(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 2 617 670 A2**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
24.07.2013 Bulletin 2013/30

(21) Application number: **12007765.6**

(22) Date of filing: **16.11.2012**

(51) Int Cl.:
B65H 51/06 *(2006.01)* ***B65H 54/10*** *(2006.01)*
B65H 59/32 *(2006.01)* ***B65H 59/36*** *(2006.01)*
B65H 59/38 *(2006.01)*

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(30) Priority: **20.01.2012 JP 2012009528**

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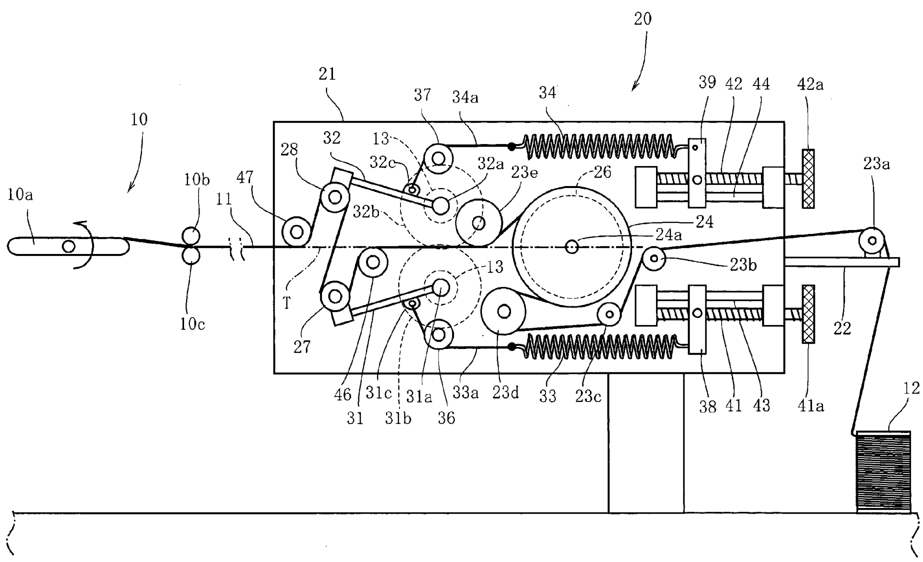
(54) **Tension device and tension applying method**

(57) A tension device and a tension applying method are provided that can absorb fluctuation in the speed of a wire rod and keep constant the tension of the wire rod sent to a winding machine even when the speed of the wire rod markedly fluctuates. A tension device 20 includes a feeding pulley 24 around which a wire rod 11 fed from a wire rod supply source 12 is wound, feeding speed controlling means 26 for controlling the rotation of the feeding pulley 24 and controlling the speed of the wire rod 11 pulled out from the supply source 12 to move toward a winding machine 10, a movable first tension pulley 27 configured to turn the wire rod 11 fed from the feeding pulley 24, a movable second tension pulley 28 configured to further turn the wire rod 11 turned by the first tension pulley 27 and direct the wire rod 11 to the winding machine 10, and urging means 33, 34 for urging the first tension pulley 27 and the second tension pulley 28 to expand a space between these tension pulleys. A pair of tension arms 31, 32 is provided rotatably about proximal ends thereof. The tension pulleys are pivotally supported at the distal ends of the tension arms.

Fig. 2



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Description

[0001] The present invention relates to a tension device and a tension applying method for applying predetermined tension to a wire rod fed from a wire rod supply source and guided to a winding machine.

[0002] As a tension device included in a winding machine that forms a coil, there has been known a device including, as shown in FIG. 8, a feeding pulley 3 around which a wire rod 2 fed from a wire rod supply source is wound, a tension arm 4 capable of pivoting about a pivoting fulcrum 4a at the proximal end thereof, a wire rod guide 5 attached to the distal end of the tension arm 4 and configured to, after allowing the wire rod 2 fed from the feeding pulley 3 to pass, turn and guide the wire rod 2 to a winding machine, an elastic member 6 configured to apply an elastic force, which corresponds to a pivoting angle of the tension arm 4, to the tension arm 4 in a predetermined position between the pivoting fulcrum 4a of the tension arm 4 and the wire rod guide 5, a potentiometer 7 configured to detect the pivoting angle of the tension arm 4, and a feeding motor 8 configured to control the rotation of the feeding pulley 3 to set the pivoting angle detected by the potentiometer 7 to a predetermined angle and control speed of the wire rod 2 moving from the feeding pulley 3 toward the winding machine, which is not shown in the figure, via the wire rod guide 5 (see, for example, Japanese Patent Application Laid-Open No. 2000-128433).

[0003] The wire rod 2 is guided to the winding machine via the wire rod guide 5 and wound around a winding core of the winding machine. The rotation of the feeding pulley 3 is controlled to set the pivoting angle of the tension arm 4 to the predetermined angle. Feeding speed of the wire rod 2 fed from the tension device in the past is balanced with the speed of the winding around the winding core. Predetermined tension is applied to the wire rod 2 by the tension arm 4 to which the elastic force is applied by the elastic member 6. When fluctuation occurs in the speed of winding the wire rod 2 about the winding core in this state, the tension of the wire rod 2 fluctuates. However, the fluctuation is absorbed by the tension arm 4 changing the pivoting angle. The change in the pivoting angle of the tension arm 4 is fed back to the rotation of the feeding pulley 3 via the potentiometer 7. Therefore, rotating speed of the feeding pulley 3 is adjusted by the feeding motor 8 to immediately set the pivoting angle of the tension arm 4 to the predetermined angle. The tension applied to the wire rod 2 is reset to a predetermined value.

[0004] As explained above, in the tension device in the past shown in FIG. 8, the tension arm 4 absorbs the fluctuation in the tension of the wire rod 2 by changing the pivoting angle. However, when the wire rod 2 is wound around a varying-diameter winding core having different outer diameters of a cross section, for example, a winding core having a rectangular sectional shape, the short side and the long side of which are extremely different, the speed of the wire rod 2 wound around the winding core periodically markedly fluctuates while the winding core rotates once. Then, the pivoting angle of the tension arm 4 that absorbs the fluctuation in the speed markedly increases or decreases.

[0005] For example, the wire rod 2 fed from the feeding pulley 3 is turned to bend at a substantially right angle with respect to the tension arm and guided to the winding machine in the wire rod guide 5 as shown in FIG. 8. In this case, when the winding speed of the wire rod 2 in the winding machine increases and the wire rod 2 is excessively wound by predetermined length L1 in a unit time, the wire rod guide 5 is pulled to move to the winding machine side by the predetermined length L1 of the excessive winding as indicated by a solid line arrow. The tension arm 4 provided with the wire rod guide 5 at the distal end thereof pivots resisting the elastic force of the elastic member 6 and allows the wire rod guide 5 at the distal end to move by the predetermined length L1.

[0006] However, when the fluctuation in the speed of the wire rod 2 wound around the winding core of the winding machine is extremely large and the speed markedly increases temporarily, the wire rod guide 5 is powerfully pulled by the wire rod 2. The pivoting of the tension arm 4 provided with the wire rod guide 5 at the distal end to absorb the fluctuation cannot follow the power of the pulled wire rod guide 5. As a result, tension exceeding the elastic force applied by the elastic member 6 is temporarily applied to the wire rod 2 between the wire rod guide 5 provided at the distal end of the tension arm 4 and the winding core.

[0007] Conversely, when the winding speed of the wire rod 2 in the winding machine decreases and an amount of the winding decreases by predetermined length L2 in a unit time, the wire rod guide 5 moves in a direction away from the winding machine by the decreased predetermined length L2 with the elastic force of the elastic member 6. The tension arm 4 provided with the wire rod guide 5 at the distal end pivots with the elastic force of the elastic member 6 and allows the wire rod guide 5 at the distal end to move by the predetermined length L2 as indicated by a broken line arrow.

[0008] However, when the fluctuation in the speed of the wire rod 2 wound around the winding core of the winding machine is extremely large and the speed of this wire rod 2 wound around the winding core of the winding machine markedly decreases temporarily, the force of the wire rod 2 for pulling the wire rod guide 5 markedly decreases temporarily. The pivoting of the tension arm 4 provided with the wire rod guide 5 at the distal end to absorb the fluctuation cannot follow the elastic force of the elastic member 6 because of an inertial force of the tension arm 4. As a result, the wire rod 2 between the wire rod guide 5 provided at the distal end of the tension arm 4 and the winding core temporarily slacks. Therefore, in the tension device in the past, when the speed of the wire rod 2 wound around the varying-diameter winding core in the winding machine markedly fluctuates, it is difficult to keep constant the tension of the wire rod 2 sent to the winding machine.

[0009] It is an object of the present invention to provide a tension device and a tension applying method that can absorb fluctuation in the speed of a wire rod and keep constant the tension of the wire rod sent to a winding machine even when the speed of the wire rod markedly fluctuates.

