

Description

FIELD OF THE INVENTION

[0001] The present invention relates to a device and method for winding wire on a bobbin.

BACKGROUND OF THE INVENTION

[0002] The manufacture of high quality coils entails the necessity of the winding device winding wire onto a bobbin while maintaining a constant tension on the wire. In order to maintain a constant tension, the speed at which the bobbin winds the wire must be equal to the speed at which the wire source feeds the wire.

[0003] When wire is wound onto the bobbin, the radius of the bobbin increases. On the other hand, the radius of the drum, onto which wire is pre-wound and which acts as a wire source, decreases. In addition, the cross sectional shape of the bobbin may not only be round. For example, when the bobbin is square, its radius varies as a result of the rotational angle of the bobbin. As a result, in order for the winding speed and the feeding speed to be equal, it is necessary to appropriately control the rotational speed of the drum depending on the variation in the radius of the drum and the bobbin.

[0004] In this regard, Tokkai Hei 3-159541 published by the Japanese Patent Office in 1991 discloses a technique of calculating the increase in the radius of the bobbin from the contour data of the bobbin and the wire and the length of wire which has been wound. The radius of the drum which acts as the wire source is detected using a sensor and the rotational speed of the drum is controlled so that the winding speed and the feeding speed are equal.

[0005] However in the conventional technique, since it is necessary for the contour data of the bobbin and the wire to be pre-input into the control device, the data must be repeatedly input each time the bobbin or the wire is changed. Furthermore, when the cross section of the bobbin is not round, the complexity of the calculation of the radius of the bobbin increases significantly.

SUMMARY OF THE INVENTION

[0006] It is therefore an object of this invention to provide a winding device and method of winding which can maintain a constant tension on a wire with a simple structure and control means.

[0007] In order to achieve the above object, this invention provides a winding device comprising a wire source feeding wire, a spindle which supports a bobbin which winds the wire and a drive mechanism which rotates the spindle. The winding device further comprises a winding speed sensor which is provided on the upstream of the bobbin and detects a winding speed of the wire which is wound onto the bobbin and a controller which controls a feeding speed of the wire fed from the

wire source depending on the winding speed.

[0008] According to an aspect of this invention, the winding speed sensor is an encoder. A pulley is fixed on a rotational axis of the encoder and the wire is lead to the bobbin via the pulley.

[0009] According to another aspect of this invention, the wire source is a spool on to which the wire is wound. The device further comprises a feeding motor which rotates the spool and the controller controls a rotational speed of the feeding motor.

[0010] According to yet another aspect of this invention, the winding device further comprises a feed relay mechanism which relays the wire from the wire source and feeds the wire. The controller controls a speed at which the feed relay mechanism feeds the wire.

[0011] According to yet another aspect of this invention, the winding device further comprises a tension exerting mechanism which exerts a predetermined tension on the wire. The tension exerting mechanism is provided between the wire source and the winding speed sensor.

[0012] According to yet another aspect of this invention, the winding device further comprises a tension sensor which detects a tension which is exerted on the wire by the tension exerting mechanism. The controller corrects the feeding speed of the wire based on the tension.

[0013] According to yet another aspect of this invention, the tension exerting mechanism comprises a rigid tension arm rotatable about a base, a guide which is provided on a tip of the tension arm and guides a wire between the wire source and the winding speed sensor, and an elastic member provided to the tension arm. The tension sensor detects a tension exerted on the wire based on a rotational angle of the tension arm.

[0014] According to yet another aspect of this invention, the tension arm becomes thick towards the base and becomes thin towards the tip.

[0015] In order to achieve the above object, this invention also provides a winding method of wire which is fed from a wire source onto a bobbin which is supported by a spindle. The method comprises detecting a winding speed of the wire wound onto the bobbin and controlling a feeding speed of the wire from the wire source depending on the winding speed.

[0016] According to an aspect of this invention, the winding method further comprises detecting a tension exerted on the wire and correcting the feeding speed based on the tension.

[0017] The details as well as other features and advantages of this invention are set forth in the remainder of the specification and are shown in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] Fig. 1 is a perspective view showing a winding device according to the present invention.

[0019] Fig. 2 is a block diagram of the control system of the winding device.

[0020] Fig. 3 is similar to Fig. 1, but shows a second embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0021] Referring to Fig. 1 of the drawings, the winding device comprises a spool 1 on which wire 2 is pre-wound and which acts as a wire source. The spool 1 is connected to a feeding motor 3 and the feeding motor 3 rotates the spool 1 to feed the wire 2.

