

TENSIONING APPARATUS

The present invention relates to a tensioning apparatus for imparting a constant tension to a wire such as a wire to be wound on a solenoid coil by a coil winding machine. More particularly, the present invention is concerned with
5 a tensioning apparatus which can vary and set the level of tension freely by using an electric motor.

Tensioning apparatus of the kind described are used in, for example, a coil winding machine for the purpose of imparting a constant level of tension to a wire which is
10 being unwound from a supply bobbin and wound on a coil bobbin.

An example of such a known tensioning apparatus is shown in Fig. 8.

The tensioning apparatus for a coil winding machine
15 generally has a main body 110 which includes a main tension pulley (brake pulley) 114 which produces a braking torque, a swingable tension bar 115 for absorbing any fluctuation of the tension on the wire, and a pulley 117 provided on the free end of the tension bar 115. In operation, a

predetermined level of tension is applied to the wire by cooperation between the main tension pulley 114 and the pulley 117. The main tension pulley 114 has a braking device which exerts a braking torque on the main tension pulley 114. The braking device includes a disk rotatable as a unit with the main tension pulley 114 and a band brake which acts on the outer periphery of the disk. The braking torque is adjustable by a mechanical control of the contact pressure between the band brake and the disk.

It is to be understood, however, that the pressure exerted by the band brake varies during long use of the brake.

It is therefore a current measure to apply the braking torque to the main tension pulley in a non-contact manner by means of a magnet and a magnetic disk which oppose each other. With this arrangement, the level of the braking torque can be freely set by adjusting the distance between the magnet and the magnetic disk.

This type of tensioning apparatus is shown in, for example, Japanese Patent Publication No. 11270/1988, Japanese Utility Model Publication No. 48609/1988, Japanese Patent Publication No. 22194/1989, Japanese Utility Model Publication No. 11419/1990 and Japanese Utility Model Publication No. 11420/1990.

A wire 103 which has passed the main tension pulley

114 is taken up by a bobbin 102 which is rotated at a high speed by a winding machine 101, through an idle pulley 118, the pulley 117 provided on the free end of the tension bar 115, an idle pulley 104 and a nozzle 105.

5 During the winding, the nozzle 105 is moved to the left and right as viewed in the drawing.

 The tension bar 115 is swingable about a fulcrum of an axle 111 of the tension bar 115 and is urged in the clockwise direction by the force of a back tension spring 112 so as to pivot in accordance with the level of the
10 tension thereby absorbing variation in the back tension, thus maintaining a constant level of tension at the position where the wire is wound.

 The back tension exerted by the tension bar 115 is
15 changeable or adjustable by replacing the tension spring or by changing the position of the tension spring after removal of the housing cover or by means of an externally operable knob.

 The above-described tensioning device has a drawback
20 that a manual adjusting work is necessary each time the specifications of the winding is changed, requiring laborious work for adjusting the level of the braking torque applied to the main tension pulley and adjustment of the back tension applied to the tension bar.

25 The necessity of the manual adjusting operations

tremendously impedes production efficiency of the conventional automatic coil winding apparatus in which a plurality of coils are wound at a time.

5 Another drawback of the conventional apparatus is that it has no means for correcting any variation in the tension, when necessary, during the winding operation.

According to the present invention, there is provided a tensioning apparatus comprising:

10 a rotatable main tension pulley on which a wire pulled out from a source is wound and which applies a tension to said wire;

a magnet brake for applying a braking torque to said main pulley;

15 a rotatable auxiliary tension pulley disposed so as to be contacted and rotated by a portion of said wire between said main tension pulley and the wire pulling out end which is on the downstream side of said main tension pulley as viewed in the direction of movement of said wire;

20 a tension bar having one end rotatably carrying said auxiliary tension roller and rotationally urged by a spring in such a direction as to tense said wire, thereby resiliently absorbing variation in the tension of said wire;

25 a brake force adjusting mechanism for adjusting the effect of said magnet brake;

a back tension adjusting means for adjusting the force exerted by said spring so as to adjust the urging force on said tension bar;

5 a brake force adjusting motor for actuating an adjusting portion of said brake force adjusting mechanism thereby enabling adjustment of the brake force; and

control circuit means for setting the brake force to a desired level and for detecting the level of the brake force, said control circuit means being capable of controlling
10 said motor so as to actuate said adjusting portion of said brake force adjusting mechanism to a position corresponding to the set level of the tension.

