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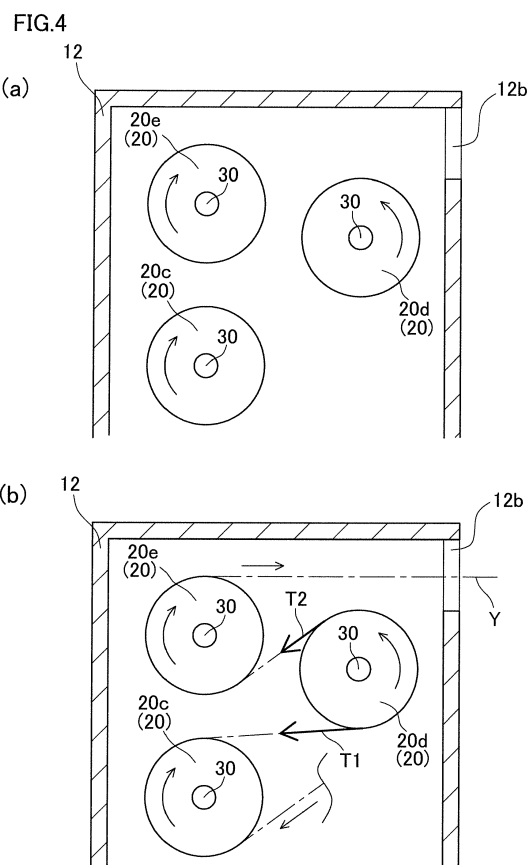
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(54) **TEXTILE MACHINE AND YARN TENSION DETECTION**

(57) The tension of yarns is always detected with ease in a textile machine, without deteriorating the quality of the yarns. The textile machine (3) of the present invention includes a godet roller (20), a motor (30) configured to generate a rotational torque in the godet roller (20), a torque information acquisition unit configured to acquire a value corresponding to the rotational torque, and a control unit (60). The control unit (60) executes: a first rotational torque information acquisition process of acquiring a first predetermined value corresponding to a first rotational torque when no yarn (Y) is wound onto the godet roller (20) while the rotation speed of the godet roller (20) is arranged to be constant at a predetermined speed; a second rotational torque information acquisition process of acquiring a second predetermined value corresponding to a second rotational torque when the yarn (Y) is wound onto the godet roller (20) while the rotation speed of the godet roller (20) is arranged to be constant at the predetermined speed; and a yarn tension calculation process of calculating a tension-related value related to the tension of the yarn (Y) wound onto the godet roller (20) based on a difference between the first predetermined value and the second predetermined value.



Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a method for detecting the tension of yarns running in a textile machine.

[0002] As a textile machine used in production or processing of yarns, Patent Literature 1 discloses a spun yarn drawing apparatus. The spun yarn drawing apparatus of Patent Literature 1 includes first heating rollers on which yarns spun out from a spinning apparatus are wound and second heating rollers on which the yarns sent from the first heating rollers are wound. Surface temperatures of the second heating rollers are higher than surface temperatures of the first heating rollers. The yarn feeding speeds of the second heating rollers are arranged to be higher than the yarn feeding speeds of the first heating rollers, and the yarns are drawn on account of this speed difference.

[0003] In the spun yarn drawing apparatus of Patent Literature 1, it is necessary to detect and suitably manage the tension of the running yarns, in order to suitably draw the yarns while maintaining the quality of the yarns. For example, typically, an operator measures the tension of yarns by using a tensiometer. In the spun yarn drawing apparatus of Patent Literature 1 (Japanese Laid-Open Patent Publication No. 2016-40429), however, there are typically many management points where the tension of the yarns must be managed in the textile machine. For example, the tension of yarns must be managed at each of the intervals of the rollers. It is therefore quite troublesome for the operator to measure the tension of the yarns at each management point. Furthermore, because the measurement is manually done by the operator, the measurement cannot be always done.