[0010] According to the present invention, there is provided a tension device including: a feeding pulley around which a wire rod fed from a wire rod supply source is wound; feeding speed controlling means for controlling the rotation of the feeding pulley and controlling the speed of the wire rod pulled out from the wire rod supply source to move toward a winding machine; a movable first tension pulley configured to turn the wire rod fed from the feeding pulley; a movable second tension pulley configured to further turn the wire rod turned by the first tension pulley and direct the wire rod to the winding machine; and urging means for urging the first tension pulley and the second tension pulley to expand a space between these tension pulleys.

[0011] In this case, it is preferable that a pair of tension arms, which are line-symmetrically formed, are provided rotatably about proximal ends thereof, the first tension pulley is pivotally supported at the distal end of one of the tension arms and the second tension pulley is pivotally supported at the distal end of the other one of the tension arms, the urging means is formed of elastic members configured to apply, to the pair of tension arms, elastic forces corresponding to pivoting angles of the pair of tension arms, pivoting-angle detecting means for detecting the pivoting angle of one or both of the pair of tension arms is provided, and the feeding speed controlling means is configured to control the rotation of the feeding pulley to set the pivoting angle detected by the pivoting-angle detecting means to a predetermined angle. It is more preferable that disk gears that mesh with each other to set the pivoting angles of the pair of tension arms to the same angle are respectively attached to the proximal ends of the pair of tension arms.

[0012] It is also possible that the tension device includes a first rail on which a first base, on which the first tension pulley is pivotally supported, is movable in the longitudinal direction thereof and a second rail which is provided coaxially with or parallel to the first rail and on which a second base, on which the second tension pulley is pivotally supported, is movable in the longitudinal direction thereof, the urging means is formed of elastic members configured to apply, to the first and second tension pulleys, elastic forces corresponding to the positions of the first and second bases with respect to the first and second rails, position detecting means for detecting the position of one or both of the first and second bases is provided, and the feeding speed controlling means is configured to control the rotation of the feeding pulley to set the position of one or both of the first and second bases detected by the position detecting means to a predetermined position.

[0013] It is preferable that the tension device further includes: a first turning pulley configured to turn the wire rod moving from the feeding pulley toward the first tension pulley and turn back the wire rod at the first tension pulley; and a second turning pulley configured to turn the wire rod moving from the second tension pulley toward the winding machine and turn back the wire rod at the second tension pulley.

[0014] Another invention is improvement of a tension applying method of controlling the rotation of a feeding pulley around which a wire rod fed from a wire rod supply source is wound and applying predetermined tension to the wire rod, which is fed from the feeding pulley and, the moving speed of which toward a winding machine is controlled.

[0015] The method is characterized by urging a first tension pulley and a second tension pulley to expand a space between these tension pulleys thereby applying a predetermined tension to the wire rod, with the movable first tension pulley being configured to wind and turn the wire rod fed from the feeding pulley and the movable second tension pulley being configured to further wind and turn the wire rod turned by the first tension pulley and direct the wire rod to the winding machine. In the tension device and the tension applying method according to the present invention, the movable first tension pulley configured to turn the wire rod fed from the feeding pulley and the movable second tension pulley configured to further turn the wire rod turned by the first tension pulley and direct the wire rod to the winding machine are provided. Therefore, the first tension pulley and the second tension pulley are urged to expand a space between the tension pulleys and the wire rod fed from the wire rod supply source is wound around both the first and second tension pulleys to use the tension pulleys like a block, whereby it is possible to reduce moving amounts of the first and second tension pulleys for absorbing fluctuation in the tension of the wire rod to a half or a quarter of those in the past. If the wire rod is wound around both the first and second tension pulleys a plurality of times, it is possible to further reduce the moving amounts.

[0016] When it is assumed that the tension of the wire rod is fixed, according to the principle of pulleys, force for urging the first tension pulley and the second tension pulley to expand the space between the tension pulleys resisting the tension of the wire rod is required to be two or four times as large as the force in the past. As the elastic member that urges the first tension pulley and the second tension pulley to expand the space between the tension pulleys in that way, an elastic member having an elastic force two, four, or more times as large as the elastic force in the past is used. However, when the elastic force of the elastic member is increased, acceleration of movement of the first and second tension pulleys is increased. Therefore, it is possible to cause the first and second tension pulleys, which move according to the speed fluctuation of the wire rod wound by the winding machine, to more quickly follow the speed fluctuation.

[0017] As explained above, the moving amounts of the first and second tension pulleys for absorbing the fluctuation in the speed of the wire rod are reduced to a half or the like of those in the past and the elastic force of the elastic member for moving the first and second tension pulleys is increased to a double or the like. Therefore, even if the varying-diameter winding core is rotated at relatively high speed, it is possible to cause the movement of the first and second tension pulleys to surely follow the winding speed. Therefore, it is possible to keep constant the tension of the wire rod sent to the winding machine.

FIG. 1 is a perspective view showing a tension device in an embodiment of the present invention;
FIG. 2 is a front view of the tension device;
FIG. 3 is a sectional view of the tension device;
FIG. 4 is a main part enlarged view showing the motion of tension pulleys of the tension device;
FIG. 5 is a diagram corresponding to FIG. 4 showing the motion of the tension pulleys in the tension device not including turning pulleys;
FIG. 6 is a diagram corresponding to FIG. 4 in which a wire rod is wound double around the tension pulleys;
FIG. 7 is a front view corresponding to FIG. 2 showing another tension device in the present invention; and
FIG. 8 is a front view corresponding to FIG. 2 showing a tension device in the past.

[0018] Modes for carrying out the present invention are explained in detail below with reference to the accompanying drawings.

[0019] A tension device 20 in the present invention is shown in FIGS. 1 to 3. The tension device 20 is used together with a winding machine 10. The tension device 20 applies predetermined tension to a wire rod 11 guided from a wire rod supply source 12 and guides the wire rod 11 to a winding core 10a such as a coil bobbin in the winding machine 10. The wire rod 11 in this embodiment is a coated copper wire, which is formed in a circular or square shape in a cross section, for forming a coil used in an electric component. The winding machine 10 forms a coil by winding the wire rod 11 made of the coated copper wire.

[0020] On the front surface of a casing 21 of the tension device 20, a wire rod guide 22 through which the wire rod 11 guided from a reel 12 (FIG. 2) functioning as a wire rod supply source is inserted, a plurality of guide pulleys 23a to 23e that draw around the wire rod 11 passed through the wire rod guide 22, and a feeding pulley 24 having a relatively large diameter are provided. The plurality of guide pulleys 23a to 23e are disposed on the front surface of the casing 21 to draw around the wire rod 11 passed through the wire rod guide 22 and wind the wire rod 11 around the feeding pulley 24.

[0021] A rotating shaft 24a of the feeding pulley 24, around which the wire rod 11 is wound, is directly connected to a feeding control motor 26 functioning as feeding speed controlling means housed in the casing 21. The rotating speed of the feeding control motor 26 is controlled by a not-shown controller. Consequently, the feeding control motor 26 functioning as the feeding speed controlling means is configured to control the rotation of the feeding pulley 24 and control the speed of the wire rod 11 drawn out from the reel 12 functioning as the wire rod supply source and moving toward the winding machine 10.

[0022] The tension device 20 according to the present invention includes a movable first tension pulley 27 configured to turn the wire rod 11 fed from the feeding pulley 24 and a movable second tension pulley 28 configured to further turn the wire rod 11 turned by the first tension pulley 27 and direct the wire rod 11 to the winding machine 10. In this embodiment, the first and second tension pulleys 27 and 28 are movably provided via a pair of tension arms 31 and 32.

[0023] Specifically, the pair of tension arms 31 and 32 is provided on the front surface of the casing 21 with an axis, which passes the rotation center of the feeding pulley 24 and extends to the winding machine 10, as an axis of symmetry T. The pair of tension arms 31 and 32 is provided further on the winding machine 10 side than the feeding pulley 24 and symmetrically to the axis of symmetry T. The proximal ends of the tension arms 31 and 32 on the feeding pulley 24 side are configured rotatable respectively with pivoting shafts 31a and 32a as fulcrums. The first tension pulley 27 is pivotally supported at the distal end of one tension arm 31 and the second tension pulley 28 is pivotally supported at the distal end of the other tension arm 32. Consequently, when the pair of tension arms 31 and 32 respectively pivots with the pivoting shafts 31a and 32a as the fulcrums, the first and second tension pulleys 27 and 28 pivotally supported at the distal ends thereof move in an arc shape. In this way, the first and second tension pulleys 27 and 28 are movably provided via the pair of tension arms 31 and 32.

