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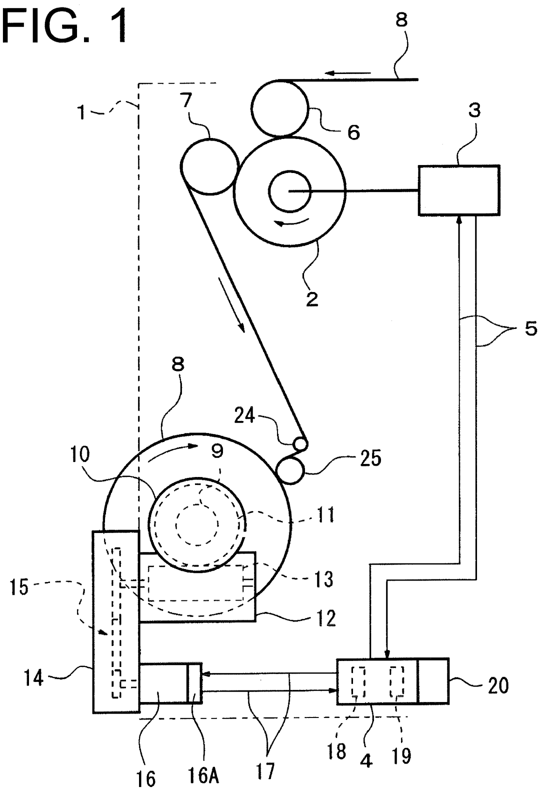
(54) METHOD FOR CONTROLLING WINDING A WOVEN CLOTH AND APPARATUS FOR WINDING A WOVEN CLOTH IN LOOM

(57) There is provided a method for controlling winding of a woven cloth (8) in a loom, wherein the cloth 88) delivered through a surface roller (2) is wound on a cloth roller (9) driven by a take-up motor (16) whose torque is controllable. The method includes the steps of setting a change command torque (21) that progressively increases or decreases a torque of the take-up motor (16), driving the take-up motor according to the change command torque (21) after setting the change command torque, detecting variation of rotation speed of the take-up motor (16), calculating load torque based on the change command torque (21), calculating winding torque based on tension and winding diameter of the cloth (8), calculating winding control torque by adding the load torque and the winding torque, and driving the take-up motor (16) according to the winding control torque. There is also provided an apparatus for winding of a woven cloth in a loom by the above-described method.

FIG. 1



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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a method for controlling winding a woven cloth and an apparatus for winding a woven cloth in a loom.

[0002] An apparatus for winding a woven cloth in a loom is known in which a cloth roller that winds a cloth delivered from a surface roller is driven by an independent motor whose torque is controllable. The torque of the independent motor for controlling winding the cloth is calculated usually based on the tension and the winding diameter of the cloth. The independent motor is controlled by a controller to generate the calculated torque.

[0003] Japanese Patent Application Publication No. 2012-1825 discloses a controller for a cloth winding apparatus in a loom. The apparatus of the Publication has an independent motor driving a cloth roller and a reduction gear unit that is operatively engaged with the independent motor. The entirety of the cloth roller driving motor and the reduction gear unit is movable supported and a load cell is provided in the apparatus for detecting the force applied to the independent motor and the reduction gear system. Based on the force detected by the load cell, the controller calculates the torque against winding a woven cloth whose magnitude substantially corresponds to that of the torque for winding the woven cloth in the cloth roller. Then, the controller calculates the tension of the woven cloth being wound on the cloth roller based on the calculated torque and performs controlling of the independent motor based on the calculated tension of the woven cloth.

[0004] The apparatus of the Publication is disadvantageous in that a load cell is needed for detecting the torque against winding the woven cloth and the entirety of the independent motor and the reduction gear unit needs to be provided in a movable manner and, therefore the cloth winding apparatus becomes complicated in structure and large is size.

[0005] The present invention is direct to providing a method that permits easy and accurate controlling of winding of a woven cloth and an apparatus that permits easy and accurate winding of a woven cloth.

SUMMARY OF THE INVENTION

[0006] There is provided a method for controlling winding of a woven cloth in a loom, wherein the cloth delivered through a surface roller is wound on a cloth roller driven by a take-up motor whose torque is controllable. The method includes the steps of setting a change command torque that progressively increases or decreases a torque of the take-up motor, driving the take-up motor according to the change command torque after setting the change command torque, detecting variation of rotation speed of the take-up motor during changing the change command torque, calculating load torque based on the change command torque in a transitional region between a rotation speed varying region and a rotation speed stabilized region of the take-up motor, calculating winding torque based on tension and winding diameter of the cloth, calculating winding control torque by adding the load torque and the winding torque, and driving the take-up motor according to the winding control torque.

[0007] There is provided an apparatus for winding a woven cloth in a loom, wherein the cloth delivered through a surface roller is wound on a cloth roller driven by a take-up motor whose torque is controllable by a controller. The apparatus includes a rotation speed detector that detects rotation speed of the take-up motor. The controller includes a change command torque transmitting section that stores a preset change command torque that progressively increases or decreases a torque of the take-up motor and transmits the change command torque for driving the take-up motor, a load torque calculating section that calculates a load torque based on the change command torque in a transitional region between a rotation speed varying region and a rotation speed stabilized region of the take-up motor, a winding torque calculating section that calculates a winding torque based on tension and winding diameter of the cloth, and a winding control torque command section that adds the winding torque and the load torque to calculate a winding control torque and commands the winding control torque for driving the take-up motor.

[0008] Other aspects and advantages of the invention will become apparent from the following description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The invention together with objects and advantages thereof, may best be understood by reference to the following description of the presently preferred embodiments together with the accompanying drawings in which:

FIG. 1 is a schematic side view of an apparatus for winding a woven cloth according to a first embodiment of the present invention;

FIG. 2 is a diagram showing relation between the progressively increasing command torque and the rotation speed of a motor in the apparatus of FIG.1;

FIG. 3 is a diagram showing relation between the progressively increasing command torque and the rotation speed of a motor in an apparatus according to a second embodiment of the present invention;

FIG. 4 is a diagram showing relation between the progressively decreasing command torque and the rotation speed of a motor in an apparatus according to a third embodiment of the present invention;

FIG. 5 is a diagram showing an example in which the load torque is decreased in the apparatus according to the third embodiment of the present invention;

FIG. 6 is a diagram showing an example in which the load torque is increased in the apparatus according to the third embodiment of the present invention;

FIG. 7 is a diagram showing an example in which the loaded torque is increased in an apparatus according to another embodiment of the present invention;

FIG. 8 is a diagram showing another example in which the loaded torque is increased in an apparatus according to still another embodiment of the present invention;

FIG. 9 is a diagram showing an example in which the loaded torque is decreased in the apparatus according to the another embodiment of the present invention; and

FIG. 10 is a diagram showing an example in which the loaded torque is decreased in the apparatus according to the still another embodiment of the present invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

First embodiment

[0010] The following will describe an apparatus according to the first embodiment of the present invention with reference to FIGS. 1 and 2. Referring to FIG. 1, the apparatus for winding a woven cloth in a loom has a surface roller 2 rotatably supported by a frame 1 of the loom and connected to a draw motor 3 provided independently of a loom drive motor (not shown). A servomotor is used for the draw motor 3. The draw motor 3 is electrically connected through signal lines 5 to a controller 4. During the weaving operation of the loom, the draw motor 3 is rotatable in synchronization with the loom drive motor. Additionally, the draw motor 3 is reversible independently of the operation of the loom drive motor.

[0011] A guide roller 6 and a press roller 7 are disposed pressed against the surface roller 2. A woven cloth 8 guided by the guide roller 6 is routed along the surface roller 2 and forwarded. During the weaving operation of the loom, the cloth 8 is drawn by the surface roller 2 rotating in the arrow direction shown in FIG. 1, and delivered through the press roller 7.

[0012] A cloth roller 9 for winding the cloth 8 is rotatably supported by the frame 1 at a position below the surface roller 2. The cloth roller 9 is connected to a take-up motor 16 through a worm wheel 11, a worm 13, and a gear train 15 which are housed in a worm wheel box 10, a worm box 12 and a gear box 14, respectively. The cloth roller 9 is driven to rotate by the take-up motor 16 in arrow direction as shown in FIG. 1 at a speed reduced by the gear train 15, the worm 13 and the worm wheel 11 thereby to wind the cloth 8 around the cloth roller 9. The winding diameter of the cloth roller 9 is increased with the progress of winding. The cloth roller 9 winds the cloth 8 delivered from the press roller 7 through a guide roller 24 and an anti-crease roller 25 that is disposed in contact with the cloth 8 being wound on the cloth roller 9. In the first embodiment, the worm wheel 11 and the worm 13 that are housed in the worm wheel box 10 and the worm box 12, respectively are used as the reducer in drive mechanism of the cloth roller 9. Alternatively, any other type of reducer may be used.