The back tension adjusting means may include a back tension adjusting motor for moving a movable
15 adjusting member for adjusting the force of the spring, and the control circuit means may be designed to be capable of setting the back tension to a desired level and detecting the level of the back tension and also capable of controlling the back tension adjusting motor
20 to move the movable adjusting member of the back tension adjusting mechanism to a position corresponding to the set level of the back tension.

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The control circuit means preferably includes: a terminal for enabling setting of the back tension; an input terminal for

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receiving an output from a back tension sensor for
5 sensing the level of the back tension; and a circuit for
controlling the operation of the brake force adjusting
motor such that the output from the back tension sensor
coincides with the set back tension.

The back tension adjusting mechanism preferably
10 includes a motion converting mechanism capable of
converting the rotational output of the back tension
adjusting motor into a linear motion. The motion
converting mechanism may include means for converting
rotational motion about a first rotational axis to
15 rotational motion about a second rotational axis
perpendicular to said first rotational axis. Such
converting means may be a combination of a worm gear and
a worm wheel.

A preferred embodiment of the present invention
20 will now be described with reference to the accompanying
drawings, in which:

Fig. 1 is a front elevational view of an embodiment
of the tensioning apparatus in accordance with the
present invention;

25 Fig. 2 is a sectional view taken along the line A-A
of Fig. 1;

Fig. 3 is a sectional view taken along the line B-B
of Fig. 1;

Fig. 4 is a rear elevational view of the embodiment shown in Fig. 1 with a rear lid removed therefrom;

Fig. 5 is a longitudinal sectional view taken along the line C-C of Fig. 4;

5 Fig. 6 is an illustration of the positional relationship between a magnet and a magnetic disk;

Fig. 7 is a block diagram of the circuit of a tensioning apparatus embodying the present invention; and

10 Fig. 8 is an illustration of the basic arrangement of known tensioning apparatus used in an ordinary coil winding machine.

The outline of the embodiment will be described first with specific reference to Figs. 1 and 2.

15 A pneumatic cylinder 45 and a mounting shaft 76 are attached to the lower surface of the main body 11 of the tensioning apparatus.

The mounting shaft 76 is used for mounting the main body 11 on a coil winding machine which is not shown. More specifically, the mounting shaft 76 is partly embedded in
20 the bottom wall of the main body 11 and is received in a bore formed in a mounting bracket 77 fixed to the coil winding machine.

The front surface of the main body 11 is covered by a front cover 12 on which are mounted a wire presser 55, a main tension pulley 22, auxiliary tension pulleys 41a, 41b, a microswitch, a snell guide 66 and a pulley 40 on the
5 end of a tension bar 36.

The snell guide 66 is adapted for guiding a wire P from a supply bobbin (not shown) to the tensioning apparatus.

The wire P supplied from the supply bobbin is guided by the snell guide 66 and is led to the main tension pulley 22
10 through the wire presser 55 so as to be wound around the main tension pulley 22. A braking torque is applied to the main tension pulley 22 by an electromagnetic brake.

The wire P is then led through auxiliary tension pulleys 41b, 41a and, after making a turn around the pulley
15 40 on the tension bar 36, taken up by and wound on a coil bobbin which is driven by the coil winding machine (not shown).

The tension bar 36 is adapted for absorbing any variation in the tension acting on the wire P, while the
20 auxiliary tension pulleys 41a, 41b are adapted for changing the direction of movement of the wire P so as to increase the lengths of the portions of the wire P wound around the main tension pulley 22 and the pulley 40.

A stepping motor 200 incorporated in the main body 11
25 is adapted for adjusting the braking force which acts on

the main tension pulley 22, while a stepping motor 210 is adapted for adjusting the rotational urging force exerted on the tension lever 36.

5 The tension acting on the running wire P is sensed by a pressure sensor 220. More specifically, the pressure sensor 220 senses any movement of the auxiliary pulley 41b from the neutral position so as to measure the pressure which acts on this pulley 41b and which indicates the tension acting in the wire P.