[0024] On the inside of the casing 21, disk gears 31b and 32b having the same shape and the same size, which mesh with each other, are respectively attached to the pivoting shafts 31a and 32a that support the proximal ends of the pair of tension arms 31 and 32. The disk gears 31b and 32b are configured to mesh with each other in the outer circumferences thereof to thereby set pivoting angles of the pair of tension arms 31 and 32 to the same angle. A potentiometer 13 that detects pivoting angles of the pivoting shafts 31a and 32a, which support the proximal ends of the pair of tension arms 31 and 32, is housed in the casing 21. The potentiometer 13 is attached to one of the pair of tension arms 31 and 32 and configured to detect the pivoting angles of the tension arms 31 and 32.

[0025] The tension device 20 according to the present invention includes urging means for urging the first tension pulley 27 and the second tension pulley 28 to expand a space between the first and second tension pulleys 27 and 28. The first and second tension pulleys 27 and 28 are movably provided via the pair of tension arms 31 and 32. In this embodiment, the urging means includes elastic members 33 and 34 that apply elastic forces corresponding to the pivoting angles of the pair of tension arms 31 and 32 to the pair of tension arms 31 and 32. Specifically, attachment brackets 31c and 32c are respectively attached to predetermined positions between the proximal ends and the distal ends of the pair of tension arms 31 and 32. One ends of coil springs 33 and 34 functioning as elastic members are attached to the brackets 31c and 32c via wires 33a and 34a. The pair of coil springs 33 and 34 holds the feeding pulley 24 and is provided in parallel to the axis of symmetry T of the pair of tension arms 31 and 32. Turning pulleys 36 and 37 that turn the wires 33a and 34a provided at the one ends of the coil springs 33 and 34 are respectively provided in symmetrical positions on the surface of the casing 21 further on the outer side than the attachment brackets 31c and 32c.

[0026] The coil springs 33 and 34 functioning as the elastic members respectively pull the pair of tension arms 31 and 32 to the outer side via the wires 33a and 34a turned by the turning pulleys 36 and 37 provided further on the outer side than the attachment brackets 31c and 32c. Therefore, the elastic members 33 and 34 apply, to both the pair of tension arms 31 and 32, elastic forces in a direction for expanding the space between the first and second tension pulleys 27 and 28 at the distal ends of the pair of tension arms 31 and 32. The elastic forces applied to both the pair of tension arms 31 and 32 are set the same by using the coil springs 33 and 34 having the same shape, the same size, and the same elastic modulus. In other words, the coil springs 33 and 34 apply the same elastic force to the pair of tension arms 31 and 32 in the direction for expanding the space between the first and second tension pulleys 27 and 28 pivotally supported at the distal ends of the pair of tension arms 31 and 32.

[0027] On the other hand, the other ends of the coil springs 33 and 34 functioning as the elastic members are fixed to moving members 38 and 39. The moving members 38 and 39 are screwed with male screws 41 and 42 provided in parallel to the coil springs 33 and 34. The moving members 38 and 39 are configured to move along guide shafts 43 and 44 as a result of the rotation of the male screws 41 and 42. Operation rings 41a and 42a are formed at the ends of the male screws 41 and 42. The male screws 41 and 42 can be rotated by gripping and rotating the operation rings 41a and 42a. The positions of the other ends of the coil springs 33 and 34 fixed to the moving members 38 and 39 can be adjusted according to the rotation of the male screws 41 and 42. The elastic forces applied to the pair of tension arms 31 and 32 by the coil springs 33 and 34 can be adjusted by adjusting the movement of the other ends.

[0028] A detection output of the potentiometer 13 functioning as pivoting-angle detecting means for detecting the pivoting angles of the pair of tension arms 31 and 32 is connected to a control input of the not-shown controller. The controller is configured to control the feeding control motor 26 functioning as the feeding speed controlling means to set the pivoting angles detected by the pivoting-angle detecting means to predetermined angles and adjust the rotation of the feeding pulley 24.

[0029] Further, a first turning pulley 46 that turns the wire rod 11 moving from the feeding pulley 24 to the first tension pulley 27 and turns back the wire rod 11 in the first tension pulley 27 and a second turning pulley 47 that turns the wire rod 11 moving from the second tension pulley 28 toward the winding machine 10 and turns back the wire rod 11 in the second tension pulley 28 are provided on the front surface of the casing 21 of the tension device 20. The first and second turning pulleys 46 and 47 are divided along a line connecting the first and second tension pulleys 27 and 28 provided at the distal ends of the pair of tension arms 31 and 32. The first turning pulley 46 is provided on the feeding pulley 24 side on the surface of the casing 21. The second turning pulley 47 is provided on the winding machine 10 side on the surface of the casing 21.

[0030] The wire rod 11 fed from the wire rod supply source 12 and wound around the feeding pulley 24 is guided to and wound around the first tension pulley 27 provided at the distal end of one tension arm 31 by the first turning pulley 46. Thereafter, the wire rod 11 is further wound around the second tension pulley 28 provided at the distal end of the other tension arm 32. In this way, the wire rod 11 can be wound around both the first and second tension pulleys 27 and 28 provided in the pair of tension arms 31 and 32. The wire rod 11 fed from the second tension pulley 28 at the distal end of the other tension arm 32 is turned by the second turning pulley 47 and guided to the winding machine 10. After passing guide rollers 10b and 10c in the winding machine 10, the wire rod 11 is wound around the outer circumference of the winding core 10a of the winding machine 10.

[0031] A method of applying tension to a wire rod for winding according to the present invention in use of the tension device is explained.

[0032] When the tension device 20 is used, the wire rod 11 from the wire rod supply source 12 is guided to the winding machine 10 through the tension device 20 and wound around the outer circumference of the rotating winding core 10a of the winding machine 10. A method of the present invention for applying predetermined tension to such a wire rod 11 is a method of controlling the rotation of the feeding pulley 24, around which the wire rod 11 fed from the wire rod supply source 12 is wound, and applying the predetermined tension to the wire rod 11, which is fed from the feeding pulley 24 and moving speed of which toward the winding machine 10 is controlled. A characteristic point of the method is to apply the predetermined tension to the wire rod 11 by urging the movable first tension pulley 27, which winds and turns the wire rod 11 fed from the feeding pulley 24, and the movable second tension pulley 28, which winds the wire rod 11 turned by the first tension pulley 27 and directs the wire rod 11 toward the winding machine 10, to expand the space between the first and second tension pulleys 27 and 28.

[0033] Specifically, feeding speed (a feeding amount) of the wire rod 11 from the feeding pulley 24 is controlled according to the rotating speed of the feeding control motor 26 to keep a balance with winding speed (a winding amount) of the wire rod 11 around the winding core 10a. The pair of tension arms 31 and 32 provided at the distal ends of the first and second tension pulleys 27 and 28 is respectively retained at predetermined pivoting angles. Consequently, elastic forces of the coil springs 33 and 34 functioning as the elastic members act on the wire rod 11 according to the pivoting angles of the pair of tension arms 31 and 32. Predetermined tension based on the elastic forces is applied to the wire rod 11. At this point, since the disk gears 31b and 32b, which mesh with each other, are respectively attached to the proximal ends of the pair of tension arms 31 and 32, the pivoting angles of the pair of tension arms 31 and 32 are always the same. Therefore, it is possible to apply elastic forces corresponding to the pivoting angles to the pair of tension arms 31 and 32.

[0034] On the other hand, when the winding machine 10 performs winding around the winding core 10a having different outer diameters, for example, when the winding machine 10 performs winding around the winding core 10a having a rectangular sectional shape, the short side and the long side of which are extremely different, the speed of the wire rod 11 wound around the winding core 10a periodically markedly fluctuates while the winding core 10a rotates once. When winging speed (a winding amount) of the wire rod 11 around such a winding core 10a changes, tension applied to the wire rod 11 fluctuates. When such tension fluctuation occurs, the first and second tension pulleys 27 and 28 around which the wire rod 11 is wound is strained or slacked. The rotating angles of the pair of tension arms 31 and 32, at the distal ends of which the first and second tension pulleys 27 and 28 are provided, change according to the straining or the slacking of the first and second tension pulleys 27 and 28. Consequently, the fluctuation in the tension is absorbed by the change in the pivoting angles of the pair of tension arms 31 and 32 to prevent the tension of the wire rod 11 from fluctuating.

[0035] In the present invention, the pair of tension arms 31 and 32 is provided and the first and second tension pulleys 27 and 28 are pivotally supported at the distal ends of the tension arms 31 and 32. Therefore, the wire rod 11 fed from the wire rod supply source 12 is wound around both the first and second tension pulleys 27 and 28 to use the first and second tension pulleys 27 and 28 like a block. Consequently, it is possible to reduce moving amounts of the first and second tension pulleys 27 and 28 for absorbing the fluctuation in the tension of the wire rod 11, i.e., the pivoting angles of the pair of tension arms 31 and 32 to a half or a quarter of those in the past.