[0022] The wire 2 passes through a feed mechanism 4 and is lead onto a bobbin 7 which is provided on the tip of a spindle 6. The spindle 6 is rotated by a drive mechanism 16. When the bobbin 7 rotates, the wire 2 is wound onto the bobbin 7.

[0023] The feed mechanism 4 is provided with a tension arm 10 on the downstream of the felt pulley 8 used to dust the wire 2. A base 10A of the tension arm 10 is supported in free rotation by a plate 9 and can rotate along the plate 9. The rotational angle of the tension arm 10 is detected by a potentiometer 11 provided on the base 10A.

[0024] A pulley 12 is provided on the tip of the tension arm 10 which guides the wire 2. The wire 2 which is lead from the spool 1 to the felt pulley 8 passes through the pulley 12 and a pulley 13 which is nearer to the bobbin 7 than the pulley 12 and is lead to the bobbin 7. Instead of the pulley 12 on the tip of the tension arm 10, a ring shaped member which leads the wire 2 may be provided.

[0025] The pulley 13 is fixed onto the rotational axis of an encoder 14 provided on the plate 9. The speed of the wire 2 which is lead to the bobbin 7 via the pulley 13 is detected by the encoder 14.

[0026] A spring 15 is provided between the tension arm 10 and a boss 8A provided on the plate 9. The spring 15 effects a force in a clockwise direction on the tension arm 10 and thus a tension corresponding to the elastic force of the spring 15 is exerted on the wire 2. When there is an increase in the tension on the wire 2, since the spring extends and the tension arm 10 rotates in a counter clockwise direction, it is possible to calculate the variation in the tension on the wire 2 from the variation of the rotational angle of the tension arm 10.

[0027] The tension arm 10 is constructed from a sufficiently rigid material which is hard to bend so that the variation in tension is accurately reflected in the rotational angle of the tension arm 10. In addition, a light material is used so that the responsiveness to the variation in tension is high. In order to achieve high rigidity and responsiveness, the tension arm becomes thick towards the base 10A and becomes thin towards the tip.

[0028] A controller 17 rotates the spindle 6 at a predetermined rotational speed. Furthermore the controller 17 controls the feeding speed of the wire 2, that is to say, the rotational speed of the feeding motor 3 based on the winding speed of the wire 2 on the bobbin 7 de-

tected by the encoder 14, the tension detected by the potentiometer 11 and the radius of the pulley 1 which is obtained by calculation or by a sensor.

[0029] Fig. 2 is a block diagram which shows the control system of the winding device.

[0030] The controller 17 comprises a D/A converter 21, a CPU (Central Processing Unit) 22, amplifiers 23, 26, an operational amplifier 24, a resistor 25 and a volume 27.

[0031] Pulses output from the encoder 14 are input into the CPU 22 after being converted into analogue signals by the D/A converter 21.

[0032] The potentiometer 11 is a variable resistor which varies the resistance value depending on the rotational angle of the tension arm 10 and which forms a non-inverse amplification circuit together with the operational amplifier 24 and the resistor 25. The output of the non-inverse amplification circuit varies depending on the value of the resistance of the potentiometer 11, is amplified by the amplifier 26 and output to the CPU 22.

[0033] The CPU 22 corrects the signal from the encoder 14 based on the variation in tension and the radius of the pulley 1 and outputs the modified signal to the amplifier 23.

[0034] When there is no variation in the tension of the wire 2, no correction of the signal is made and the rotational speed of the feeding motor 3 is controlled so that the wire 2 is fed at the same speed as the winding speed of the wire 2 onto the bobbin 7 as detected by the encoder 14. In contrast, when there is variation in the tension on the wire 2 and the potentiometer 11 moves from its zero point, the variation in tension is fed back to the amplifier 23 and regulates the rotational speed of the feeding motor 3.

[0035] The volume 27 is a variable resistor which regulates the output voltage of the non-inverse amplification circuit. When the potentiometer 11 is at zero point, in other words, when the rotational angle of the tension arm 10 takes an angle which exerts a predetermined tension on the wire 2, the output of the non-inverse amplification circuit is regulated to take a value of zero.

[0036] The arrangement of the control system is not limited to the circuit shown in Fig. 2. For example, the variation in tension or the winding speed of the wire 2 could be detected using a device other than the encoder 14 or the potentiometer 11. It is possible to use an AC motor, a DC motor, a step motor or the like as the feeding motor 3. The detected signal from the encoder 14 need not be converted into an analogue signal by the D/A converter 21 but may be directly processed digitally and the feed back control can be performed by hardware or software.