10 A description will now be given of the detail of the major parts of the apparatus, as well as operations of such major parts.

15 The wire presser 55 clamps the wire P between pads so as to lead the wire P guided by the snell guide 66 towards the main tension pulley 22 thereby preventing the wire P from coming off the main tension pulley 22 and any slack of the wire P. The force with which the wire presser 55 presses the wire can be adjusted freely by rotating an
20 adjusting nut which is not shown.

 The braking force is generated through a cooperation between a permanent magnet 48 and a magnetic disk 49 which opposes the magnet 48.

25 As shown in Fig. 2, the main tension pulley 22 is fixed to a disk base plate 21 by means of a base plate fixing screw 51 and a nut 85. The above-mentioned magnetic

disk 49 is fixed to the disk base plate 21 so that the magnetic disk 49 rotates as a unit with the main tension pulley 22. The main tension pulley 22 and the magnetic disk 49 are rotatably supported by radial bearings 63, 63 provided on the front cover 12, so that the unitary structure including the main tension pulley 22 and the magnetic disk 49 smoothly rotates with respect to the front cover 12.

On the other hand, the permanent magnet 48 opposing the magnetic disk 49 is fixed by bonding to a magnet pole base plate 17 which in turn is fixed to a magnetic pole shaft 16 by means of a magnet pole base plate fixing screw 47.

Fig. 6 shows the relationship between the magnet and the magnetic disk for generating the braking force. The magnet and the magnetic disk are shown in an exploded view exploded around the axis of rotation.

As will be seen from Fig. 6, the permanent magnet 48 has a plurality of permanent magnet pole pieces of N and S polarities arranged alternately in the circumferential direction. Alternately, a ring-shaped ferromagnetic member is magnetized to provide the magnetic poles shown in Fig. 6.

In operation, eddy current is generated in the magnetic disk 49 as the magnetic disk 49 under the

influence of the magnetic poles of N and S poles of the permanent magnet 48, whereby a braking torque is generated between the permanent magnet 48 and the magnetic disk 49.

5 The level of the braking torque is determined by the size of the gap between the permanent magnet 48 and the magnetic disk 49. The setting of the torque, therefore, is conducted by displacing the permanent magnet 48 towards and away from the magnetic disk 49.

10 A gear 203 is fixed to the magnet pole shaft 16 by means of a gear mounting screw 206. The gear 203 is driven by a gear 201 fixed to the shaft of the stepping motor 200 through an idle gear 202.

15 On the other hand, a torque adjusting ring 204 is rotatably supported through a screwing engagement by a torque adjusting ring support frame 205 which is fixed to the main body 11. This torque adjusting ring 204 also is fixed to the magnetic shaft 16.

20 By rotating the torque adjusting ring 204 through the operation of the stepping motor 200, therefore, it is possible to move the permanent magnet 48 towards and away from the magnetic disk 49, thereby adjusting the size of the gap between the permanent magnet 48 and the magnetic disk 49.

25 The control of the stepping motor 200 is conducted through a control section 230 (see Fig. 7). When the power is turned on, the stepping motor 200 is reversed to move

the permanent magnet to an ordinary position and is then operated to set the permanent magnet to a position determined by the specifications of the coil winding.

The detection of the above-mentioned ordinary position
5 is conducted by sensing a change in the sensor output which detects the size of the gap between the permanent magnet 48 and the magnetic disk 49 or by de-synchronization of the stepping motor 200.

A description will now be given on the arrangement for
10 imparting back tension to the wire P which is being pulled out from the supply bobbin.

As shown in Fig. 1, the pulley 40 for imparting or adjusting the back tension is secured to the end of the tension bar 36 by means of a pulley mounting piece and a
15 radial bearing which are not shown. A tension shaft 31 is fixed to a tension bar ring 37 which in turn is fixed to the other end of the tension bar 36.

The tension shaft 31 is rotatably supported on a tension shaft seat 35 provided on the front cover 12
20 through radial bearings 65, 65 as shown in Fig. 3. A tension lever 32 is fixed at its one end to the inner end of the tension shaft 31 through a tension lever ring 33. Therefore, the tension bar 36, the tension shaft 31 and the tension lever 32 rotate as a unit with each other.