[0036] As shown in detail in FIG. 4, in this embodiment, the wire rod 11 moving from the feeding pulley 24 toward the first tension pulley 27 is turned by the first turning pulley 46 and turned back in the first tension pulley 27. The wire rod 11 moving from the second tension pulley 28 toward the winding machine 10 is turned by the second turning pulley 47 and turned back again in the second tension pulley 28. Therefore, it is possible to reduce the moving amounts of the first and second tension pulleys 27 and 28 for absorbing the fluctuation in the tension of the wire rod 11, i.e., the pivoting angles of the pair of tension arms 31 and 32 to about a quarter of those in the past compared with the case in which the wire rod 11 is turned to be bent in a crank shape in the first and second tension pulleys 27 and 28 (FIG. 5).

[0037] Specifically, for example, when the winding speed of the wire rod 11 fed from the feeding pulley 24 increases in the winding machine 10 and the wire rod 11 is excessively wound by predetermined length L1 in a unit time, since the wire rod 11 is wound around both the first and second tension pulleys 27 and 28, the wire rod 11 only has to be fed by about a half of the length L1 in each of the portions of the wire rod 11 wound around the first and second tension pulleys 27 and 28. The wire rod 11 is turned to be turned back in the first and second tension pulleys 27 and 28. Therefore, the first and second tension pulleys 27 and 28 move in the direction of the folded-back wire rod 11 by about a quarter of the length L1, whereby the wire rod 11 wound around each of the first and second tension pulleys 27 and 28 is excessively fed by about a half of the length L1. In other words, when the first and second tension pulleys 27 and 28 move close to each other by about a quarter of the length L1, a sum of the moving amounts of both the first and second tension pulleys 27 and 28 is a half of L. Since the wire rod 11 is turned back to the first and second tension pulleys 27 and 28 respectively by the first and second turning pulleys 46 and 47, if it is assumed that the wire rod 11 is not fed anew from the feeding pulley 24, an amount of the wire rod 11 moving from the second turning pulley 47 toward the winding machine 10 is a double of the sum of the moving amounts. As a result, the wire rod 11 is pulled and excessively fed from the second turning pulley 47 to the winding machine side by the predetermined length L1 of the excessively wound wire rod 11.

[0038] Therefore, when the wire rod 11 is turned back to the first and second tension pulleys 27 and 28 by the first and second turning pulleys 46 and 47, it is possible to feed the wire rod 11 from the second turning pulley 47 toward the winding machine side by length four times as long as the moving amounts of the first and second tension pulleys 27 and 28. The tension arms 31 and 32, at the distal ends of which the first and second tension pulleys 27 and 28 are provided, pivot resisting the elastic forces of the elastic members 33 and 34 to allow the first and second tension pulleys 27 and 28 at the distal ends thereof to move close to each other by a quarter of the length L.

[0039] Conversely, when the winding speed of the wire rod 11 in the winding machine 10 decreases and an amount of the wound wire rod 11 decreases by predetermined length L2 in a unit time, the first and second tension pulleys 27 and 28 separate from each other by about a quarter of the length L2 with the elastic forces of the elastic members 33 and 34. When the wire rod 11 is turned back to the first and second tension pulleys 27 and 28 by the first and second turning pulleys 46 and 47, if it is assumed that the wire rod 11 is not fed anew from the feeding pulley 24, it is possible to pull back the wire rod 11 from the second turning pulley 47 to the feeding pulley 24 side by length four times as large as the moving amounts of the first and second tension pulleys 27 and 28. Therefore, it is possible to absorb the predetermined length L2, which is the decrease in the amount of winding in the unit time, by separating the first and second tension pulleys 27 and 28 from each other by about a quarter of the length L2.

[0040] As explained above, in the present invention, it is possible to further reduce the moving amounts of the first and second tension pulleys 27 and 28 for absorbing the fluctuation in the tension of the wire rod 11 than in the past. Therefore, even if the varying-diameter winding core 10a is rotated and wound at relatively high speed, it is possible to cause the pivoting of the pair of tension arms 31 and 32, at the distal ends of which the first and second tension pulleys 27 and 28 are provided, to surely follow the winding speed. A change in the pivoting angles of the pair of tension arms 31 and 32 is detected by the potentiometer 13 and fed back to the not-shown controller, which is feeding speed controlling means. The controller that receives the feedback controls the rotating speed of the feeding control motor 26 to reset the pivoting angles of the pair of tension arms 31 and 32 to the predetermined angles and balances the feeding speed of the wire rod 11 from the lead-out pulley 24 with the winding speed around the winding core 10a. Consequently, the pivoting angles of the pair of tension arms 31 and 32 are reset to the predetermined angles. Therefore, it is possible to reset the tension applied to the wire rod 11 to the predetermined value.

[0041] Since the wire rod 11 is wound around both the first and second tension pulleys 27 and 28 provided in the pair of tension arms 31 and 32, if it is assumed that the tension of the wire rod 11 is fixed, according to the principle of pulleys, force for pulling the pair of tension arms 31 and 32 resisting the tension of the wire rod 11 is required to be two or four times as large as the force in the past. As the coil springs 33 and 34 functioning as the elastic members that pull the pair of tension arms 31 and 32 in that way, elastic members having elastic forces two or four times as large as the elastic force in the past is used. However, when the elastic forces of the coil springs 33 and 34 are increased, angular accelerations of the pair of tension arms 31 and 32 are increased. Therefore, it is possible to cause the pair of tension arms 31 and 32, which moves according to the tension fluctuation, to more quickly follow the tension fluctuation. Therefore, even if the varying-diameter winding core 10a is rotated and wound at relatively high speed, it is possible to cause the pivoting of the pair of tension arms 31 and 32 to surely follow the winding speed. As a result, it is possible to always keep constant the tension of the wire rod 11 sent to the winding machine 10.

[0042] When an operator desires to change the tension acting on the wire rod 11 from the pair of tension arms 31 and 32, the operator grips and rotates the operation rings 41a and 42a formed in the male screws 41 and 42 to move the moving members 38 and 39 and adjust fixed positions at the other ends of the coil springs 33 and 34 functioning as the elastic members. Consequently, it is possible to change the lengths of the coil springs 33 and 34 functioning as the elastic members when the pair of tension arms 31 and 32 are set to the predetermined pivoting angles and adjust the elastic forces applied from the coil springs 33 and 34 functioning as the elastic members to the pair of tension arms 31 and 32. Therefore, it is possible to set the tension acting on the wire rod 11 to desired tension.

[0043] As explained above, according to the present invention, even when fluctuation in the winding speed of the wire rod 11 during winding work is extremely large, it is possible to transitionally absorb the speed fluctuation by dispersing the speed fluctuation to the first and second tension pulleys 27 and 28 provided at the distal ends of the pair of tension arms 31 and 32 and moving the first and second tension pulleys 27 and 28. Therefore, even if the varying-diameter winding core 10a is rotated at relatively high speed to perform winding, it is possible to cause the pivoting of the pair of tension arms 31 and 32 to surely follow the winding speed. At the same time, a change in the pivoting angles of the pair of tension arms 31 and 32 involved in the movement of the first and second tension pulleys 27 and 28 is fed back to the rotation of the feeding pulley 24 that lets out the wire rod 11. Therefore, it is possible to cause the feeding speed of the wire rod 11 to follow the winding speed. Consequently, the tension of the wire rod 11 is accurately reset to the predetermined value. Therefore, it is possible to always keep constant the tension of the wire rod 11 sent to the winding machine 10.

[0044] In the embodiment explained above, the wire rod 11 is turned back in the first and second tension pulleys 27 and 28 using the first and second turning pulleys 46 and 47. The moving amounts of the first and second tension pulleys 27 and 28 for absorbing the fluctuation in the tension of the wire rod 11, i.e., the pivoting angles of the pair of tension arms 31 and 32 are reduced to about a quarter of those in the past. However, if it is sufficient to reduce the moving amounts of the first and second tension pulleys 27 and 28 to about a half of those in the past, the first and second turning pulleys 46 and 47 are not always necessary. The tension device 20 not including the first and second turning pulleys 46 and 47 is shown in FIG. 5. In the tension device 20 shown in FIG. 5, the wire rod 11 moving from the feeding pulley 24 toward the winding machine 10 is turned to be bent in a crank shape in the first and second tension pulleys 27 and 28. Then, it is possible to reduce the moving amounts of the first and second tension pulleys 27 and 28 for absorbing the fluctuation in the tension of the wire rod 11, i.e., the pivoting angles of the pair of tension arms 31 and 32 to a half of those in the past.

[0045] Specifically, for example, when the winding speed of the wire rod 11 fed from the feeding pulley 24 increases in the winding machine 10 and the wire rod 11 is excessively wound by predetermined length L1 in a unit time, the first and second tension pulleys 27 and 28 move close to each other as indicated by a solid line arrow by about half the L1 length. Then, the sum of the moving amounts of both the first and second tension pulleys 27 and 28 is L1. The wire rod 11 moving from the feeding pulley 24 toward the winding machine 10 is turned to be bent in a crank shape in the first and second tension pulleys 27 and 28. Therefore, if it is assumed that the wire rod 11 is not fed anew from the feeding pulley 24, an amount of the wire rod 11 moving from the second tension pulley 28 directly toward the winding machine 10 is L1, which is the sum of the moving amounts of both the first and second tension pulleys 27 and 28. As a result, the wire rod 11 is excessively fed from the second tension pulley 28 directly to the winding machine 10 by the predetermined length L1 of the excessively-wound wire rod 11.