[0004] Under this circumstance, the tension of running yarns can always be measured if a tension sensor is provided at each management point. For example, Patent Literature 2 (Japanese Laid-Open Patent Publication No. 2019-157313) discloses an arrangement in which a tension sensor configured to measure the tension of yarns is provided in a yarn path in a draw texturing machine which is a textile machine.

SUMMARY OF THE INVENTION

[0005] Such a tension sensor, however, is typically of a contact type, and the quality of the yarns may be deteriorated due to the friction between the running yarns and the tension sensor.

[0006] An object of the present invention is to always detect the tension of yarns with ease in a textile machine, without deteriorating the quality of the yarns.

[0007] According to a first aspect of the invention, a textile machine includes: a roller which is capable of winding a running yarn onto a circumferential surface of the roller; a rotational driving unit which is configured to gen-

erate a rotational torque in the roller; a torque information acquisition unit which is configured to acquire a value corresponding to the rotational torque; and a control unit, the control unit executing: a first rotational torque information acquisition process of arranging rotation speed of the roller to be constant at a predetermined speed, and acquiring, by the torque information acquisition unit, a first predetermined value corresponding to a first rotational torque generated in the roller when no yarn is wound on the roller; a second rotational torque information acquisition process of arranging the rotation speed of the roller to be constant at the predetermined speed, and acquiring, by the torque information acquisition unit, a second predetermined value corresponding to a second rotational torque generated in the roller when the yarn is wound on the roller; and a yarn tension calculation process of calculating a tension-related value related to the tension of the yarn wound onto the roller, based on the first predetermined value and the second predetermined value.

[0008] According to this aspect of the invention, the tension-related value of the yarn can be calculated based on predetermined values which correspond to a rotational torque in a case where the yarn is wound onto the roller and a rotational torque in a case where the yarn is not wound onto the roller. It is therefore unnecessary to provide a tension sensor to detect the tension of the yarn. In this way, it is possible in the textile machine to always detect the tension of the yarn with ease, without deteriorating the quality of the yarn.

[0009] According to a second aspect of the invention, the textile machine of the first aspect is arranged such that the tension-related value is a tension difference between the tension of the yarn on the upstream of the roller in a yarn running direction in which the yarn runs and the tension of the yarn on the downstream of the roller in the yarn running direction.

[0010] A tension difference between the tension of the yarn on the upstream of the roller in the yarn running direction and the tension of the yarn on the downstream of the roller in the yarn running direction is determined in advance based on the characteristics (e.g., the rotation speed and the magnitude of the rotational torque) of the roller and the type of the yarn to be wound. According to the aspect of the invention, it is possible to easily determine whether the tension of the yarn is appropriate, by comparing a tension difference calculated in the yarn tension calculation process with a tension difference determined in advance.

[0011] According to a third aspect of the invention, the textile machine of the first or second aspect is arranged such that the rotational driving unit includes an output unit configured to output a current and a motor configured to generate a rotational torque corresponding to the current output from the output unit, and the control unit acquires a first current as the first predetermined value in the first rotational torque information acquisition process, acquires a second current as the second predetermined

value in the second rotational torque information acquisition process, and calculates the tension-related value based on the first current and the second current in the yarn tension calculation process.

[0012] According to the aspect of the invention, because it is possible to calculate the tension-related value of the yarn based on the current flowing in the motor when the rotational torque is generated in the roller, the tension of the yarn is easily detected as compared to a case where the tension-related value is directly detected.

[0013] According to a fourth aspect of the invention, the textile machine of the third aspect is arranged such that the torque information acquisition unit includes a rotational angle detection unit configured to detect a rotational angle of a rotor of the motor and a torque current calculation unit configured to calculate a current corresponding to the rotational torque based on the rotational angle.

[0014] According to the aspect of the invention, because the current corresponding to the rotational torque is acquired based on the rotational angle of the rotor of the motor, complicated control is not required and the tension of the yarns Y can be further easily detected.

[0015] According to a fifth aspect of the invention, the textile machine of any one of the first to fourth aspects is arranged such that the control unit further executes: a first failure determination process of determining whether the first predetermined value acquired in the first rotational torque information acquisition process is out of a first predetermined range; and a first notification process of notifying that there is a failure in the textile machine, when it is determined in the first failure determination process that the first predetermined value is out of the predetermined range.