A contact roller 34 is secured to the other end of the tension lever 32 by means of a screw 81 and a nut 86. As will be seen from Fig. 4, the contact roller 34 is always held in contact with the lower surface of a swing lever 25. Fig. 4 shows a state in which no tension is applied at all to the wire P.

The swing lever 25 is swingably supported by a lever shaft 24 provided on the inner surface of the front cover 12, through radial bearings 64, 64, so as to swing about a fulcrum constituted by the lever shaft 24. A movable spring retainer 29 is screwed to an adjusting screw 27 which is supported by the frame of the swing lever 25. The spring retainer nut 29 is urged downwardly as viewed in Fig. 4 by an adjusting spring 30, so that the swing lever 25 is always urged counter-clockwise as viewed in Fig. 4.

Counter-clockwise swinging of the swing lever 25, however, is limited because the counter-clockwise rotation of the tension lever 32 also is limited by a rubber stop ring 67 fitted on an inner projection 12a provided on the inner surface of the front cover 12.

The other end of the adjusting spring 30 is retained by a retaining hole 42a which is provided in a V-shaped lever 42. The V-shaped lever 42 is swingably supported by a shaft pin 61 provided on the inner surface of the front cover 12 so as to freely swing around this pin 61. In

ordinary condition of operation, the pneumatic cylinder 45 operates to extend a pneumatic cylinder rod 45a as shown in Fig. 4 so as to push a contact roller 43 on the V-shaped lever 42, whereby the V-shaped lever 42 is held at a fixed position. As a consequence, the position of the retainer hole 42a formed in the V-shaped lever 42, i.e., the lower end of the adjusting screw, is fixed.

The detail of the mechanism employing the V-shaped lever is described in detail in Japanese Utility Model Publication No. 48609/1989. In this invention, however, the structure of and around the V-shaped lever 42 does not constitute any feature of the present invention. Thus, the mechanism should be understood merely as being a form for fixing the lower end of the adjusting spring.

Consequently, the force which acts to cause the counter-clockwise swinging of the swing lever 25 is determined solely by the position of the movable spring retainer nut 29 which retains the upper end of the adjusting spring 30. Since the lower end of the swing lever 25 constantly presses the contact roller 34 on the tension lever 32, the level of the back tension imparted to the pulley 40 is determined by the position of the movable spring retainer nut 29.

The spring retainer nut 29 has a female screw thread

to which the adjusting screw 27 is screwed. Therefore, the spring retainer nut 29 moves in the direction of axis of the adjusting screw 27 when a worm wheel 215 fixed to one end of the adjusting screw 27 is rotated.

5 The level of the back tension is adjusted as the distance between the spring retainer nut 29 and the lever shaft 24 serving as the fulcrum is changed. In order to indicate the level of the back tension thus adjusted, marks 70 are painted in red color on a portion of the movable
10 spring retainer nut 29. These marks are observable from the exterior of a back lid 13.

As will be seen from Figs. 4 and 5, the worm wheel 215 is rotated by a gear 211 fixed to the shaft of a stepping motor 210, through gears 212, 213 and a worm 214.

15 In the illustrated embodiment, the axis of rotation is turned by the use of the worm 214 and the worm wheel 215. This arrangement, however, is only illustrative and the plane of rotation may be changed by using meshing spiral gears. In such a case, the gears may be arranged
20 orthogonally of the diameters of both spiral gears are equal.

Referring to Fig. 4, the adjusting screw 27 is rotated by the stepping motor 210 and causes the movable spring retainer nut 29 to move to the left as
25 viewed in this figure, thereby raising the level of the

back tension. Conversely, the back tension is lowered when the spring retainer nut 29 is moved to the right.

The stepping motor 210 is controlled through the controller (control circuit) 230. When the power is turned
5 on, the control circuit operates to reverse the stepping motor 210 so as to reset the movable spring retainer nut 29 to an ordinary position and then sets the same to a position determined by the winding specifications in accordance with numerical data which have been input
10 beforehand.