[0046] Conversely, when the winding speed of the wire rod 11 fed from the feeding pulley 24 decreases in the winding machine 10 and an amount of the wound wire rod 11 decreases by the predetermined length L2 in a unit time, the first and second tension pulleys 27 and 28 move away from each other by about a half of the length L2 as indicated by a broken line arrow. Then, the sum of the moving amounts of the first and second tension pulleys 27 and 28 is L2. The wire rod 11 moving from the feeding pulley 24 to the winding machine 10 is turned to be bent in a crank shape in the first and second tension pulleys 27 and 28. Therefore, if it is assumed that the wire rod 11 is not fed anew from the feeding pulley 24, an amount of the wire rod 11 pulled back from the second tension pulley 28 toward the feeding pulley 24 is L2, which is the sum of the moving amounts of both the first and second tension pulleys 27 and 28. As a result, an amount of the wire rod 11 fed from the second tension pulley 28 decreases by the predetermined length L2, which is a decrease in an amount of the wound wire rod 11. In other words, when the wire rod 11 moving from the feeding pulley 24 toward the winding machine 10 is turned to be bent in a crank shape in the first and second tension pulleys 27 and 28, it is possible to feed the wire rod 11 toward the winding machine 10 or pull back the wire rod 11 by length two times as large as the moving amounts of the first and second tension pulleys 27 and 28.

[0047] On the other hand, if it is insufficient to reduce the moving amounts of the first and second tension pulleys 27 and 28 to about a quarter of those in the past, the wire rod 11 may be wound around the first and second tension pulleys 27 and 28 a plurality of times. The tension device 20 in which the wire rod 11 is wound around the first and second tension pulleys 27 and 28 twice is shown in FIG. 6. In the tension device 20, in FIG.6, the wire rod 11 is wound twice around the respective first and second tension pulleys 27 and 28. When the wire rod 11 is wound twice in this way, according to the principle of pulleys, it is possible to further reduce the moving amounts of the first and second tension pulleys 27 and 28 by an amount two times as large as the amount reduced when the wire rod 11 is wound once as shown in FIG. 4. Since the moving amounts are reduced to a quarter in FIG. 4, the moving amounts are reduced to one eighth in FIG. 6. Therefore, it is possible to reduce the moving amounts of the first and second tension pulleys 27 and 28 for absorbing the fluctuation in the tension of the wire rod 11, i.e., the pivoting angles of the pair of tension arms 31 and 32 to one eighth in the past.

[0048] In the explanation in the embodiment, the first and second tension pulleys 27 and 28 are pivotally supported at the distal ends of the pair of tension arms 31 and 32. However, the pair of tension arms 31 and 32 is not always necessary as long as the first tension pulley 27 and the second tension pulley 28 are urged by the urging means to expand the space between the first and second tension pulleys 27 and 28.

[0049] For example, instead of the tension arms 31 and 32, as shown in FIG. 7, the tension device 20 may include a first rail 52 on which a first base 51, on which the first tension pulley 27 is pivotally supported, is movable in the longitudinal direction thereof and a second rail 54 that is provided coaxially with or parallel to the first rail 52 and on which a second base 53, on which the second tension pulley 28 is pivotally supported, is movable in the longitudinal direction thereof. In this case, the urging means is desirably elastic members 33 and 34 that apply, to the first and second tension pulleys 27 and 28, elastic forces corresponding to the positions of the first and second bases 51 and 53 with respect to the first and second rails 52 and 54. As position detecting means for detecting the position of one or both of the first and second bases 51 and 53, and the linear potentiometer 13 that detects positions on straight lines extending along the first and second rails 52 and 54 is used.

[0050] As explained above, even if the first and second rails 52 and 54 are used instead of the tension arms 31 and 32, it is possible to transitionally absorb the fluctuation in the winding speed of the wire rod 11 during the winding work by dispersing the speed fluctuation to the first and second tension pulleys 27 and 28, which move along the first and second rails 52 and 54, and moving the first and second tension pulleys 27 and 28. Therefore, even if the varying-diameter winding core 10a is rotated at relatively high speed to perform winding, it is possible to cause the movement of the first and second tension pulleys 27 and 28 to surely follow the winding speed. At the same time, the rotation of the feeding pulley 24 is controlled to set the position of one or both of the first and second bases 51 and 53 detected by the liner potentiometer 13 functioning as the position detecting means to a predetermined position, whereby a change in the position involved in the movement of the first and second tension pulleys 27 and 28 is fed back to the rotation of the feeding pulley 24 that lets out the wire rod 11. Then, it is possible to cause the feeding speed of the wire rod 11 to follow the winding speed. Consequently, the tension of the wire rod 11 is accurately reset to the predetermined value. Therefore, it is possible to always keep constant the tension of the wire rod 11 sent to the winding machine 10.

[0051] In the example explained in the embodiment, the elastic members functioning as the urging means for urging the first tension pulley 27 and the second tension pulley 28 to expand the space between the first and second tension pulleys 27 and 28 are coil springs. However, fluid pressure cylinders that urge rods in a retracting or projecting direction with fluid pressure such as air pressure may be used as the elastic member functioning as the urging means. When the fluid pressure cylinders are used as the elastic members, when it is desired to change elastic forces of the fluid pressure cylinders, it is possible to change the elastic forces relatively easily by changing the fluid pressure of compressed air or the like in the cylinders.

[0052] In the explanation in the embodiment, the feeding speed controlling means for controlling the rotation of the feeding pulley 24 to control the speed of the wire rod 11 is the feeding control motor that directly rotates the feeding pulley 24. However, the feeding speed controlling means may be a brake device that limits the rotation of the feeding pulley 24 rotated by the wire rod 11 wound by the winding machine 10.

[0053] Further, in the explanation in the embodiment, the wire rod 11 is made of the coated copper wire formed in a circular or square shape in a cross section and the winding machine 10 forms a coil by winding the wire rod 11 made of the coated copper wire. However, although not shown in the figures, the wire rod 11 may be an elongated film as long as the film extends long like a thread. As an example of the winding machine 10 that winds the wire rod 11 such as the elongated film, there is a winding machine that winds a film deposited with metal to form a capacitor.

List of references

[0054]

10	winding machine
11	wire rod
12	wire rod supply source
13	potentiometer (pivoting-angle detecting means)
20	tension device
24	feeding pulley
26	feeding control motor (feeding speed controlling means)
27	first tension pulley
28	second tension pulley
31, 32	tension arms
31b, 32b	disk gears
33, 34	coil springs (urging means)
46	first turning pulley
47	second turning pulley
51	first base
52	first rail
53	second base
54	second rail

Claims

1. A tension device comprising:

a feeding pulley (24) around which a wire rod (11) fed from a wire rod supply source (12) is wound;
feeding speed controlling means (26) for controlling rotation of the feeding pulley (24) and controlling speed of the wire rod (11) pulled out from the wire rod supply source (12) to move toward a winding machine (10);
a movable first tension pulley (27) configured to turn the wire rod (11) fed from the feeding pulley (24);
a movable second tension pulley (28) configured to further turn the wire rod (11) turned by the first tension pulley (27) and direct the wire rod (11) to the winding machine (10); and
urging means (33, 34) for urging the first tension pulley (27) and the second tension pulley (28) to expand a space between these tension pulleys.

2. The tension device according to claim 1, wherein

a pair of tension arms (31, 32) which are line-symmetrically formed are provided rotatably about proximal ends thereof,
the first tension pulley (27) is pivotally supported at a distal end of one of the tension arms (31) and the second tension pulley (28) is pivotally supported at a distal end of the other one of the tension arms (32),
the urging means is formed of elastic members (33, 34) configured to apply, to the pair of tension arms (31, 32), elastic forces corresponding to pivoting angles of the pair of tension arms (31, 32),
pivoting-angle detecting means (13) for detecting the pivoting angle of one or both of the pair of tension arms (31, 32) is provided, and
the feeding speed controlling means (26) is controlled to control rotation of the feeding pulley (24) to set the pivoting angle detected by the pivoting-angle detecting means (13) to a predetermined angle.

3. The tension device according to claim 2, wherein disk gears (31b, 32b) that mesh with each other to set the pivoting angles of the pair of tension arms (31, 32) to a same angle are respectively attached to the proximal ends of the pair of tension arms (31, 32).