[0016] The first predetermined value is a value corresponding to the rotational torque of the roller when no yarn is wound onto the roller. In the aspect of the invention, it is possible to detect a failure of the textile machine based on the first predetermined value, before the yarn is wound. It is therefore possible to promptly detect a failure of the textile machine.

[0017] According to a sixth aspect of the invention, the textile machine of any one of the first to fifth aspects is arranged such that the control unit further executes: a second failure determination process of determining whether the tension-related value calculated in the yarn tension calculation process is out of a second predetermined range; and a second notification process of notifying that there is a failure in the tension of the yarn wound onto the roller, when it is determined in the second failure determination process that the tension-related value is out of the second predetermined range.

[0018] According to the aspect of the invention, the operator is able to reliably know whether the tension of the yarn wound onto the roller is normal or not.

[0019] According to a seventh aspect of the invention, the textile machine of any one of the first to sixth aspects is arranged such that the control unit further executes: a

second failure determination process of determining whether the tension-related value calculated in the yarn tension calculation process is out of a second predetermined range; and an adjustment process of adjusting the rotational torque generated in the roller by the rotational driving unit, when it is determined in the second failure determination process that the tension-related value is out of the second predetermined range.

[0020] According to the aspect of the invention, the tension of the yarn wound on the roller is maintained to be always appropriate, and hence the quality of the yarn is maintained to be constant in the textile machine.

[0021] According to an eighth aspect of the invention, the textile machine of any one of the first to seventh aspects is arranged such that the control unit further executes: a third failure determination process of determining whether the tension-related value calculated in the yarn tension calculation process is out of a third predetermined range; and a third notification process of notifying that the yarn is broken, when it is determined in the third failure determination process that the tension-related value is out of the third predetermined range.

[0022] According to this aspect of the invention, the operator is able to reliably and promptly know that the yarn is broken.

[0023] According to a ninth aspect of the invention, the textile machine of any one of the first to eighth aspects is arranged such that, conversion information is set in advance to convert the first predetermined value and the second predetermined value into the tension-related value, and the control unit calculates the tension-related value based on the conversion information in the yarn tension calculation process.

[0024] According to this aspect of the invention, because the tension-related value is calculated based on the conversion information set in advance, a complicated calculation process is unnecessary, and the tension of the yarn can be further easily detected.

[0025] A tenth aspect of the invention relates to a yarn tension detection method for detecting the tension of a running yarn which runs in a textile machine and is wound onto a roller capable of winding the yarn onto a circumferential surface of the roller, the textile machine comprising: a rotational driving unit generating a rotational torque in the roller; and a torque information acquisition unit acquiring a value corresponding to the rotational torque, the method comprising: a first rotational torque information acquisition step of arranging rotation speed of the roller to be constant at a predetermined speed, and acquiring, by the torque information acquisition unit, a first predetermined value corresponding to a first rotational torque generated in the roller when no yarn is wound on the roller; a second rotational torque information acquisition step of arranging the rotation speed of the roller to be constant at the predetermined speed, and acquiring, by the torque information acquisition unit, a second predetermined value corresponding to a second rotational torque generated in the roller when the yarn is

wound on the roller; and a yarn tension calculation step of calculating a tension-related value related to the tension of the yarn wound onto the roller, based on the first predetermined value and the second predetermined value.

[0026] According to this aspect of the invention, the tension-related value of the yarn can be calculated based on predetermined values which correspond to a rotational torque in a case where the yarn is wound onto the roller and a rotational torque in a case where the yarn is not wound onto the roller. It is therefore unnecessary to provide a tension sensor to detect the tension of the yarn. In this way, it is possible in the textile machine to always detect the tension of the yarn with ease, without deteriorating the quality of the yarn.

[0027] It is possible in the textile machine to always detect the tension of the yarn with ease, without deteriorating the quality of the yarn.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028]

FIG. 1 is a schematic representation of a spun yarn take-up machine including a spun yarn drawing apparatus of an embodiment.