[0037] The winding device of the present invention performs winding as set out below.

[0038] The wire 2 fed from the spool 1 is lead to the bobbin 7 through the feed mechanism 4 and is wound onto the bobbin 7 which rotates at a predetermined rotational speed.

[0039] The feeding motor 3 feeds a necessary length of wire 2 by rotating the spool 1. The rotational speed of the feeding motor 3 is controlled based on the wire winding speed of the bobbin 7 detected by the encoder 14 and the radius of the spool 1 obtained by a sensor or by calculation.

[0040] As a result, it is possible to make the feeding speed of the wire 2 from the spool 1 agree with the winding speed of the bobbin 7 and stabilize the tension of the wire 2. Hence, it is not necessary to calculate the increase in the radius of the bobbin 7 due to the wound wire 2.

[0041] When the cross sectional shape of the bobbin 7 is not round, as shown in Fig. 1, the radius of the bobbin 7 varies according to the rotational angle. However as opposed to the conventional technique, it is not necessary to calculate the variation in the radius according to contour data of the bobbin 7, etc.

[0042] Furthermore when the wire 2 is slack and the encoder 14 rotates in the inverse direction, the controller 17, which receives the detection signal from the encoder 14, rotates the feeding motor 3 in the inverse direction and returns the wire 2 in the direction of the spool 1.

[0043] The rotational displacement of the tension arm 10 due to the variation in the tension is fed back to the feeding motor 3 and the rotational speed of the feeding motor 3 is regulated. In this way, momentary minute variations in the tension of the wire 2 can be automatically absorbed. Since the tension arm 10 is controlled to maintain a constant angle, normally a constant tension is exerted on the wire 2.

[0044] When a tension variation on the wire 2 is generated by a disturbance or the like, the displacement of the tension arm 10 is detected by the potentiometer 11 and fed back to the feeding motor 3 which automatically regulates the rotational speed of the feeding motor 3.

[0045] Fig. 3 shows another embodiment of the present invention.

[0046] This embodiment differs from the previous embodiment in that a feed relay mechanism 43 comprising a pulley 41 and a feeding motor 42 is provided on the downstream of a spool 40 which acts as the wire source.

[0047] The provision of the feed relay mechanism 43 allows the wire 2 which is wound beforehand on the spool 40 to be provided to the tension arm 10 after being temporarily wound on the pulley 41 which is driven rotationally by the feeding motor 42.

[0048] In this case, since the amount of wire 2 wound on the pulley 41 is constant and the radius of the pulley 41 does not vary, the length of wire 2 fed from the pulley 41 is determined depending on the number of rotations of the pulley 41.

[0049] Hence according to this embodiment, the feeding speed of the wire 2 is decided only by the rotational speed of the feeding motor 42. Thus, it is not necessary to correct the rotational speed of the feeding motor 42 depending on the radius of the spool 1 as in the previous embodiment.

[0050] The embodiments of this invention in which an exclusive property or privilege is claimed are defined as follows:

Claims

1. A winding device comprising:

a wire source feeding wire (2),
a spindle (6) which supports a bobbin (7) which winds said wire (2) and
a drive mechanism (16) which rotates said spindle (6) **characterized in that** said winding device further comprises:
a winding speed sensor which is provided on the upstream of said bobbin (7) and detects a winding speed of said wire (2) which is wound onto said bobbin (7) and
a controller (17) which controls a feeding speed of said wire (2) fed from said wire source depending on said winding speed.

2. A winding device according to Claim 1 **characterized in that** said winding speed sensor is an encoder (14), a pulley (13) is fixed on a rotational axis of said encoder (14) and said wire (2) is lead to said bobbin (7) via said pulley (13).

3. A winding device according to Claim 1 **characterized in that** said wire source is a spool (1) on to which said wire (2) is wound and said device further comprises a feeding motor (3) which rotates said spool (1) and wherein said controller (17) controls a rotational speed of said feeding motor (3).

4. A winding device according to Claim 1 **characterized in that** said device further comprises a feed relay mechanism (43) which relays said wire (2) from said wire source and feeds said wire (2), and said controller (17) controls a speed at which said feed relay mechanism (43) feeds said wire (2).

5. A winding device according to Claim 1 **characterized in that** said device further comprises a tension exerting mechanism which exerts a predetermined tension on said wire (2) and is provided between said wire source and said winding speed sensor.

6. A winding device according to Claim 5 **characterized in that** said device further comprises a tension sensor (11) which detects a tension which is exerted on said wire (2) by said tension exerting mechanism and said controller (17) corrects said feeding speed of said wire (2) based on said tension.