4. The tension device according to claim 1, further comprising:

a first rail (52) on which a first base (51), on which the first tension pulley (27) is pivotally supported, is movable in the longitudinal direction thereof; and
a second rail (54) which is provided coaxially with or parallel to the first rail (52) and on which a second base (53), on which the second tension pulley (28) is pivotally supported, is movable in the longitudinal direction thereof,
the urging means is formed of elastic members (33, 34) configured to apply, to the first and second tension pulleys (27, 28), elastic forces corresponding to positions of the first and second bases (51, 53) with respect to the first and second rails (52, 54),
position detecting means (13) for detecting a position of one or both of the first and second bases (51, 53) is provided, and
the feeding controlling means (26) is configured to control rotation of the feeding pulley (24) to set the position of one or both of the first and second bases (51, 53) detected by the position detecting means (13) to a predetermined position.

5. The tension device according to claim 1, further comprising:

a first turning pulley (46) configured to turn the wire rod (11) moving from the feeding pulley (24) toward the first tension pulley (27) and turn back the wire rod (11) at the first tension pulley (27); and
a second turning pulley (47) configured to turn the wire rod (11) moving from the second tension pulley (28) toward the winding machine (10) and turn back the wire rod (11) at the second tension pulley (28).

6. A tension applying method of controlling rotation of a feeding pulley (24) around which a wire rod (11) fed from a wire rod supply source (12) is wound and applying predetermined tension to the wire rod (11) which is fed from the feeding pulley (24), and the moving speed of which toward a winding machine (10) is controlled,
the method comprising: urging a first tension pulley (27) and a second tension pulley (28) to expand a space between these tension pulleys (27, 28) thereby applying a predetermined tension to the wire rod (11)
with the movable first tension pulley (27) being configured to wind and turn the wire rod (11) fed from the feeding pulley (24), and the movable second tension pulley (28) being configured to further wind and turn the wire rod (11) turned by the first tension pulley (27) and direct the wire rod (11) to the winding machine (10).

Fig. 1

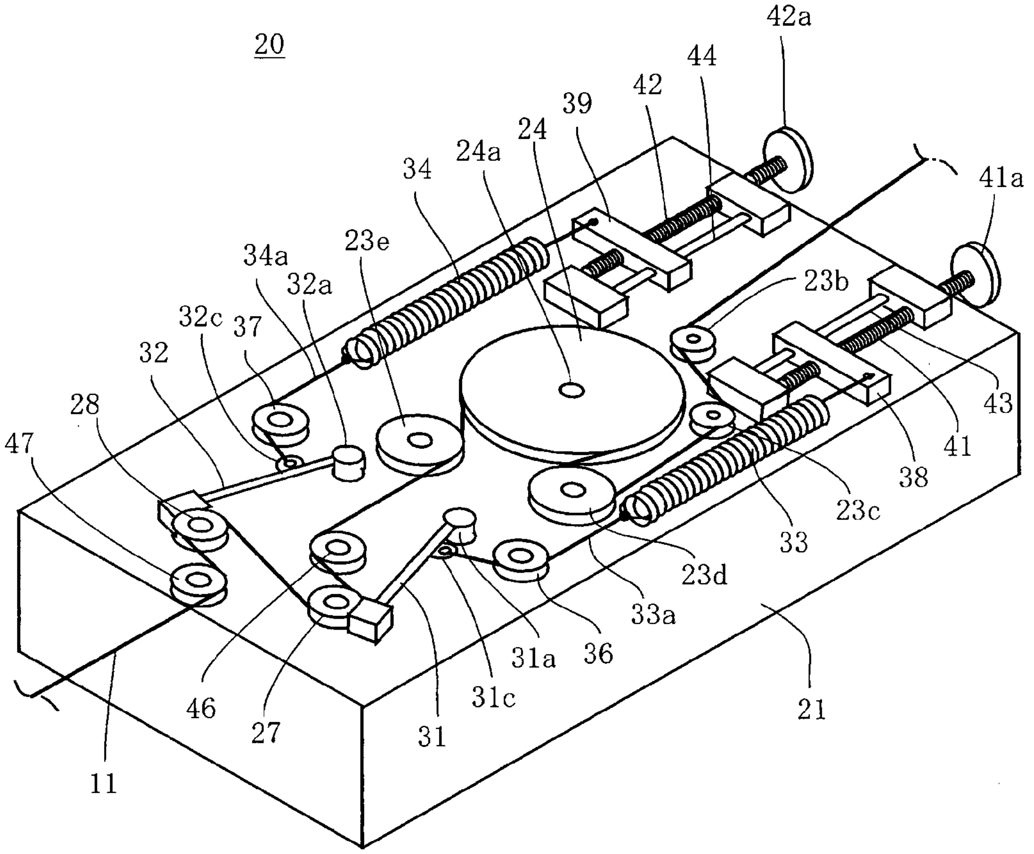
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Fig. 2

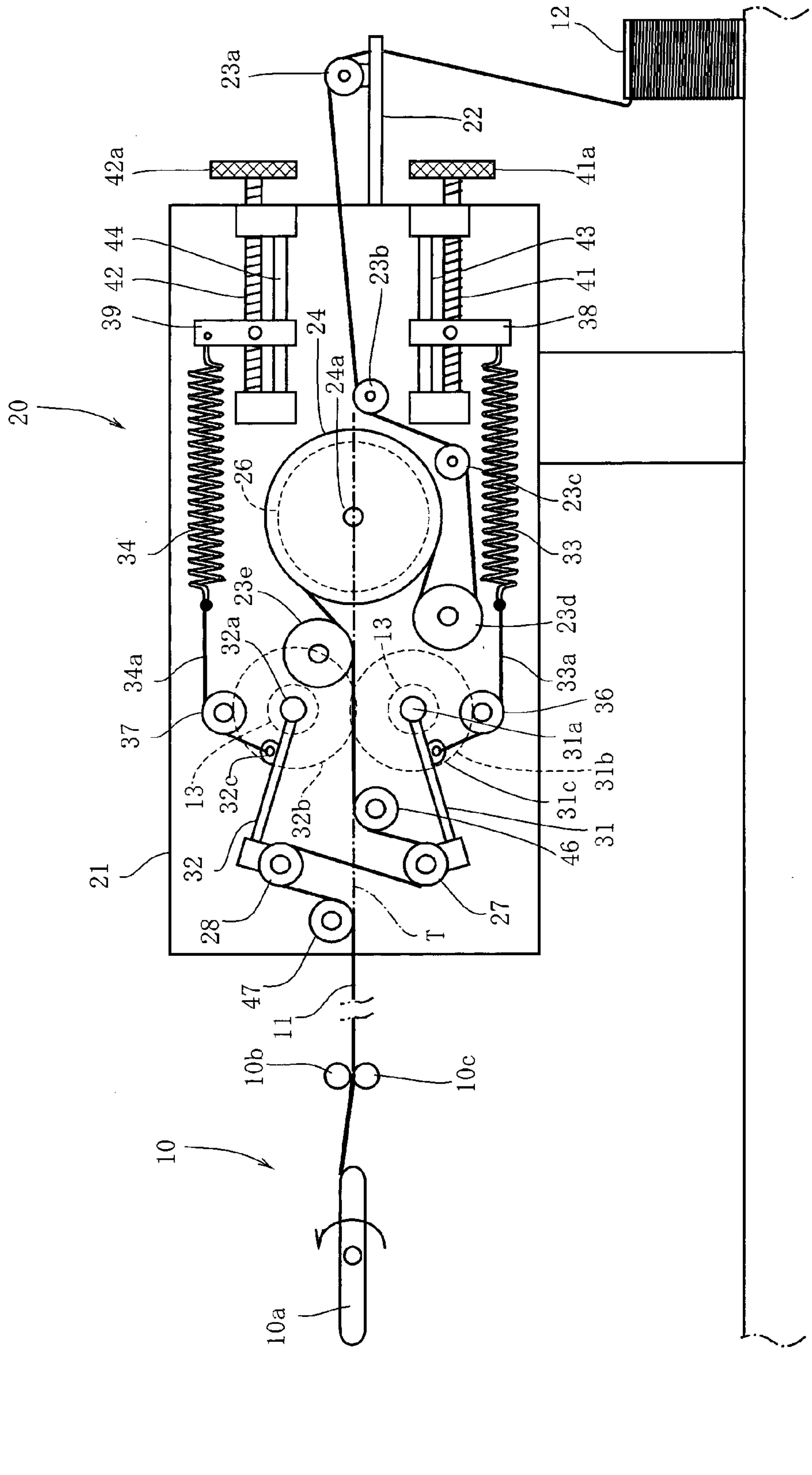
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Fig. 3