FIG. 2 is an enlarged view of the spun yarn drawing apparatus shown in FIG. 1.

FIG. 3 is a block diagram schematically showing a godet roller and an electric configuration of a motor connected to the godet roller.

FIG. 4(a) shows the spun yarn drawing apparatus in which no yarn is wound onto the godet rollers in a first rotational torque information acquisition step.

FIG. 4(b) shows the spun yarn drawing apparatus in which yarns are wound onto the godet rollers in a second rotational torque information acquisition step.

FIG. 5 is a flow chart of operations when the spun yarn drawing apparatus of the embodiment detects the tension of yarns wound onto a roller.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

(Overall Structure of Spun Yarn Take-Up Machine 1)

[0029] The following will describe a preferred embodiment of the present invention with reference to figures.

[0030] In the present embodiment, a spun yarn drawing apparatus 3 is employed as a textile machine. FIG. 1 is a schematic representation of a spun yarn take-up machine 1 including a spun yarn drawing apparatus 3 of the present embodiment. FIG. 2 is an enlarged view of the spun yarn drawing apparatus 3 shown in FIG. 1. Hereinafter, the up-down direction on the plane of FIG. 1 is an up-down direction, and the left-right direction of the plane is a left-right direction. Furthermore, the direction perpendicular to the plane of FIG. 1 is a front-rear direc-

tion, and the front side of the plane is a front side.

[0031] As shown in FIG. 1, the spun yarn take-up machine 1 is configured to draw, by a spun yarn drawing apparatus 3, plural (six in this embodiment) yarns Y serially spun out from a spinning apparatus 2 and made of a solidified molten fibrous material such as polyester, and then to wind the yarns Y by a yarn winding apparatus 4.

[0032] The spinning apparatus 2 is configured to generate the yarns Y by continuously spinning out a molten fibrous material such as polyester. To the yarns Y spun out from the spinning apparatus 2, oil is applied at an oil guide 10. The yarns Y are then sent to the spun yarn drawing apparatus 3 via a guide roller 11.

[0033] The spun yarn drawing apparatus 3 is an apparatus for heating and drawing the yarns Y and is provided below the spinning apparatus 2. The spun yarn drawing apparatus 3 includes plural (five in this embodiment) godet rollers 20 (20a to 20e) housed in a thermal insulation box 12. When these rollers are simply termed the godet rollers 20, the five godet rollers 20a to 20e are not distinguished from one another. As shown in FIG. 2, each of the godet rollers 20a to 20e is rotationally driven by a later-described motor 30 at a predetermined yarn feeding speed. (The rotational direction of each of the godet rollers 20a to 20e is indicated by the corresponding arrow in FIG. 2.) The godet rollers 20a to 20e are induction heating rollers which are induction-heated by power supply to a coil. Yarns Y are wound onto these godet rollers. At a lower part of a right side portion of the thermal insulation box 12, an inlet 12a is formed to introduce yarns Y into the thermal insulation box 12. At an upper part of the right side portion of the thermal insulation box 12, an outlet 12b is formed to take yarns Y out from the thermal insulation box 12. The yarns Y are wound onto each of the godet rollers 20a to 20e at a winding angle of less than 360 degrees. The yarns Y are wound onto the godet rollers 20a to 20e in order, from the lowest godet roller 20a.

[0034] The lower three godet rollers 20a to 20c are preheating rollers for preliminarily heating the yarns Y before drawing them. The roller surface temperature of each of these rollers is arranged to be equal to or higher than the glass transition temperature of the yarns Y (e.g., set at about 90 to 100 degrees centigrade). Meanwhile, the upper two godet rollers 20d and 20e are conditioning rollers for thermally setting the drawn yarns Y. The roller surface temperature of each of these rollers is arranged to be higher than the roller surface temperatures of the lower three godet rollers 20a to 20c (e.g., set at about 150 to 200 degrees centigrade). The yarn feeding speeds of the upper two godet rollers 20d and 20e are higher than those of the lower three godet rollers 20a to 20c.