The detection of the above-mentioned ordinary position is detected by measuring a change in the output from a sensor (not shown) such as a photoelectric sensor for detecting the position of the movable spring retainer nut
15 29 or by a circuit after de-synchronizing the stepping motor 210.

A description will now be given of the method for adjusting the tension of the wire during winding.

When the wire P is pulled in the winding direction, the
20 wire P receives a tension of a level of a predetermined range which is determined by the braking force exerted by the main tension pulley 22 and the back tension applied by the tension bar 36.

A small change in the tension is absorbed as the
25 tension bar 36 delicately swing so as to attain a balance

between the tension of the wire P on the pulley 40 and the urging force applied to the tension bar 36.

5 The pressure sensor 220 shown in Fig. 1 senses any large tension which cannot be absorbed by the swinging of the tension bar 36.

10 The pressure sensor 220 is housed in an auxiliary pulley holder guide 53 which is fixed to the front cover 12. The auxiliary pulley 41b is fixed to an auxiliary pulley holder 52 which is movable along the inner surface of the auxiliary pulley holder guide 53 towards and away from the portion where the auxiliary pulley 41b contacts the wire P.

15 During ordinary winding operation, the auxiliary pulley 41b lightly contacts the pressure sensor 220. However, when the tension on the wire P is increased, the pressure sensor 220 delivers an output corresponding to the tension to the control section 230, so that the control section 230 operates to control the stepping motor 200 in the direction for reducing the braking force exerted on the main tension pulley 220. As a result, the pressure sensor 220 delivers to the control section 230 an output of a level corresponding to the reduced tension on the wire P, so that the control section 230 operates the stepping motor 200 in the direction increasing the braking force exerted on the main tension pulley 22.

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In the described embodiment, the tension on the wire P is controlled in accordance with the output from the pressure sensor 220. This, however, is only illustrative and the control of the tension may be conducted in accordance with an output from a photoelectric sensor which
5 detects the position of the tension bar 36 which indicates the level of the back tension.

In order to indicate the instant level of the braking force exerted on the main tension pulley 22, scales are
10 provided in the front surface of a dial 15 fixed to the rotary shaft of the stepping motor 200 so as to be visible from the exterior of the rear lid 13.

Fig. 7 is a block diagram of an electric circuit incorporated in the tensioning apparatus of the present
15 invention. The operator can input necessary data concerning the back tension to the control circuit 230. It will be obvious that wires of greater diameters generally require greater levels of back tension and wires of smaller diameters require lower levels of the back tension because
20 the wire may be cut during the winding by too strong back tension. The control circuit 230 then controls the stepping motor 200 in accordance with the input data so as to set the brake torque to a suitable level and also controls the stepping motor 210 so as to set the back
25 tension spring to a position where it provides a suitable

level of back tension.

Data outputs from the sensors are delivered to the control circuit 230 through data lines 231, 232.

5 The state of the brake torque setting means 201-206 are confirmed through indicating portions 70. The position of the back tension spring also is known from the position of the spring retainer nut 29 indicated on the indicating portion 70 for observation from the exterior of the apparatus.

10 The operation or method of use of the apparatus of the present embodiment is as follows:

15 The main body of the tensioning apparatus is mounted on and fixed to a coil winding machine (not shown) through the mounting shaft 76. Then, a wire P led from a supply bobbin is threaded through the snell guide 66. Then, the wire P is partly clamped by the line presser 55 and, after making about 3/4 rotation around the main tension pulley 22, led through the auxiliary tension pulleys 41a, 41b and then wound around the pulley 40. A plurality of wires P, 20 corresponding to the number of coils to be formed simultaneously are supplied in the above-described manner.

Subsequently, numerical data concerning the braking force to be applied to the main tension pulley and the back tension to be produced by the tension bar are input to the

control section through a manipulating portion in
accordance with the coil winding specifications. Then, the
coil winding machine is started so that the stepping motors
200, 210 of the tension adjusting mechanisms operate to
5 automatically set the braking force and the back tension to
predetermined levels. Any change in the tension applied to
the wire P during winding is sensed by the pressure sensor
220 and the control section operates in accordance with the
output from the pressure sensor 220 so as to control the
10 stepping motor 200 thereby compensating for such a change
in the tension.

