.

A first carriage 20 is axially slidable on ways 21 on the bed. The carriage is driven by the lead screw by being

2

threadedly connected thereto. Therefore the lead screw and the mandrel turn at proportional rate, and the carriage will move at a rate proportional to the rate of rotation of the mandrel. Gearing 13 is ordinarily subject to ratio change such as by gear box (not shown) so that different ratios of motion between the axial movement of the first carriage and the rate of rotation of the mandrel can be obtained. The location of the first motor relative to the first carriage and lead screw has been shifted in some of the figures for convenience in illustration.

A second carriage 22 is mounted to ways 23 on the first carriage. Ways 23 extend parallel to axis 16. Carriage 22 carries a wire-paying means 24 which is ordinarily a reel of wire with a brake thereon which pays out wire at a constant tension under demand by the mandrel.

A third carriage 25 moves on ways 26 which extend laterally relative to axis 16. In the preferred embodiment, the axis 27 of ways 26 lies normal to axis 16 in the plan view of FIG. 1. In the operation of this device, a helix of uniform pitch will be wound on the mandrel should there be no relative motion between the first and second carriages. In that event the wire-paying device will move along at a uniform rate with the first carriage. This rate and the pitch of the coil are determined by the ratio between the rate of movement of the first carriage and the rate of rotation of the mandrel. Should the second carriage be moved to the left in FIG. 1 relative to the first carriage while the first carriage is in motion, then the pitch of the helix will be increased, while if it moves to the right, the pitch will be decreased relative to the uniform rate which otherwise would occur. In order to provide for variation of pitch, control means is provided to move the second carriage relative to the first carriage.

The control means includes a first template-tracer valve system 30 which is interposed between first carriage 20 and third carriage 25. This system includes a tracer valve 31 yet to be described which has a stylus 32 which traces a first template 33. Template 33 has a first control contour 34 contacted and traced by the stylus. An adjustable mount 35 is provided for an initial adjustment between the spacing of the third carriage and the template.

The first templates includes segments 36, 37, 38 yet to be described. Included in system 30 is a second motor means 39 which is preferably a fluid motor. Although rotary, geared motors may be used, for simplicity a cylinder-piston type is shown which includes a cylinder 40, a piston 41 and a rod 42 attached to the piston.

The cylinder is attached to the third carriage, and the piston rod is attached to the first carriage, so that fluid applied to the cylinder on opposite sides of the piston through motor supply lines 43, 44 will tend to shift the third carriage relative to the first carriage. The tracer valve includes a pressure inlet 45 supplied by pressure line 46 and an exhaust outlet 47 from which liquid is conveyed through exhaust line 48. The internal details of the tracer valve will be described below.

A second template-tracer valve system 50 in the control includes a tracer valve 51 identical to tracer valve 31 which is mounted to the second carriage. This tracer valve includes a stylus 52. A second template 53 includes a second control contour 54. An adjustable mount 55 may be provided to enable adjustment of the initial relative positions of the second and third carriages. The second control contour 54 includes segments 56 and 58. The system 50 includes third motor means 59 which, again, may be geared rotary motors, if desired. Shown for simplicity is a cylinder-piston type, including a cylinder 60, a piston 61 and a piston rod 62.

3

The cylinder is attached to the second carriage as shown in FIG. 4, and the piston rod is attached to the first carriage. Motor supply lines 63, 64 enter the cylinder on opposite sides of the piston so as to shift the cylinder relative to the piston and thereby shift the second carriage relative to the first carriage.

Tracer valve 51 includes a pressure inlet 65 supplied by a pressure line 66 and an exhaust outlet 67 from which exhaust fluid is conducted by an exhaust line 68.

A reservoir 69 receives exhaust fluid from exhaust lines 48 and 68, and pumps 70, 71 withdraw fluid from the reservoir and supply it to the respective pressure lines 46 and 66. The pumps are equipped with normal pressure regulating and return-flow means which need not be shown here.

As can be seen from the aforesaid, the first template-tracer valve system 30 is interposed between the first and third carriages, and the second template-tracer valve system 50 is interposed between the second and third carriages. The control system includes the third carriage, both templates and both tracer valves together with the motors which power the second and third carriages.