7. A winding device according to Claim 6 **characterized in that** said tension exerting mechanism com-

prises a rigid tension arm (10) rotatable about a base (10), a guide which is provided on a tip of said tension arm (10) and guides a wire (2) between said wire source and said winding speed sensor, and an elastic member (15) provided to said tension arm (10) and said tension sensor (11) detects a tension exerted on said wire (2) based on a rotational angle of said tension arm (10). 5

8. A winding device according to Claim 7 **characterized in that** said tension arm (10) becomes thick towards said base (10A) and becomes thin towards said tip. 10

9. A winding method of wire (2) which is fed from a wire source onto a bobbin (7) which is supported by a spindle (6) **characterized in that** said method comprises: 15

detecting a winding speed of said wire (2) wound onto said bobbin (7) and controlling a feeding speed of said wire (2) from said wire source depending on said winding speed. 20

10. A winding method according to Claim 9 **characterized in that** said method further comprises: 25

detecting a tension exerted on said wire (2) and correcting said feeding speed based on said tension. 30

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FIG.1

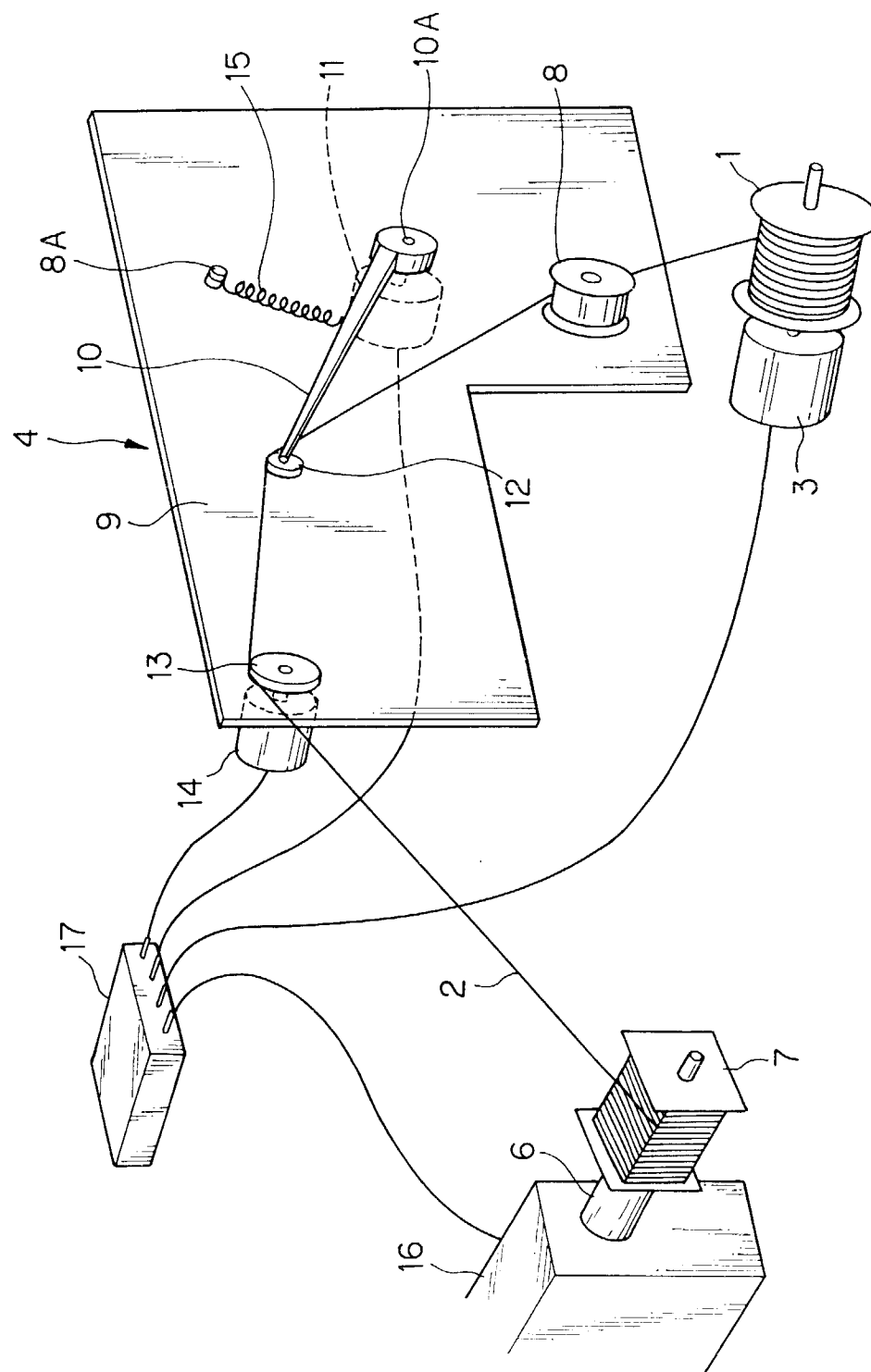


FIG. 2

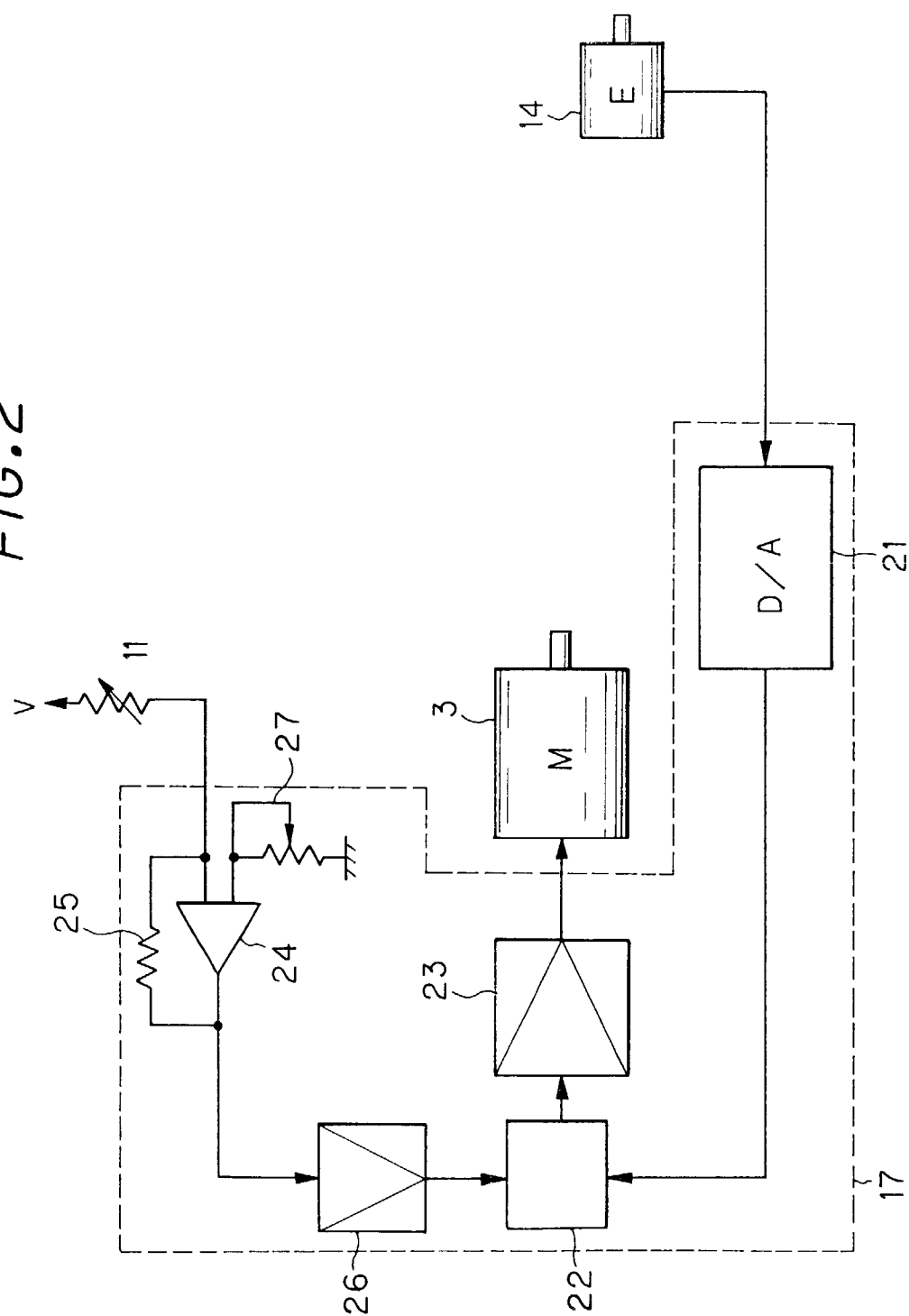


FIG. 3