As has been described, there is provided a
tensioning apparatus having a main tensioning pulley which
applies a braking force to a moving wire and an auxiliary
15 tension pulley which imparts a back tension to the wire
thereby controlling the tension on the wire, wherein the
braking torque applied to the main tension pulley and the
back tension applied to the lever supporting the auxiliary
tension pulley are set to predetermined levels by
20 automatically-controlled stepping motors, thus eliminating
troublesome and laborious manual adjusting works which
heretofore have been necessary upon each change of the
winding condition, e.g., size of the wire, presence or
absence of the sheath on the wire, size of the coil bobbin
25 and form of the coil bobbin.

Thus, there can be quick and easy adjustment of the tension when the winding specifications are changed. This feature is advantageous particularly in the cases where coil winding has to be conducted on a plurality of coil bobbins simultaneously. Thus, the tensioning apparatus makes it possible to improve reliability of the products and efficiency of the winding operation, particularly when combined with an automatic coil winding machine.

Furthermore, any change in the tension incurred during winding can be corrected for, by the control of the braking torque on the main tension pulley which is conducted in accordance with the output from a sensor which senses the tension on the moving wire. This contributes to an improvement in products quality which are to be finished with specifically high grade of quality.

At least in its preferred forms, the present invention provides: a tensioning apparatus in which the braking torque applied to the main tension pulley and the back tension are automatically adjusted and set to desired levels in accordance with winding specifications by an adjusting motor, when the power is turned on or when the tension level is to be changed during the winding; and a tensioning apparatus which is capable of correcting any variation in the tension of the wire, when necessary, during winding.



Claims

1. A tensioning apparatus comprising:

a rotatable main tension pulley on which a wire pulled out from a source is wound and which applies a tension to said wire;

5 a magnet brake for applying a braking torque to said main pulley;

a rotatable auxiliary tension pulley disposed so as to be contacted and rotated by a portion of said wire between said main tension pulley and the wire pulling out end which
10 is on the downstream side of said main tension pulley as viewed in the direction of movement of said wire;

a tension bar having one end rotatably carrying said auxiliary tension roller and rotationally urged by a spring in such a direction as to tense said wire, thereby
15 resiliently absorbing variation in the tension of said wire;

a brake force adjusting mechanism for adjusting the effect of said magnet brake;

a back tension adjusting means for adjusting the force exerted by said spring so as to adjust the urging force on
20 said tension bar;

a brake force adjusting motor for actuating an adjusting portion of said brake force adjusting mechanism thereby enabling adjustment of the brake force; and



control circuit means for setting the brake force to a desired level and for detecting the level of the brake force, said control circuit means being capable of controlling said motor so as to actuate said adjusting portion of said brake force adjusting mechanism to a position corresponding to the set level of the tension.

2. A tensioning apparatus according to Claim 1, wherein said back tension adjusting means includes a back tension adjusting motor for moving a movable adjusting member for adjusting the force exerted from said spring, and wherein said control circuit means is capable of setting the back tension to a desired level and detecting the level of the back tension and also capable of controlling said back tension adjusting motor to move said movable adjusting member of said back tension adjusting means to a position corresponding to the set level of the back tension.

3. A tensioning apparatus according to Claim 2, wherein said control circuit means includes: a terminal for enabling setting of the back tension; an input terminal for receiving an output from a back tension sensor for sensing the level of the back tension; and a circuit for controlling the operation of said brake force adjusting motor such that the output from said back tension sensor coincides with the set back tension.



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4. A tensioning apparatus according to Claim 2, wherein
said back tension adjusting means includes a motion
converting mechanism capable of converting the
rotational output of said back tension adjusting motor
5 into linear motion.

5. A tensioning apparatus according to Claim 4, wherein
said motion converting mechanism includes means for
converting rotational motion about a first rotational
10 axis to rotational motion about a second rotational axis
perpendicular to said first rotational axis.

6. A tensioning apparatus according to Claim 5, wherein
said motion converting means includes a worm gear and a
15 worm wheel.

7. Tensioning apparatus substantially as hereinbefore
described with reference to Figures 1 to 7 of the
accompanying drawings.

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