[0013] The take-up motor 16 is a torque-controllable motor such as a servo motor or a torque motor and may be driven independently of the main drive motor of the loom. The take-up motor 16 is electrically connected through signal lines 17 to the controller 4. During the weaving operation of the loom, the take-up motor 16 is rotated in synchronization with the main drive motor and the draw motor 3. However, the take-up motor 16 is reversible independently of the operation of the main drive motor and the draw motor 3. The torque of the take-up motor 16 is controlled in response to a command transmitted from the controller 4 so that the cloth 8 maintains a predetermined tension while the winding diameter of the cloth roller 9 is increased with winding of the cloth 8.

[0014] The controller 4 includes a memory 18 for data storage and a processor 19 for data calculation and also for transmission and receipt of signals. The controller 4 further includes an input device 20 in the form of a function panel (none of these being shown). The input device 20 includes a data display, a data input device, a take-up motor control switch, a loom control switch, and other various switches (none of these being shown).

[0015] The data such as rotation speed of the loom, weft yarn density, cloth tension, diameter of the surface roller 2, and reduction ratio of the worm wheel 11, the worm 13 and the gear train 15 are inputted through the input device 20 and stored in the memory 18. The controller 4 receives rotation speed data from a rotation detector (not shown) of the draw motor 3 through the signal lines 5, rotation speed data from a rotation speed detector 16A of the take-up motor 16 through the signal lines 17, and rotation speed data from a rotation detector (not shown) of the loom drive motor and stores such data in the memory 18.

[0016] The following will describe various programs for the processor 19, which are stored in the memory 18 of the controller 4. The programs are used for controlling a series of steps for weaving operation.

(1) A program for calculating the winding diameter of the cloth 8 on the cloth roller 9 based on the rotation speed of the main drive motor, the weft yarn density, the rotation speed of the draw motor 3, and the ratio

between the diameters of the surface roller 2 and the cloth roller 9 (a cloth winding diameter calculating section).

(2) A program for calculating the cloth winding torque based on the tension of the cloth 8 and the winding diameter of the cloth 8 on the cloth roller 9 (a winding torque calculating section).

(3) A program for calculating the ordinary rotation speed of the take-up motor 16, that is the rotation speed of the take-up motor 16 that allows the cloth 8 delivered from the surface roller 2 to be wound on the cloth roller 9 without looseness, based on the rotation speed of the main drive motor, the weft yarn density, the winding diameter of the cloth, and the reduction ratio, (an ordinary rotation speed calculating section).

(4) It is noted that the command torque according to the present invention indicates a command torque which is predetermined so that torque of the take-up motor 16 is increased or decreased progressively. A program for controlling the take-up motor 16 in response to a command signal from the controller 4 based on the progressive increase command torque graph 21 (see FIG. 2) that is stored in the memory 18 (a change torque command section). It is noted that the progressive increase command torque graph 21 is set so that torque is increased progressively with the increment torque U after elapse of a predetermined length of time T as shown in FIG. 2.

(5) A program for comparing the rotation speed of the take-up motor 16 detected when the torque is to be changed according to the progressive increase command torque graph 21 with the ordinary rotation speed (a comparing section).

(6) A program for calculating the load torque when the take-up motor 16 has stopped its speed fluctuation due to coincidence of the detected rotational speed of the take-up motor 16 with the ordinary rotation speed, based on the command torque 21C in the transitional region FTB (see FIG. 2) between the rotation speed varying region FT (see FIG. 2) and the rotation speed stabilized region ST (see FIG. 2) (a load torque calculating section).

(7) A program for controlling the take-up motor 16 to be driven based on the winding control torque figured out by adding the load torque to the winding torque (a winding control torque command section).

[0017] The following will describe control for weaving operation. After a cloth roller having a wound cloth is doffed and a new cloth roller is installed in place in the loom, the end of a new cloth is wound around the newly installed cloth roller 9 and the loom is started for weaving operation. At the start of the weaving operation, as shown in FIG. 2, the controller 4 transmits to the take-up motor 16 a signal based on the progressive increase command torque graph 21 according to the program stored in the memory 18.

[0018] Since the take-up motor 16 is at a stop, the cloth 8 delivered extending from the surface roller 2 is loosened between the press roller 7 and the cloth roller 9, and, therefore, the tension of the cloth 8 is zero. When the controller 4 generates a signal based on the command torque 21A to the take-up motor 16, the rotation of the take-up motor 16 is started and its rotation speed increases quickly as indicated by dotted line R1 of FIG. 2 and the cloth roller 9 winds the cloth 8. However, the take-up motor 16 stops when the load torque, especially, the load torque due to friction resistance of the anti-crease roller 25 exceeds the command torque 21A. After an elapse of time T after the stop of the take-up motor 16, the controller 4 generates to the take-up motor 16 a command signal to increase the motor torque by the increment torque U from the command torque 21A to the command torque 21B. As a result, the rotation speed of the take-up motor 16 is increased quickly again as indicated by dotted line R2 of FIG. 2 and the take-up motor 16 winds the cloth 8. When the load torque increased by friction resistance of the anti-crease roller 25 exceeds the command torque 21B, the take-up motor 16 stops again.

[0019] With a further elapse of time T, the controller 4 sends to the take-up motor 16 a command signal to increase the command torque from 21B to 21C by the increment torque U. Accordingly, the rotation speed of the take-up motor 16 is increased quickly again as indicated by R3 in FIG. 2 and the cloth 8 is wound. The rotation speed of the take-up motor 16 is then varied rapidly in a region adjacent to the region of the rotation speed R3. Then, the rotation speed R3 is larger than the aforementioned ordinary rotation speed. With a still further elapse of time T, the controller 4 sends to the take-up motor 16 a command signal to increase the command torque from 21C to 21D by the increment torque U. In this case, rapid change in the rotation speed of the take-up motor 16 does not occur by drive force of the command torque 21D, but converges to the ordinary rotation speed R4.

[0020] Thereafter, the take-up motor 16 maintains the ordinary rotation speed R4 during the torque increase of the take-up motor 16 according to the progressive increase command torque graph 21. That is, two different rotation changing regions appear in the controlling the take-up motor 16, namely the rotation speed varying region FT between the command torques 21A and 21C and the rotation speed stabilized region ST at the command torque 21D. In the rotation speed varying region FT, the command torques 21A and 21 B are lower than the load torque, especially, the load torque due to the friction resistance of the anti-crease roller 25, with the result that the rotation of the take-up motor 16 is brought to a stop. At the command torque 21C, on the other hand, the take-up motor 16 is not stopped by the command torque 21C, but its rotation speed is larger than the ordinary rotation speed R4 and varies greatly. The rotation speed of the take-up motor 16 becomes larger than the ordinary rotation speed R4 because a loosen cloth is then being wound. The rotation speed of the take-up motor 16 varies greatly because the load torque is approximated to the command torque 21C and, therefore, controlling to increase or decrease the torque is repeated in a short time.

[0021] In the rotation speed stabilized region ST, the command torque 21D is greater than the sum of the winding torque by the tension of the cloth 8 and load torque, which means that the take-up motor 16 stably rotates the cloth roller 9 in according with the speed of the cloth 8 delivered for the surface roller 2. In the rotation speed varying region FT, the transitional region FTB is a transitional region between the rotation speed varying region FT and the rotation speed stabilized region ST, in which the rotation speed is changed greatly at the command torque 21C. When the controller 4 calculates the ordinary rotation speed R4 of the take-up motor 16 according to the program and generates a command signal for the command torque 21 D, the controller 4 compares the rotation speed detected and transmitted by the rotation speed detector 16A of the take-up motor 16 with the calculated ordinary rotation speed R4.

[0022] When the rotation speed detected by the rotation speed detector 16A is converged to and stabilized at the ordinary rotation speed R4, the controller 4 determines that the fluctuation of the rotation speed of the take-up motor 16 is ended. The controller 4 calculates the load torque for controlling the take-up motor 16 based on the command torque 21C in the transitional region FTB in which the rotation speed varying region FT is shifted to the rotation speed stabilized region ST. In the first embodiment, the value of the command torque 21C is calculated as load torque. The load torque calculating section is stored in the memory 18 of the controller 4.