A fragment of tracer valve 31 is shown in FIG. 5. Such a tracer valve includes an outer sleeve 75 which surrounds an internal spool 76, the inside of the sleeve and the outside of the spool being cylindrical. The spool is provided with a central pressure groove 77 and exhaust grooves 78, 79. The inside of the sleeve is provided with a pair of motor supply grooves 80, 81. Motor supply ports 82, 83 are connected to respective motor supply lines 43, 44, while the pressure inlet 45 passes through the sleeve so as to be in constant communication with the pressure groove of the spool. The manifolded exhaust outlet is in continuous communication with the two exhaust grooves. In accordance with well-known tracer valve operation, more complete details of which may be found in Rosebrook Patent No. 2,753,145, issued July 3, 1956, or Rosebrook Patent No. 2,835,466, issued May 20, 1958, the valve is in equilibrium in FIG. 5, with the spool centered in the sleeve. Accordingly, no pressure flows to either motor supply groove. However, if stylus 32 were moved to the left in order to follow a receding contour under impulse of backup spring 84, then the pressure groove would be in communication with motor supply groove 80, and pressure would be on in motor supply line 43, while exhaust groove 79 would have overlapped motor supply groove 81 so as to place motor supply line 44 under exhaust connection. Then the second motor would be operated so as to shift the third carriage toward the mandrel.

Were the pool to have moved to the right, then the exhaust and pressure connections to the motor supply lines would have been reversed, and the carriage would have been moved outwardly which is the condition which will result if the control contour of the template approaches the stylus. This is a standard four-way tracer valve which requires no further details here.

The same valve is useful for tracer valve 51, contact of its stylus with a portion of the control contour which moves it to the left in FIG. 3, serving to put motor supply line 63 under pressure so as to shift the second carriage to the left.

Coil 85 is shown being wound in FIG. 1 on the mandrel. The coil is started by holding one end of the wire to the mandrel by means of a collar 86 and then placing the device in operation. Thus far in operation, the machine is shown as having wound two regions 87, 88 of different pitch which were essentially derived as follows. On the first template, segment 36 has already been traversed (the carriage moving to the left in FIG. 1), and segment 37 is now being traversed. During the traversal of segment 36, the operation of tracer valve 31 caused the third carriage to move in a direction away from the mandrel (and away from the first template). At this time, as-

4

suming that the lower edge of the second template and the right-hand edge of the first template were the starting points of both templates, during the withdrawal of the third carriage, the second tracer valve caused the second carriage to move to the left so as to increase the axial velocity of the wire-paying means relative to the first carriage, thereby laying down a helix of larger pitch (region 87). This differential motion continued so long as the stylus of the second tracer valve encountered a varying contour as the third carriage was retracted. When the stylus reached segment 37 which is parallel to axis 16, then there is no relative movement of the third carriage relative to the second tracer valve so that there is no relative movement of the second carriage relative to the first, and a segment of constant pitch is wound (region 88). When segment 38 is reached, motion of the third carriage will be resumed, but at a faster rate than caused by segment 36, because of the steeper slope. It will also be noted that segment 58 has a steeper slope so that the pitch of the helix region to be wound under their control will be greater than the pitch of region 87.

It will be seen that the first template 33 essentially determines the axial position of the regions of different pitch because it controls the relative location between the second template and the second tracer valve. The second template, on the other hand, controls what the pitch will be by its slope, because it, in combination with the motion imparted to it by the first tracer valve, determines the rate at which the second carriage moves relative to the first carriage.

Regions of constant pitch will be wound either at the pre-set rate in combination with segments such as segment 37 which are parallel to axis 16, or at a constant rate wherein the segments concurrently traced by the two templates are straight lines. Should a continuously varying pitch be desired, it will ordinarily be preferred to use straight line segments on the first template, and then use curved segments on the second template. Continuously varying pitches can be achieved by the use of curved control contours.

FIG. 2 illustrates a template 95 which might be used in place of second template 53. This shows segments 96 which have "climbing" contours and segments 97 which have "receding" contours. Segments 96 will result in an increasing pitch, and segments 97 will result in a decreasing pitch on the helix.