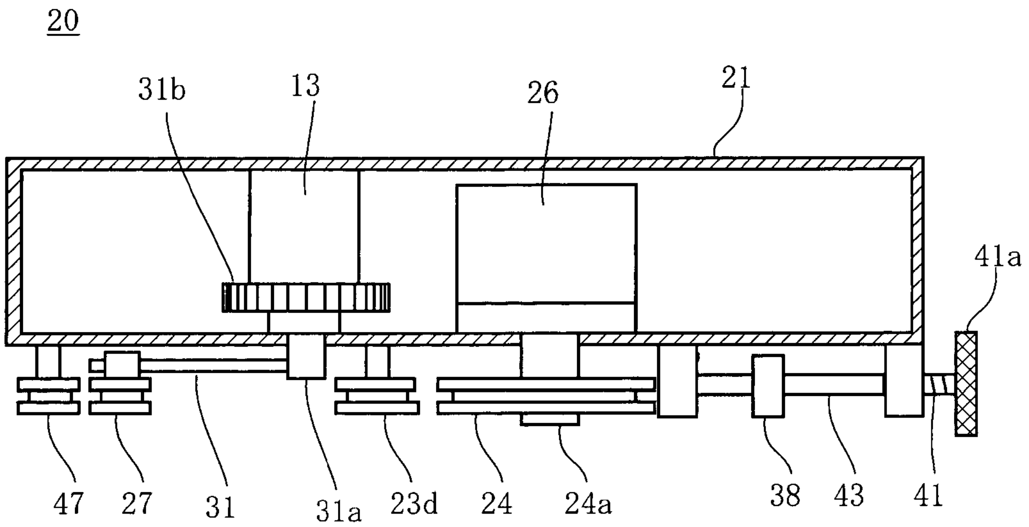

Fig. 4

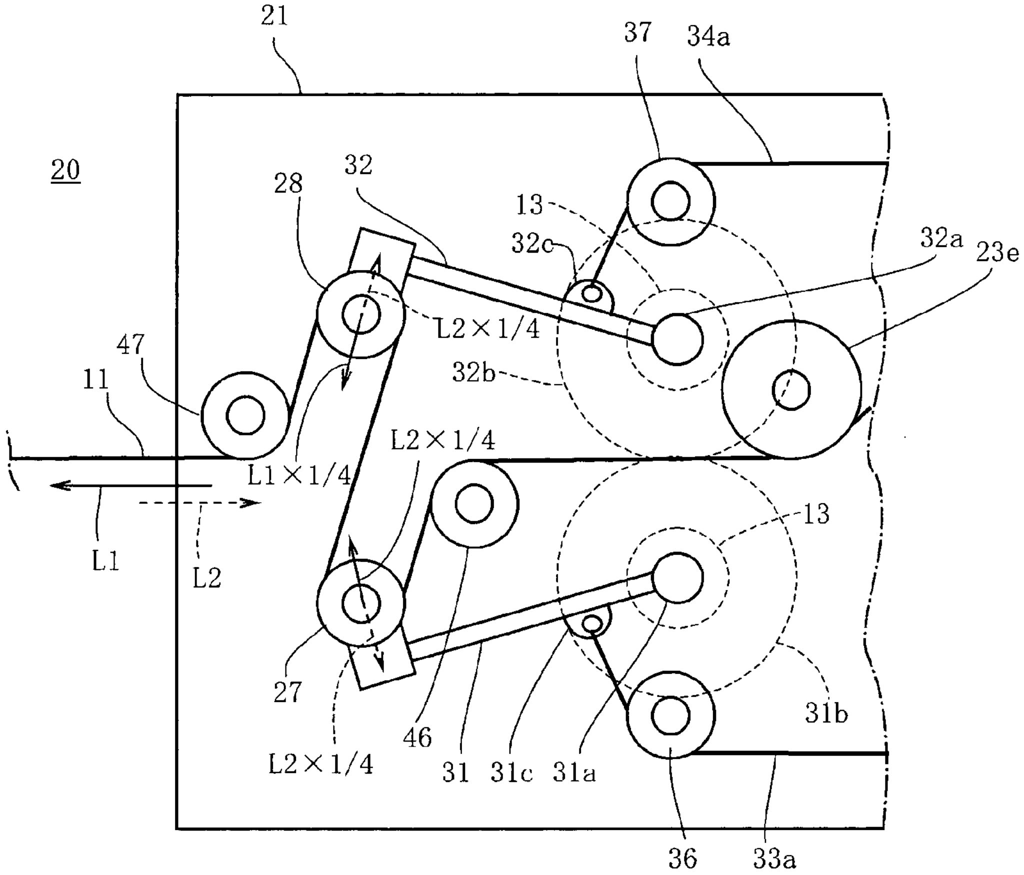
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Fig. 5

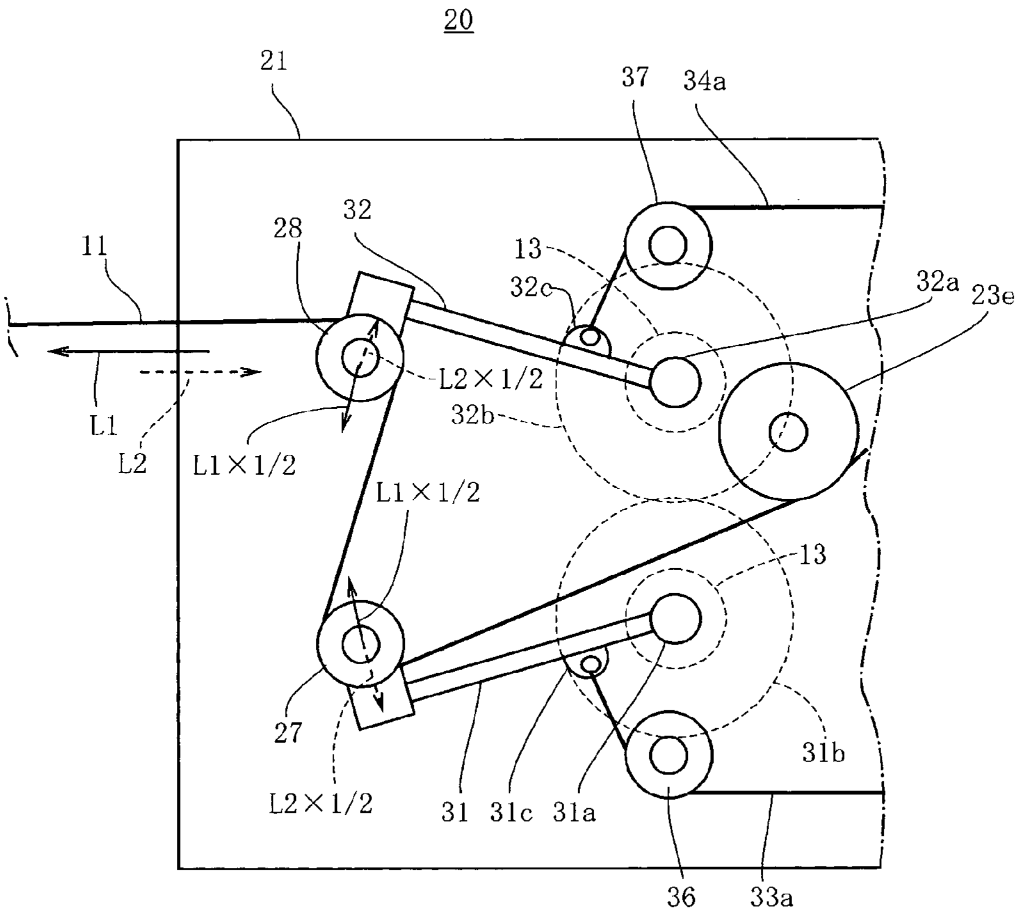
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Fig. 6

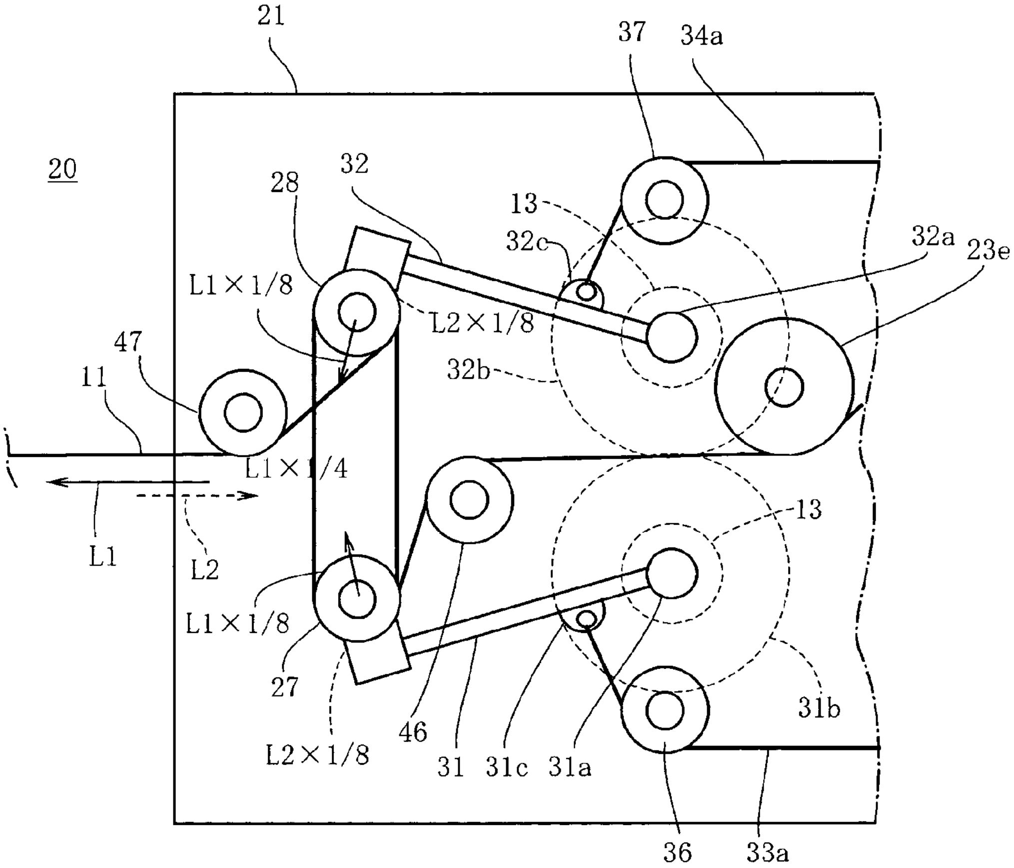
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Fig. 7