[0023] The controller 4 then calculates the winding control torque by adding the calculated winding torque and the load torque of the command torque 21C and generates a command signal for the winding control torque to the take-up motor 16. The torque of the take-up motor 16 is controlled in response to the signal for the winding control torque sent by the controller 4, so that the cloth roller 9 is driven so as to wind the cloth 8 at a predetermined tension.

[0024] In the first embodiment, the take-up motor 16 should be rotated reverse for a predetermined amount before a start for actual weaving operating and the take-up motor 16 be operated according to the progressive increase command torque graph 21. The tension of the cloth 8 can be reduced to zero by reversing the take-up motor 16, with the result that the weaving operation is performed according to the progressive increase command torque graph 21 without considering the tension of the cloth 8 and the load torque can be calculated accurately in any loom.

[0025] Since the load torque varies with the change of winding diameter of the cloth 8 on the cloth roller 9, the load torque should be calculated regularly or randomly based on the winding diameter of the cloth roller 9 and the load torque thus calculated should be used for calculating the winding control torque.

[0026] In the first embodiment, winding torque for winding the cloth against the tension of the cloth and load torque caused by inertia moment of the cloth roller 9 and sliding resistance by an axis of the cloth roller 9 are generated during driving of the cloth roller 9. When the anti-crease roller 25 such as a touch roller or a nip roller is used for anti-crease, large load torque is generated by friction resistance of the anti-crease roller 25.

[0027] In the configuration according to the first embodiment, load torque is easily calculated based on the command torque in the transitional region FTB between the rotation speed varying region FT and the rotation speed stabilized region ST without disposition of a load cell. The load torque generated in the apparatus for winding a woven cloth can be calculated easily based on the fluctuation of the rotation speed of the take-up motor 16 by the progressive increase command torque graph 21 which has values that are stepwise increased at every time T and is sent as a command signal. Since the take-up motor 16 is controlled based on the winding control torque calculated on the basis of the load torque, cloth winding tension can be controlled with high accuracy.

Second embodiment

[0028] The following will describe the second embodiment of the present invention with reference to FIG. 3. The same reference numerals will be used to denote those components or elements which correspond to their counterparts of the first embodiment and the description thereof will not be reiterated. The second embodiment differs from the first embodiment in that the second embodiment relates to a method for calculating the load torque during operating a loom in controlling the winding of a cloth. During operating the loom, the take-up motor 16 may be stopped by a large load torque that applies to the take-up motor 16 for some reason.

[0029] Referring to FIG. 3, when the take-up motor 16 is driven at the winding control torque CT in response to a command from the controller 4, the rotation speed of the take-up motor 16 is reduced due to a large load torque and the take-up motor 16 is stopped (see R5). It is noted that the surface roller 2 then continues to rotate and the looseness of the cloth 8 occurs and the cloth 8 is loosened between the surface roller 2 and the cloth roller 9. The controller 4 sends to the take-up motor 16 a signal commanding the take-up motor 16 to operate at the command torque 21E that corresponds to the sum of the current winding control torque CT and the increment torque U. The take-up motor 16 then winding the loosened cloth 8 increases its rotation speed quickly (see R6). Because the load torque is approximated to the command torque 21E, the rotation speed of the take-up motor 16 varies quickly, with the result that rapid fluctuation in the rotation speed of the take-up motor 16 occurs in the rotation speed varying region FT.

[0030] When the time T has passed, the controller 4 sends a signal commanding the command torque 21F that corresponds to the sum of the command torque 21E and the increment torque U, with the result that the rotation speed of the take-up motor 16 is converged to and stabilized at the ordinary rotation speed R7 in the rotation speed stabilized region ST. FTB shows the region between the rotation speed varying region FT and the rotation speed stabilized region ST, in which the rotation speed of the take-up motor 16 is fluctuated greatly at the command torque 21E. The controller 4 calculates the load torque based on the command torque 21E in the transitional region FTB. It is noted that the load torque is calculated in the same manner in the first embodiment. The controller 4 calculates the next winding torque by adding the calculated load torque to the current winding torque and sends a signal for the calculated winding torque to the take-up motor 16. In the description of the second embodiment, though only one step of torque increasing in the rotation speed varying region FT is shown in FIG. 3, a plurality of progressive torque increasing steps is performed in a similar manner as described with reference to the first embodiment if the take-up motor 16 is stopped in the rotation speed varying region FT.

[0031] In the second embodiment, after weaving operating the loom is started, the load torque can be calculated easily during the winding of the cloth 8, so that the second embodiment offers the same advantageous effects as the first embodiment.

Third embodiment

[0032] Referring to FIG. 4 showing the third embodiment of the present invention, the mechanical structure and a part of the controlling function of the controller are substantially the same as those of the first embodiment. The same reference numerals will be used to denote those components or elements which correspond to their counterparts of the first embodiment and the description thereof will not be reiterated. The third embodiment uses a progressive decrease torque command instead of the progressive increase torque of the first embodiment. The take-up motor in taking-up operation is driven according to the progressive decrease command torque. The load torque during the weaving operation of the loom is not constant, but it varies because the winding diameter of the cloth 8 increases with the progress of the winding operation. For example, the frictional resistance of the anti-crease roller 25 which is set in contact with the cloth 8 being wound on the cloth roller 9 varies and hence the load torque due to such frictional resistance increases with an increase of the winding diameter of the cloth 8.

[0033] If winding the cloth 8 is performed based on the load torque calculated at the beginning of the weaving operation, there is a fear that the tension of the cloth 8 is reduced when the load torque is increasing and increased when the load torque tends to be increasing, and the tension is increased when the load torque tends to be decreasing. In either case, the tension of the cloth tends to vary out of a predetermined tension, with the result that the cloth 8 may be degraded. The third embodiment uses a method in which the load torque is calculated at any appropriate time during the operation of the loom, for example, each time when the winding diameter of the cloth 8 increases by a predetermined amount, or each time when the loom is restarted after a stop of the loom due to a trouble associated with mispicking or yarn break, thus the cloth winding torque being controlled successfully.

[0034] Referring to FIG. 4, the following will describe the progressive decrease command torque graph 26 showing the relation between command torque and rotation speed of motor in the third embodiment. In the third embodiment, the programs (4)-(6) of the programs (1)-(7) in the first embodiment are stored in the memory 18 of the controller 4 in the way that is described below. The rest of the programs is stored in the same way as in the first embodiment.

(4) A program for controlling the take-up motor 16 in response to a command signal from the controller 4 based on the progressive decrease command torque graph 26 that is stored in the memory 18 (a change torque command section). It is noted that the progressive decrease command torque graph 26 is set so that the torque is decreased progressively with the decrement torque D after elapse of a predetermined length of time T, as shown in FIG. 4.

(5) A program for comparing the rotation speed of the take-up motor 16 detected when the torque is to be changed according to the progressive decrease command torque graph 26 with zero (a comparing section).

(6) A program for calculating the load torque when the take-up motor 16 has stopped its speed fluctuation due to a stop of the take-up motor 16, based on the command torque 26A in the transitional region FTB between the rotation speed varying region FT and the rotation speed stabilized region ST, when the fluctuation of the rotation speed of the take-up motor 16 has ended due to the stopping of the take-up motor 16 (a load torque calculating section).

[0035] As shown in FIG. 4, according to the progressive decrease command torque graph 26, the controller 4 sends a signal for the progressive decrease command torque graph 26 by the decrement torque D each time T to the take-up motor 16. The controller 4 sends signals for the respective target command torques 26A, 26B and

26C in this order. When the signal for the command torque 26C is sent, the rotation speed of the take-up motor 16 is changed from the ordinary rotation speed R9 and fluctuates as indicated by R10. After the fluctuation, the take-up motor 16 stops and the rotation speed becomes zero R11 at the time T2. The large fluctuation of the rotation speed at the command torque 26C occurs because the load torque is approximated to the target command torque 26C and the speed fluctuation occurs as in the case of the first embodiment.

[0036] Thus, the rotation speed of the take-up motor 16 in the rotation speed stabilized region ST at the command torques 26A, 26B and the rotation speed varying region FT at the command torque 26C varies. The rotation speed varying region FT includes the transitional region FTB that appears after the rotation speed stabilized region ST. The take-up motor 16 stops its rotation as indicated by R11 when the command torque 26C becomes smaller than the load torque. The rotation speed of the take-up motor 16 is detected by the rotation speed detector 16A after the time T1 and the controller 4 determines whether or not the detected rotation speed is zero through comparison by the comparing section.