[0035] The yarns Y introduced into the thermal insulation box 12 through the inlet 12a are, to begin with, preliminarily heated to a drawable temperature while being transferred by the godet rollers 20a to 20c. The preliminarily-heated yarns Y are drawn on account of a difference in yarn feeding speed between the godet roller 20c

and the godet roller 20d. Subsequently, the yarns Y are further heated while being transferred by the godet rollers 20d and 20e, with the result that the drawn state is thermally set. The yarns Y having been drawn in this way go out from the thermal insulation box 12 through the outlet 12b.

[0036] The yarns Y drawn by the spun yarn drawing apparatus 3 are sent to the yarn winding apparatus 4 via the guide roller 13. The yarn winding apparatus 4 is an apparatus for winding the yarns Y, and is provided below the spun yarn drawing apparatus 3. The yarn winding apparatus 4 includes members such as a bobbin holder 14 and a contact roller 15. The bobbin holder 14 is cylindrical in shape, and extends in the front-rear direction. The bobbin holder 14 is rotationally driven by an unillustrated motor. To the bobbin holder 14, bobbins B are attached along the axial direction to be side by side. By rotating the bobbin holder 14, the yarn winding apparatus 4 simultaneously winds the yarns Y onto the bobbins B, so as to produce packages P. The contact roller 15 makes contact with the surfaces of the packages P to adjust the shape of each package P by applying a predetermined contact pressure to each package P.

[0037] In this regard, in order to suitably perform the drawing while maintaining the quality of the yarns Y in the spun yarn drawing apparatus 3, it is necessary to detect the tension of the yarns Y running between each pair of neighboring godet rollers and suitably manage the tension. In order to detect the tension of the yarns Y running in the yarn running direction, the tension has been typically measured by an operator by using a tensiometer, or measured by a tension sensor. However, in the former case, because there are many points where the tension must be detected, it is troublesome for the operator to perform measurement at these points, and the measurement cannot always be done. The measurement can always be done in the latter case. However, the tension sensor is typically of a contact type, and the quality of the yarns may be deteriorated due to the friction between the running yarns and the tension sensor.

[0038] The spun yarn drawing apparatus 3 of the present embodiment therefore includes a motor 30 configured to rotationally drive a godet roller 20 so as to generate a rotational torque in the godet roller 20, a motor controller 40 configured to control the motor 30, and a rotational angle detection circuit 50 (rotational angle detection unit of the present invention) configured to detect the rotational angle of the rotor of each motor 30. The motor 30, the motor controller 40, and the rotational angle detection circuit 50 are provided for each of the godet rollers 20a to 20e. An explanation will be given with reference to FIG. 3.

[0039] The motor 30 is a permanent magnet synchronous motor which employs a permanent magnet in a rotor. The motor 30 is connected to the godet roller 20 and the motor controller 40, and is able to generate a rotational torque in the godet roller 20 in accordance with a current output from the motor controller 40.

[0040] The motor controller 40 includes an inverter 41 (output unit of the present invention) and a control unit 60. The inverter 41 is an AC inverter which is configured to convert a direct current supplied from an unillustrated power source into a sine wave alternating current. The control unit 60 is configured to control the magnitude and frequency of the alternating current output from the inverter 41. The rotational torque generated in the godet roller 20 is determined by the magnitude of the alternating current output from the inverter 41, whereas the rotation speed (i.e., yarn feeding speed) of the godet roller 20 rotationally driven by the motor 30 is determined by the frequency of the alternating current.

[0041] The rotational angle detection circuit 50 is connected to the motor 30 and the motor controller 40 and is configured to detect the rotational angle of the rotor of the motor 30 based on a current supplied to the motor 30. Information regarding the rotational angle of the rotor of the motor 30 detected by the rotational angle detection circuit 50 is sent to the control unit 60 of the motor controller 40.