This device has the advantage over known coil winding machines that a varying or changing pitch can be related to a standard pitch wound by the machine. The standard pitch is determined by the gear ratio between the mandrel and the lead screw. Then it is an easy matter to calculate the proper lengths, shapes and angles of the control contours on the first template for axial locations on the spring, and on the second template to determine either a different pitch or the rate of change of pitch.

This invention thereby provides a coil winding machine which has great flexibility, ease of setup, and accuracy in construction of coils of complex or varying pitches.

This invention is not to be limited by the embodiment shown in the drawings and described in the description which is given by way of example and not of limitation, but only in accordance with the scope of the appended claims.

I claim:

1. In a coil winding machine having a bed, and a mandrel having an axis, said mandrel being mounted to the bed for rotation around its axis, the improvement comprising: a first carriage movably mounted to the bed; a second carriage movably mounted to the first carriage, the said first and second carriages being mounted for motion parallel to the axis of the mandrel; a wire-paying means mounted to said second carriage, whereby constant relative motion between the mandrel and the first carriage,

5

without relative motion between the first and second carriages, results in winding of a coil of constant pitch on the mandrel; and control means interposed between the bed and the second carriage adapted to move the second carriage relative to the first carriage to vary the pitch of the coil wound on the mandrel, said control means comprising a third carriage mounted to the first carriage, said third carriage being adapted to move laterally relative to the axis of the mandrel, contour-responsive means for moving the third carriage relative to the first carriage, and contour-responsive means for moving the second carriage relative to the first carriage.

2. In a coil winding machine having a bed, and a mandrel having an axis, said mandrel being mounted to the bed for rotation around its axis, the improvement comprising: a first carriage movably mounted to the bed; a second carriage movably mounted to the first carriage, the said first and second carriages being mounted for motion parallel to the axis of the mandrel; a wire-paying means mounted to said second carriage, whereby constant relative motion between the mandrel and the first carriage, without relative motion between the first and second carriages, results in winding of a coil of constant pitch on the mandrel; and control means interposed between the bed and the second carriage adapted to move the second carriage relative to the first carriage to vary the pitch of the coil wound on the mandrel, said control means comprising a third carriage mounted to the first carriage adapted to move laterally relative to the axis of the mandrel, a first template-tracer valve system interposed between the third carriage and bed, and a second template-tracer valve system interposed between the second carriage and the third carriage.

3. Apparatus according to claim 2 in which first motor means drives the mandrel and the first carriage, and in which second motor means drives the third carriage relative to the first carriage under control of the first template-tracer valve system, and in which third motor means drives the second carriage relative to the first carriage under control of the second template-tracer valve system.

4. A coil winding machine comprising: a bed; a mandrel having an axis, said mandrel being mounted to the bed for rotation around its axis; a first carriage movably mounted to the bed; first motor means drivingly connected to said mandrel and first carriage to move the first carriage axially at a rate proportional to the rate of rotation of the

6

mandrel; a second carriage movably mounted to the first carriage; a wire-paying means mounted to said second carriage; a third carriage movably mounted to the first carriage, said first and second carriages being mounted for motion parallel to the axis of the mandrel and the third carriage being mounted for motion lateral to the axis of the mandrel; a second motor means drivingly connected to said first and third carriages; a third motor means drivingly connected to the first and second carriages; a first template mounted to the bed, said first template having a first control contour; a first tracer valve mounted to said third carriage and so disposed and arranged as to follow said first control contour and proportionally move the third slide by operating said second motor means; a second template mounted to the third carriage, said second template having a second control contour; a second tracer valve mounted to the second carriage and so disposed and arranged as to follow said second contour and proportionally move the second carriage relative to the first carriage by operating said third motor means, the first control contour determining the axial region of constant or varying pitch of the wound coil, and the second control contour determining, at least in part, the rate of change of pitch.

5. Apparatus according to claim 4 in which the second and third motor means comprise fluid motors, and in which the tracer valves are four-way valves adapted selectively to connect pressure or exhaust connections to opposite sides of the respective fluid motors to actuate the same, or to stop the motors when the tracer valves are in equilibrium with their respective control edges.

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