[0037] When the rotation speed detected by the rotation speed detector 16A becomes zero, the controller 4 determines that the fluctuation of the rotation speed of the take-up motor 16 has ended. The controller 4 also calculates the load torque for controlling the operation of the take-up motor 16 based on the command torque 26C in the transitional region FTB. In the third embodiment, the value of the command torque 26C is calculated as the load torque.

[0038] After the load torque (or the command torque 26C) is calculated, the winding control torque command section in the controller 4 calculates the winding control torque by adding the calculated winding torque and the load torque and sends a signal for the winding control torque to the take-up motor 16. The torque of the take-up motor 16 that drives the cloth roller 9 is controlled according to the signal for the winding control torque from the controller 4 and the cloth roller 9 winds the cloth 8 at a predetermined tension.

[0039] Referring to FIG. 5 showing an example of the thirds embodiment, the following will describe a method for calculating the load torque when the load torque LT1 is decreasing during the operation of the loom. The predetermined target command torque is shown as the progressive decrease command torque graph 27 and includes a predetermined tension and load torque of the cloth 8. Though the progressive decrease command torque graph 27 is set to be decreased linearly, it may be set to be varied progressively in the same way as the third embodiment shown in FIG. 4. It is noted that the constant winding control torque CT during the operation of the loom is indicated by dotted line for comparison with the progressive decrease command torque graph 27.

[0040] When the winding diameter of the cloth 8 reaches a predetermined value at an arbitrarily selected time T1 during the operation of the loom, the controller 4 sends a signal for the predetermined progressive decrease command torque graph 27 to the take-up motor 16. After the signal for the progressive decrease command torque graph 27 is sent, the command torque 27A at the time T2 becomes the same as the torque that corresponds to the sum of the predetermined tension TS1 of the cloth 8 at the time T2 and the load torque LT2 in the load torque LT1 being decreased. Therefore, the take-up motor 16 stops, so that the rotation speed of the take-up motor 16 becomes zero in the transitional region FTB.

[0041] When the rotation speed detected by the rotation speed detector 16A becomes zero, the controller 4 determines that the fluctuation of the rotation speed of the take-up motor 16 has ended and calculates the load torque LT2 for controlling to drive the take-up motor 16 based on the command torque 26A in the transitional region FTB between the rotation speed varying region FT and the rotation speed stabilized region ST. In the third embodiment, the value of the calculated load torque LT2 is used as the command torque 27A. The calculated load torque LT2 is obtained by subtracting the predetermined tension TS1 from the command torque 27A.

[0042] After the load torque LT2 is calculated, the controller 4 calculates the new winding control torque by adding the load torque LT2 to the winding torque calculated by the program in the winding control command torque section and sends a signal for the calculated winding control torque to the take-up motor 16. The take-up motor 16 is controlled according to the new winding control torque sent by the controller 4, drives the cloth roller 9 and restarts winding the cloth 8, accordingly. In the third embodiment, the new calculated winding control torque is modified appropriately by subtracting the unnecessary load torque LT3 from the conventional winding control torque CT that is set to be larger than a desired value and the cloth 8 is wound, accordingly. Therefore, the controlling of winding of the cloth 8 can be performed with a high degree of accuracy without increasing the tension of the cloth 8.

[0043] Referring to FIG. 6 showing another example of the third embodiment, the following will describe a method for calculating the load torque when the load torque LT4 is increasing during the operation of the loom. For example, when the winding diameter of the cloth 8 reaches a predetermined value, the controller 4 sends a signal for the predetermined progressive decrease command torque graph 28 to the take-up motor 16. The command torque 28A at the time T1 becomes the same as the torque that corresponds to the sum of the predetermined tension TS2 of the cloth 8 at the time T2 and the load torque LT5 being increased. Therefore, the take-up motor 16 stops and the rotation speed of the take-up motor 16 becomes zero, accordingly, in the transitional region FTB.

[0044] When the rotation speed detected by the rotation speed detector 16A becomes zero, the controller 4 determines that the fluctuation of the rotation speed of the take-up motor 16 has ended. The controller 4 calculates the load torque LT5 based on the command torque 28A in the transitional region FTB. The calculated load torque LT5 is calculated by subtracting the predetermined tension TS2 of the cloth 8 from the command torque 27A. The calculated load torque LT5 is used for calculating the winding control torque in the same way as in the case of the example shown in FIG. 5. The new calculated winding control torque is modified appropriately by subtracting the unnecessary load torque LT6 from the conventional winding control torque CT that is set to be larger than a desired value and the cloth 8 is wound, accordingly. Therefore, the controlling of winding of the cloth 8 can be performed with a high degree of accuracy.

[0045] In the third embodiment including the examples in FIGS. 5 and 6, even when fluctuation of the load torque occurs in the apparatus for winding a woven cloth, the load torque can be calculated easily based on the fluctuation of the rotation speed of the take-up motor 16 at the progressive decrease command torque graphs 26, 27, and 28. Controlling of winding of the cloth 8 can be performed with a high degree of accuracy because the take-up motor 16 is controlled according to the winding control torque figured out by the calculated load torque. Therefore, controlling of winding of the cloth 8 can be performed with a high degree of accuracy.

[0046] The present invention is not limited to the above-described embodiments, but may be variously modified as exemplified below within the scope of the invention.

(1) As shown in FIG. 7, the progressive increase command torque graph 21 according to the first and second embodiments, which is indicated by the two-dot line in FIG. 7, may be replaced with the progressive increase command torque graph 22 that includes the torque increasing curves L1, L2, L3 that are connected into a continuous curve with the increment torques U1, U2, U3, respectively. Each of the torque increasing curves L1, L2, L3 represents a torque increase in a predetermined length of time T

(2) As shown in FIG. 8, the progressive increase command torque graph 21 according to the first and second embodiments, which is indicated by the two-dot line in FIG. 8, can be replaced with the progressive increase command torque graph 23 according to which the torque is increased continuously along a curve.

(3) As shown in FIG. 9, the progressive decrease command torque graphs 26, 27, 28 according to the third embodiment may be replaced with the progressive decrease command torque graph 29 that includes the torque decreasing curves L4, L5, L6 that are connected into a continuous curve with the decrement torques D1, D2, D3, respectively. Each of the torque decreasing curves L4, L5, L6 represents a torque decrease in a predetermined length of time T.

(4) As shown in FIG. 10, the progressive decrease command torque graphs 26, 27, 28 according to the third embodiment may be replaced with the progressive decrease command torque graph 30 according to which the torque is decreased continuously along a curve.

(5) The time T and the increment torque U in the progressive increase command torque graph 21 according to the first embodiment need not be constant. For example, in the case that the command torque 21A is changed to the command torque 21B, the command torque 21A may be changed to the command torque 21 B before the time T is passed if a stop of the take-up motor is detected.

(6) The controller 4 may be configured so that the progressive increase command torque graphs 21, 22, 23, the progressive decrease command torque graphs 26, 27, 28, 29, 30, the rotation speed of the take-up motor 16 driven according to the command torque graphs 21-23, 26-30, and the calculated load torque are indicated on a display of the input device 20 of the controller 4.

(7) In the first embodiment, it may be so configured that the controller 4 determines that the rotation speed of the take-up motor 16 is stabilized by recognizing that no variation occurs in the rotation of the take-up motor 16 when the command torque increase is commanded, instead of comparing the rotation speed of the take-up motor 16 with the ordinary rotation speed.

(8) In the first embodiment, when the cloth roller 9 is newly installed, load torque is calculated, so that the take-up motor 16 is driven based on the winding control torque figured out by adding the load torque to the current winding control torque.

(9) In the first embodiment, if large load torque is generated during winding of the cloth 8 or if load torque is continuously varied by winding of the cloth 8, load torque is detected rapidly and the take-up motor 16 is driven based on the winding control torque figured out by adding the load torque to the current winding control torque. Therefore, cloth winding tension can be controlled with high accuracy during operation of the loom.

(10) In the third embodiment, even when fluctuation of the load torque occurs in the apparatus for winding the woven cloth 8, the load torque can be calculated regularly or randomly without stopping operation of

the loom. Therefore, load torque can be calculated as required during operation of the loom and the take-up motor 16 can wind the cloth 8 with appropriate winding control torque.

[0047] There is provided a method for controlling winding of a woven cloth in a loom, wherein the cloth delivered through a surface roller is wound on a cloth roller driven by a take-up motor whose torque is controllable. The method includes the steps of setting a change command torque that progressively increases or decreases a torque of the take-up motor, driving the take-up motor according to the change command torque after setting the change command torque, detecting variation of rotation speed of the take-up motor, calculating load torque based on the change command torque, calculating winding torque based on tension and winding diameter of the cloth, calculating winding control torque by adding the load torque and the winding torque, and driving the take-up motor according to the winding control torque. There is also provided an apparatus for winding of a woven cloth in a loom by the above-described method.