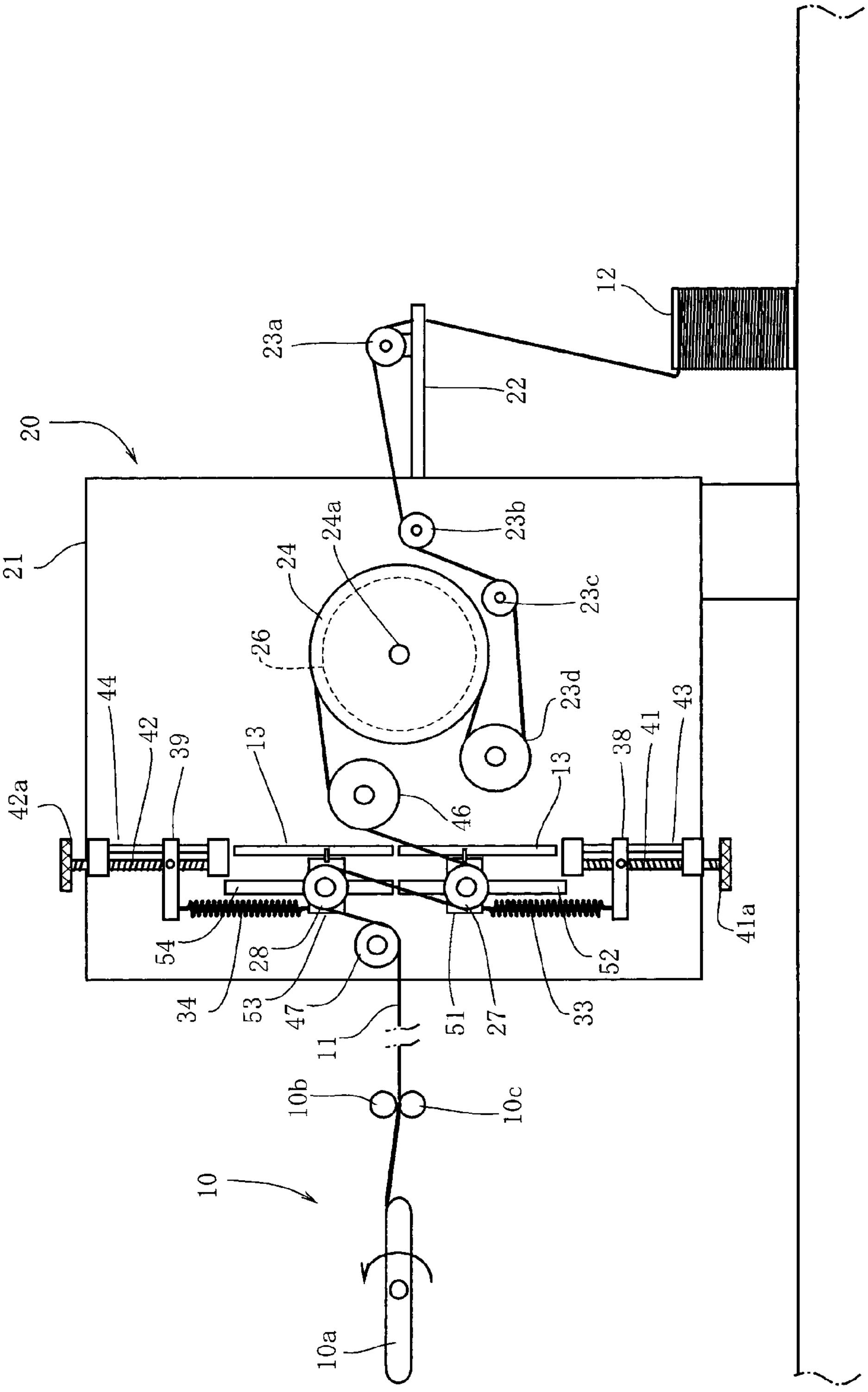
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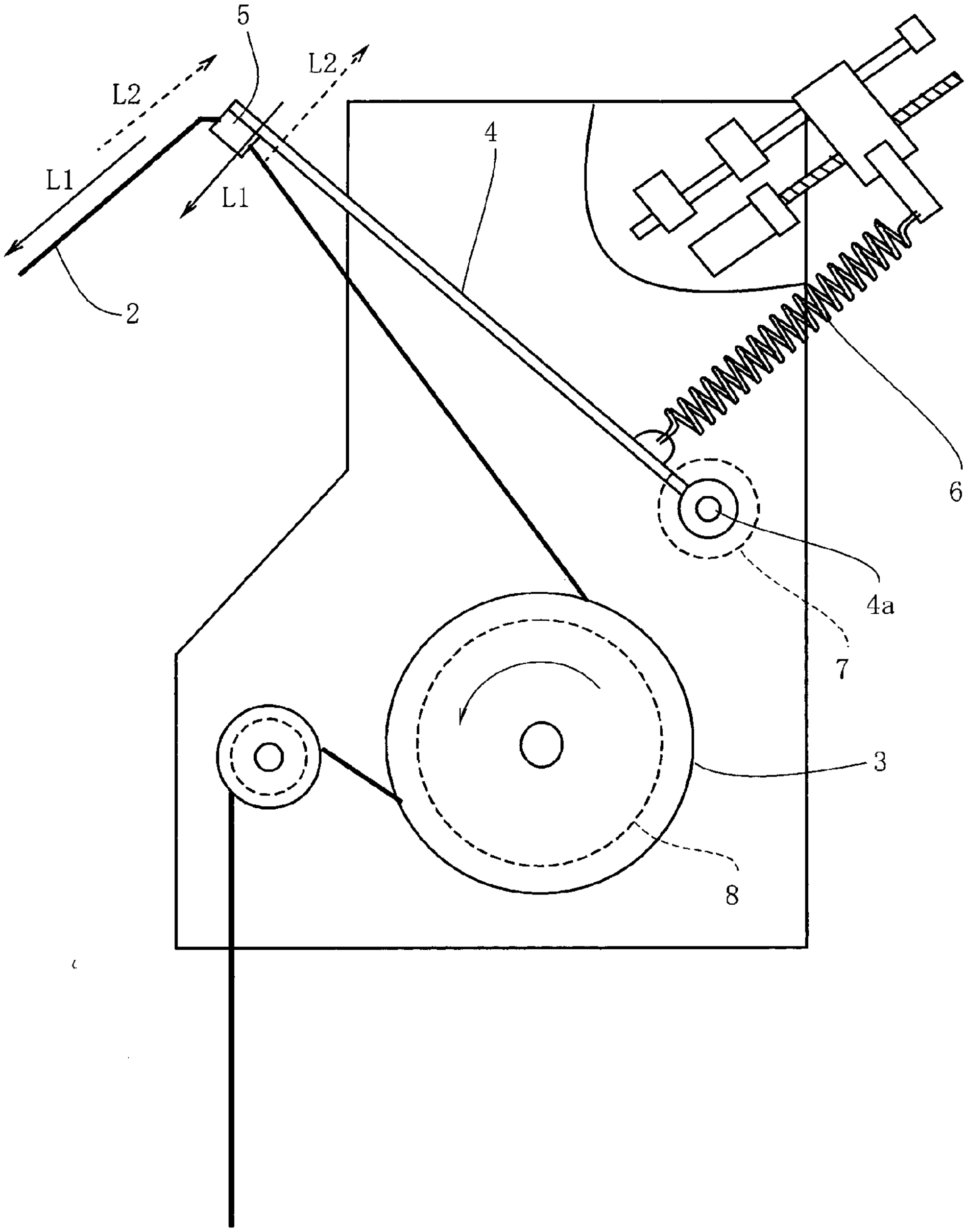
Fig. 8



REFERENCES CITED IN THE DESCRIPTION

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