Claims

1. A method for controlling winding of a woven cloth (8) in a loom, wherein the cloth (8) delivered through a surface roller (2) is wound on a cloth roller (9) driven by a take-up motor (16) whose torque is controllable, **characterized in that** the method includes the steps of:

setting a change command torque (21, 21A, 21B, 21C, 21D, 21E, 21F, 22, 23, 26, 26A, 26B, 26C, 27, 27A, 28, 28A, 29, 30) that progressively increases or decreases a torque of the take-up motor (16);
driving the take-up motor (16) according to the change command torque (21, 21A, 21B, 21C, 21D, 21E, 21F, 22, 23, 26, 26A, 26B, 26C, 27, 27A, 28, 28A, 29, 30) after setting the change command torque (21, 21A, 21B, 21C, 21D, 21E, 21F, 22, 23, 26, 26A, 26B, 26C, 27, 27A, 28, 28A, 29, 30);
detecting variation of rotation speed of the take-up motor (16) during changing the change command torque (21, 21A, 21B, 21C, 21D, 21E, 21F, 22, 23, 26, 26A, 26B, 26C, 27, 27A, 28, 28A, 29, 30);
calculating load torque based on the change command torque (21, 21A, 21B, 21C, 21D, 21E, 21F, 22, 23, 26, 26A, 26B, 26C, 27, 27A, 28, 28A, 29, 30) in a transitional region (FTB) between a rotation speed varying region (FT) and a rotation speed stabilized region (ST) of the take-up motor (16);
calculating winding torque based on tension and winding diameter of the cloth (8);
calculating winding control torque (CT) by adding the load torque and the winding torque; and
driving the take-up motor (16) according to the winding control torque (CT).

2. The method for controlling winding the woven cloth (8) in the loom according to claim 1, wherein the change command torque (21, 21A, 21B, 21C, 21D, 21E, 21F, 22, 23, 28, 28A) is a progressive increase command torque that progressively increases the torque of the take-up motor (16), wherein the step of driving the take-up motor (16) is a step of driving the take-up motor (16) at a stop according to the progressive increase command torque (21, 21A, 21B, 21C, 21D, 21E, 21F, 22, 23, 28, 28A) and wherein the step of calculating the load torque is a step of calculating the load torque based on the progressive increase command torque (21, 21A, 21B, 21C, 21D, 21E, 21F, 22, 23, 28, 28A) in the transitional region (FTB) when the take-up motor (16) transitions from the rotation speed varying region (FT) to the rotation speed stabilized region (ST).

3. The method for controlling winding the woven cloth (8) in the loom according to claim 1, wherein the change command torque (26, 26A, 26B, 26C, 27, 27A, 29, 30) is a progressive decrease command torque that progressively decreases the torque of the take-up motor (16), wherein the step of driving the take-up motor (16) is a step of driving the take-up motor (16) in taking-up operation according to the progressive decrease command torque (26, 26A, 26B, 26C, 27, 27A, 29, 30) and wherein the step of calculating the load torque is a step of calculating the load torque based on the progressive decrease command torque (26, 26A, 26B, 26C, 27, 27A, 29, 30) in the transitional region (FTB) when the take-up motor (16) transitions from the rotation speed stabilized region (ST) to the rotation speed varying region (FT).

4. The method for controlling winding the woven cloth (8) in the loom according to claim 2, further comprising a step of rotating the take-up motor (16) at a stop reversely, wherein the step of calculating the load torque is performed after the step of rotating the take-up motor (16) at a stop reversely.

5. The method for controlling winding the woven cloth (8) in the loom according to any one of claims 1 through 4, wherein the step of calculating the load torque is performed when operation of the loom is started.

6. The method for controlling winding the woven cloth (8) in the loom according to any one of claims 1 through 5, wherein the step of calculating the load torque is performed when operation of the loom is started and while the woven cloth (8) is wound.

7. An apparatus for winding a woven cloth (8) in a loom, wherein the cloth (8) delivered through a surface roller (2) is wound on a cloth roller (9) driven by a take-up motor (16) whose torque is controllable by a controller (4),
characterized in that
the apparatus includes
a rotation speed detector (16A) that detects rotation speed of the take-up motor (16), the controller (4) comprising:

a change command torque transmitting section that stores a preset change command torque (21, 21A, 21B, 21C, 21D, 21E, 21F, 22, 23, 26, 26A, 26B, 26C, 27, 27A, 28, 28A, 29, 30) that progressively increases or decreases a torque of the take-up motor (16) and transmits the change command torque (21, 21A, 21B, 21C, 21D, 21E, 21F, 22, 23, 26, 26A, 26B, 26C, 27, 27A, 28, 28A, 29, 30) for driving the take-up motor (16);
a load torque calculating section that calculates a load torque based on the change command torque (21, 21A, 21B, 21C, 21D, 21E, 21F, 22, 23, 26, 26A, 26B, 26C, 27, 27A, 28, 28A, 29, 30) in a transitional region (FTB) between a rotation speed varying region (FT) and a rotation speed stabilized region (ST) of the take-up motor (16);
a winding torque calculating section that calculates a winding torque based on tension and winding diameter of the cloth (8); and
a winding control torque (CT) command section that adds the winding torque and the load torque to calculate a winding control torque (CT) and commands the winding control torque (CT) for driving the take-up motor (16).

FIG. 1

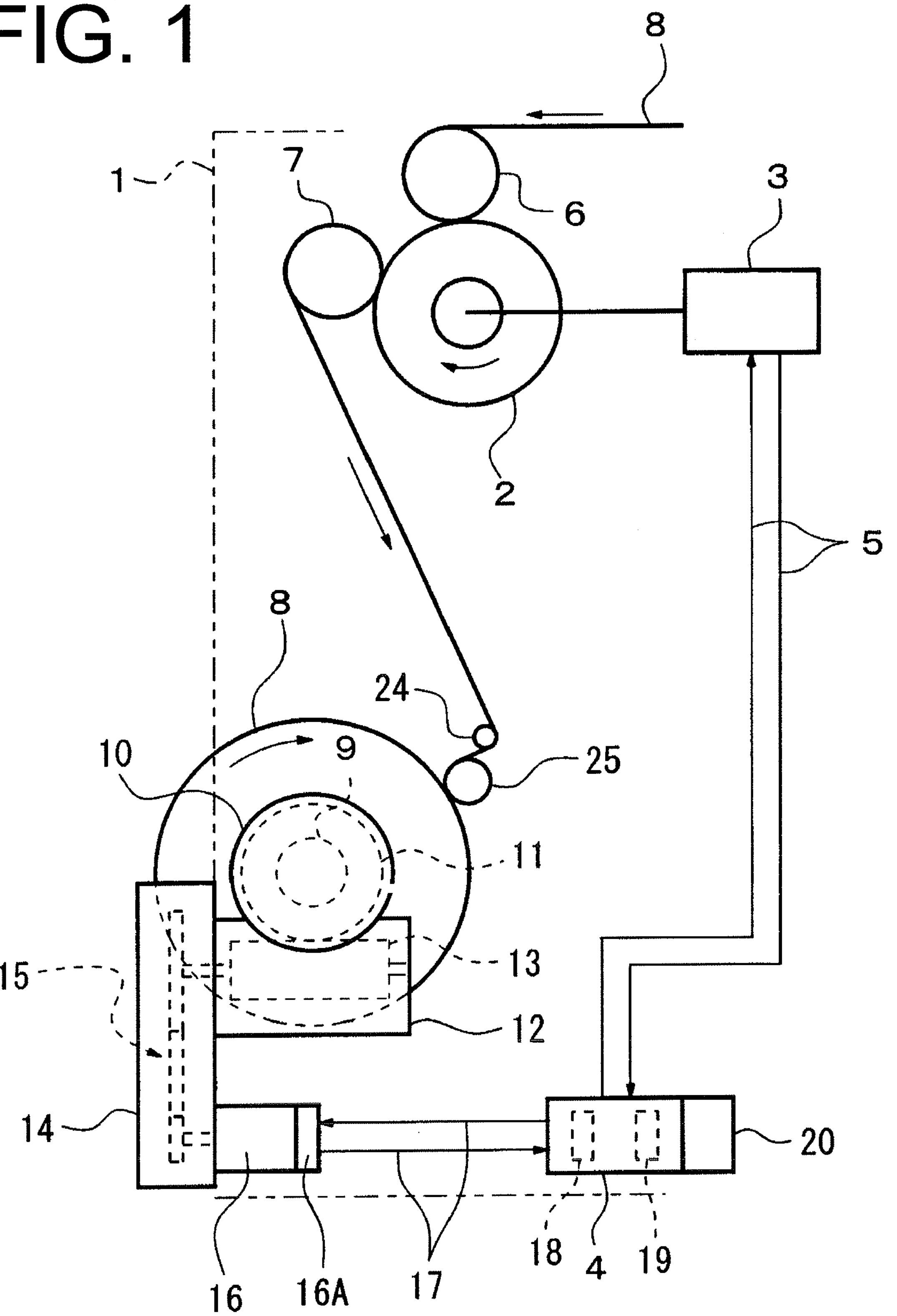


FIG. 2

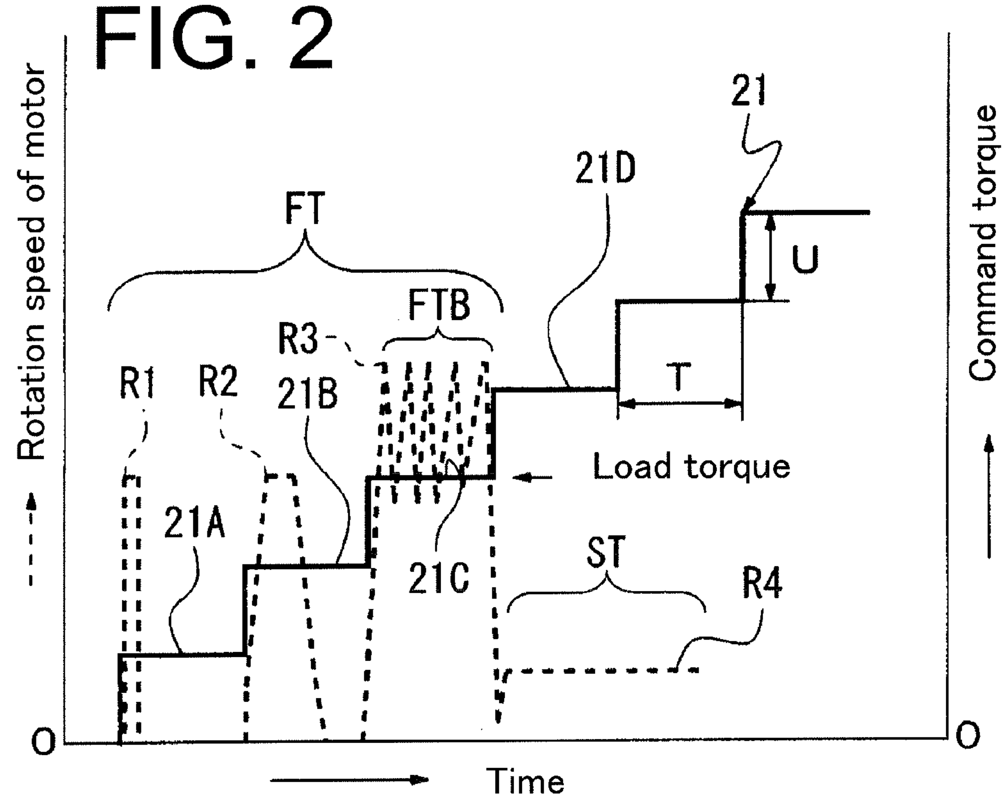

21
21D
FT
FTB
R3
R1
R2
21B
21A
21C
Load torque
U
T
ST
R4
Rotation speed of motor
Command torque
O
O
Time

FIG. 3

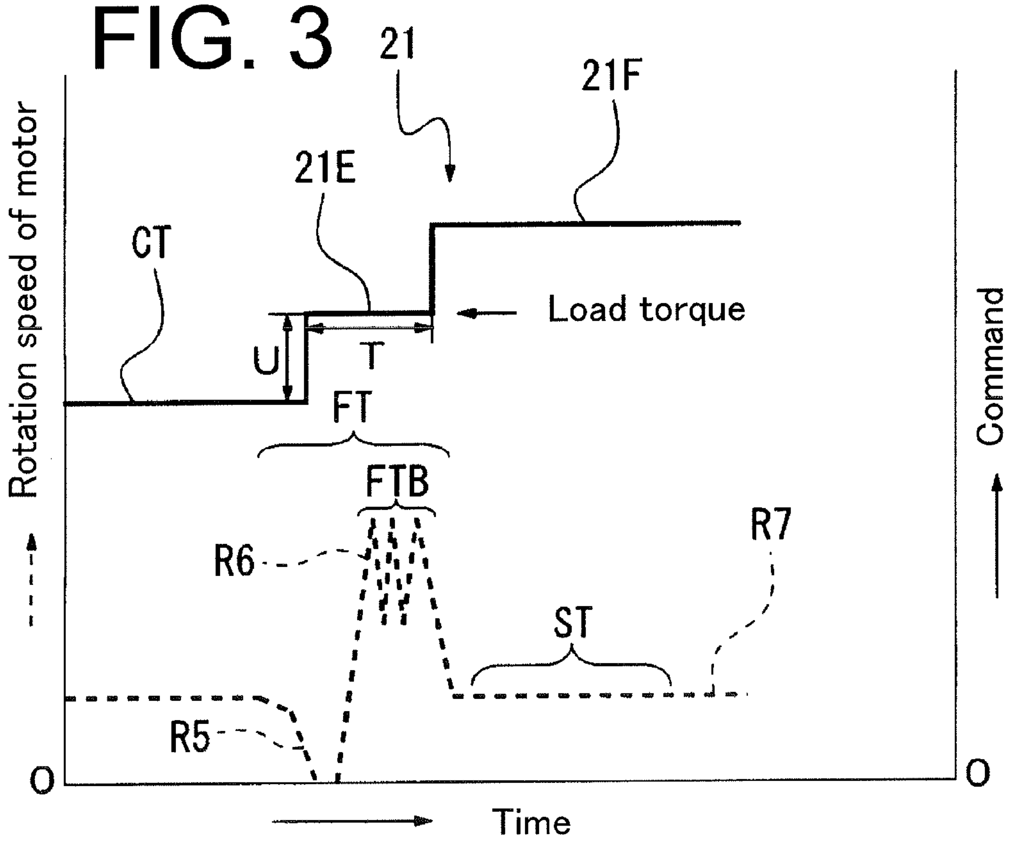

21
21F
21E
CT
U
T
Load torque
FT
FTB
R6
R7
ST
R5
Rotation speed of motor
Command
O
O
Time

FIG. 4

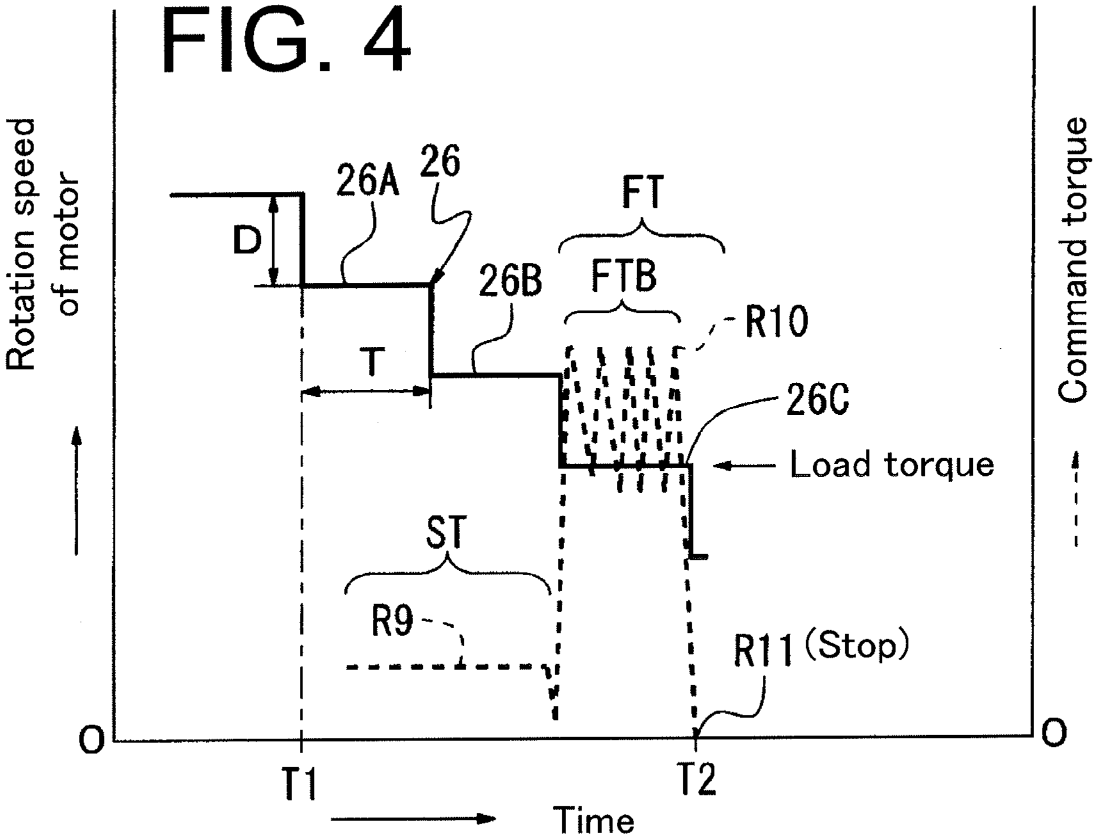

Rotation speed of motor
Command torque
26A
26
D
T
26B
FT
FTB
R10
26C
Load torque
ST
R9
R11 (Stop)
O
T1
T2
O
Time

FIG. 5

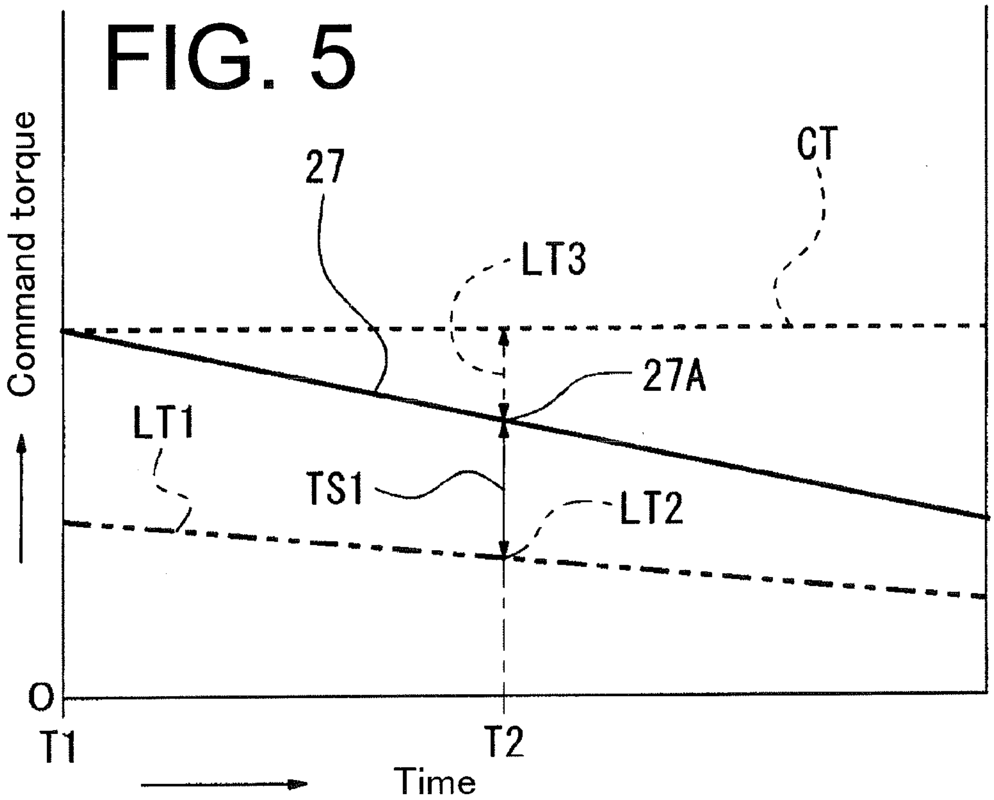

Command torque
27
CT
LT3
27A
LT1
TS1
LT2
O
T1
T2
Time

FIG. 6

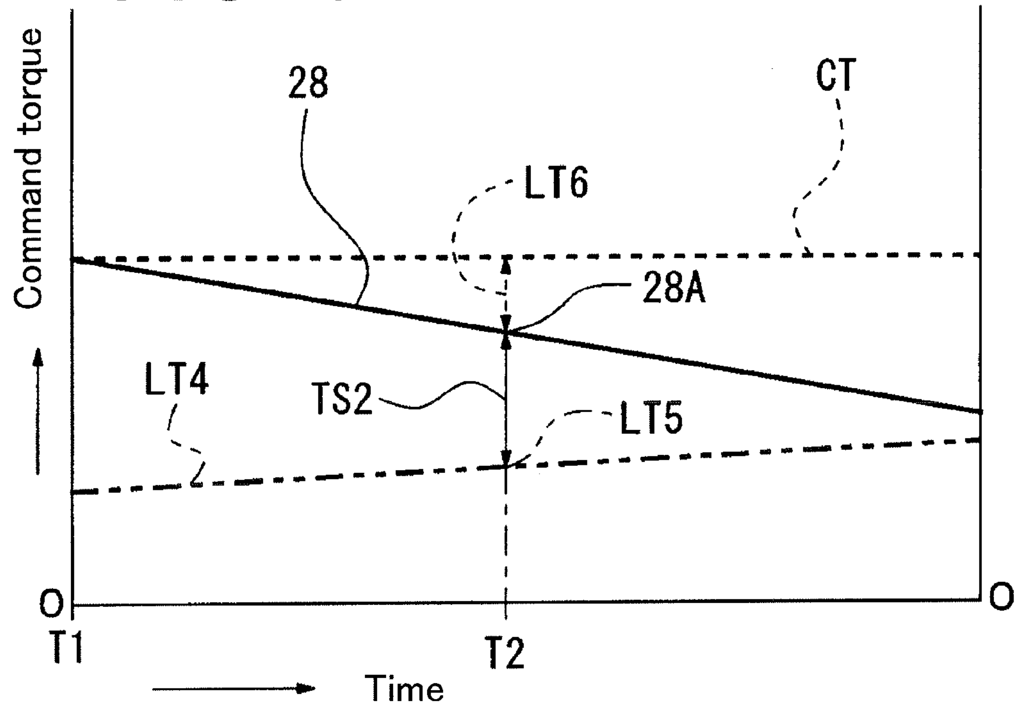

Command torque
28
CT
LT6
28A
LT4
TS2
LT5
O
O
T1
T2
Time

FIG. 7

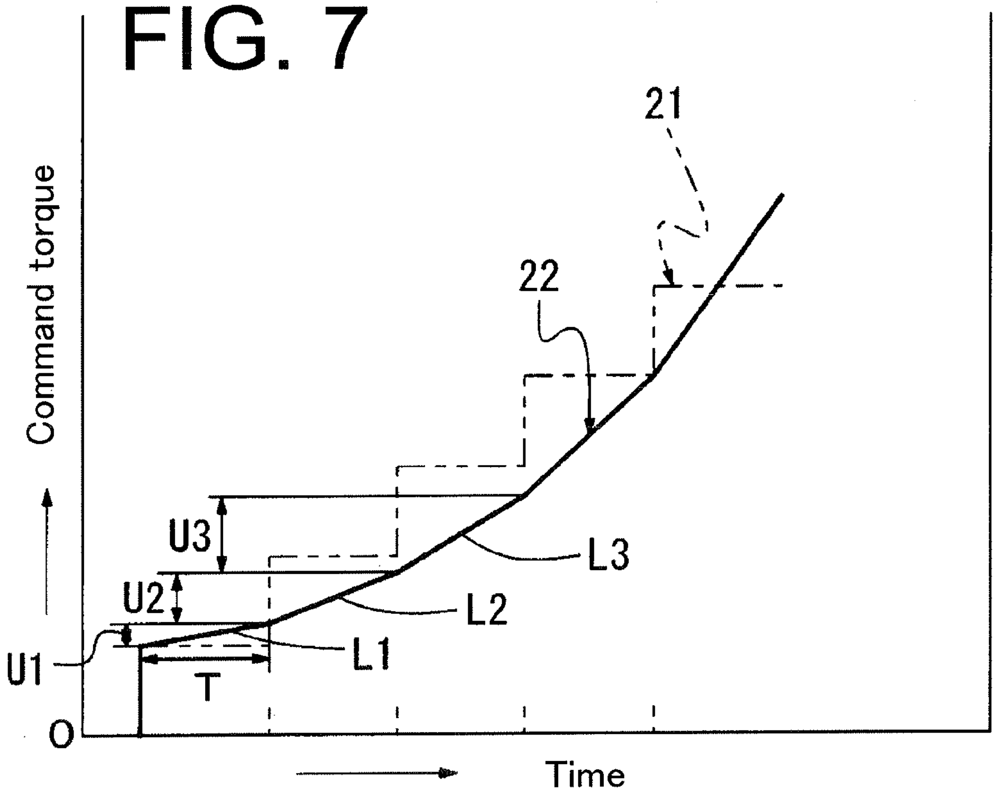

21
22
Command torque
U3
L3
U2
L2
U1
L1
T
O
Time

FIG. 8

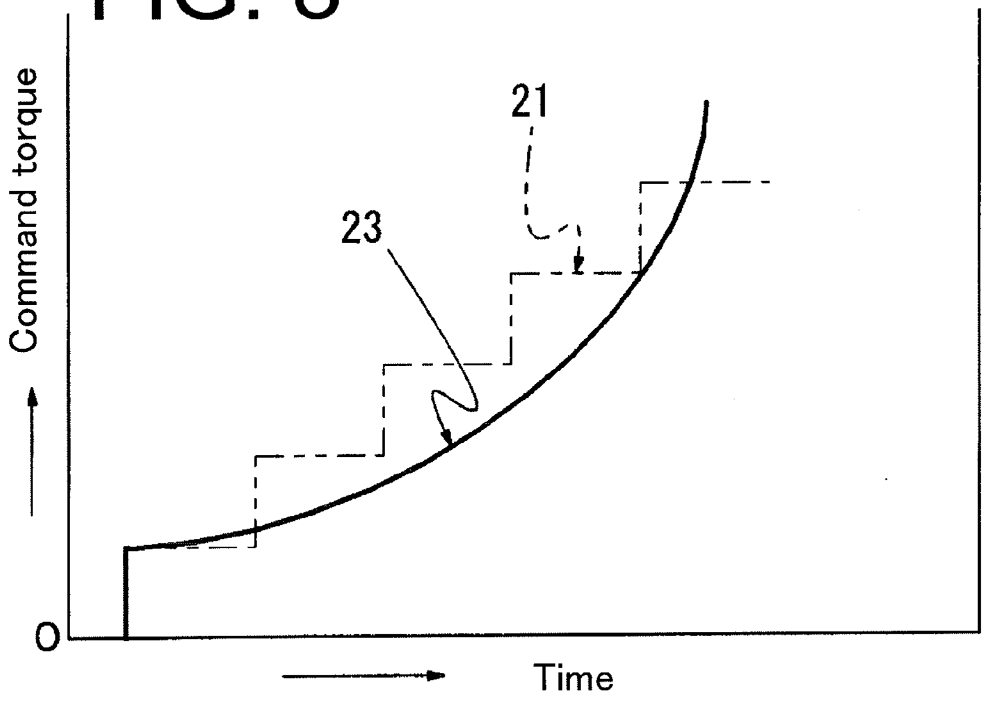

Command torque
21
23
0
Time

FIG. 9

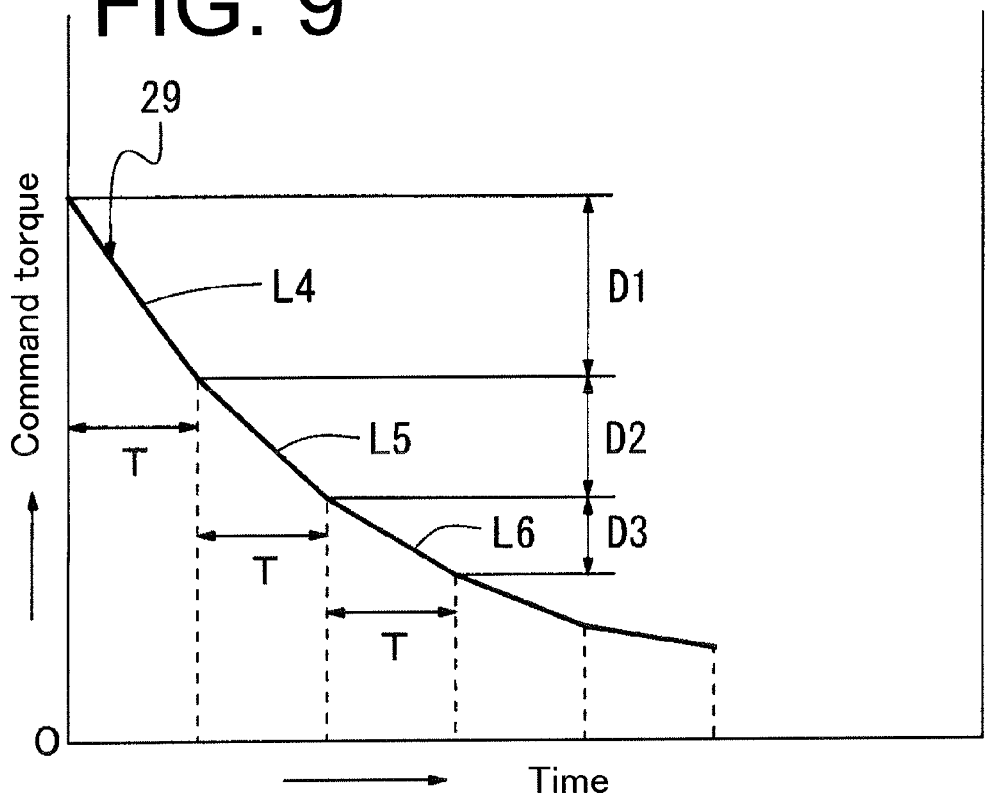
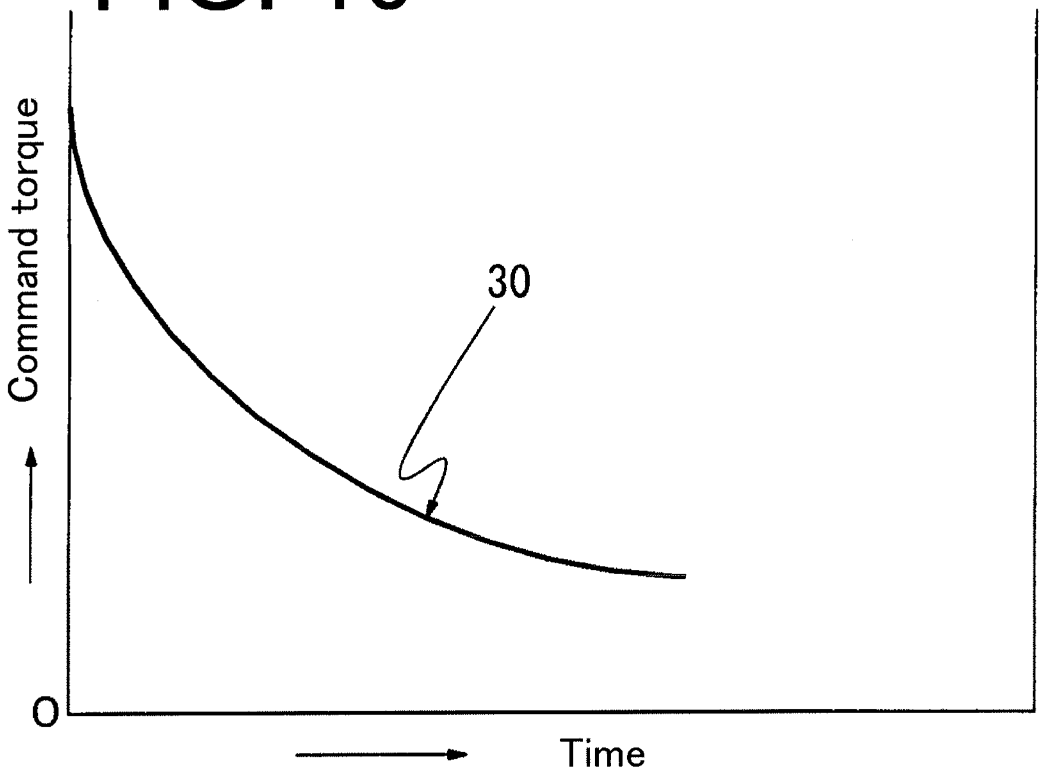

Command torque
29
L4
D1
L5
D2
L6
D3
T
T
T
0
Time

FIG. 10



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EUROPEAN SEARCH REPORT

Application Number
EP 15 15 7933

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D03D
B65H

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	13 July 2015	Louter, Petrus

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