[0042] The control unit 60 calculates a current by which a magnetic field is generated at the rotor in order to rotationally drive the godet roller 20 and a current by which a rotational torque is generated, based on a rotational angle of the rotor and a current flowing in the motor 30. In other words, in the present embodiment, the control unit 60 includes a torque current calculation unit.

[0043] In addition to the above, the control unit 60 controls an output of the inverter 41 based on the calculated currents. To be more specific, the control unit 60 performs so-called vector control so as to independently control a current for generating a magnetic field at the rotor and a current for generating a rotational torque. Furthermore, the control unit 60 includes a memory (not illustrated) which is configured to store a rotational torque generated in each of the godet rollers 20a to 20e, in association with a current by which the rotational torque is generated.

[0044] The following will describe a method of calculating a tension-related value related to the tension of yarns Y wound onto each of the godet rollers 20a to 20e in the spun yarn drawing apparatus 3 of the present embodiment, with reference to FIG. 4 and FIG. 5. In FIG. 4, for simplicity, only the godet rollers 20c to 20e are shown and the godet rollers 20a and 20b are omitted.

(First Rotational Torque Information Acquisition Process)

[0045] To begin with, as shown in FIG. 4(a), the control unit 60 arranges the frequency of a sine wave alternating current output from each inverter 41 to be constant at a predetermined value so that the rotation speed of each of the godet rollers 20a to 20e is constant at a predetermined speed when no yarns Y are wound onto each of the godet rollers 20a to 20e.

[0046] In this connection, when each of the godet rollers 20a to 20e is rotated, load is applied to each of the godet rollers 20a to 20e due to, for example, windage

loss associated with the rotation of the roller and friction loss at a bearing of the motor 30. Each motor 30 therefore generates a predetermined rotational torque corresponding to the load applied to each of the godet rollers 20a to 20e, in order to keep the rotation speed of each of the godet rollers 20a to 20e, to which the load is applied due to windage loss, friction loss, etc., to be constant at a predetermined speed. The rotational torque at this stage is termed a first rotational torque. For each of the godet rollers 20a to 20e, the control unit 60 acquires a first current (first predetermined value) output to the motor 30 in accordance with the first rotational torque and stores the first current in the memory, based on the rotational angle of the rotor of the motor 30 detected by the rotational angle detection circuit 50 (step S1).

(First Failure Determination Process)

[0047] For each of the godet rollers 20a to 20e, the control unit 60 performs a first failure determination process of determining whether the first current acquired in the first rotational torque information acquisition process is out of a first predetermined range (step S2). The first predetermined range is a range of currents output to the motor 30 when the spun yarn drawing apparatus 3 operates normally. The first predetermined range is, for example, set for each of the godet rollers 20a to 20e by an operator in advance.

(First Notification Process)

[0048] When it is determined in the first failure determination process that the first current corresponding to a godet roller 20 is out of the first predetermined range (YES in S2), the control unit 60 executes a first notification process of notifying the operator that there is a failure in the spun yarn drawing apparatus 3 (step S3). The notification is, for example, done by producing warning sound or by a notification on a display or a warning lamp. The notification may be done in various ways as long as the operator is notified that there is a failure in the spun yarn drawing apparatus 3. After the first notification process, the control unit 60 stops the spun yarn drawing apparatus 3.

(Second Rotational Torque Information Acquisition Process)

[0049] When it is determined in the first failure determination process that the first currents corresponding to all godet rollers 20 fall within the first predetermined range (NO in S2), as shown in FIG. 4(b), the yarns Y spun out from the spinning apparatus 2 are wound onto the godet rollers 20a to 20e (step S4). This winding of the yarns Y may be done by the operator or may be automatically done by a robot. The control unit 60 then arranges the frequency of a sine wave alternating current output from each inverter 41 to be constant at a predetermined value

so that the rotation speed of each of the godet rollers 20a to 20e is constant at a predetermined speed while yarns Y are wound onto each of the godet rollers 20a to 20e. The rotation speed of each of the godet rollers 20a to 20e at this stage is identical with the rotation speed of each of the godet rollers 20a to 20e in the first rotational torque information acquisition step.

[0050] In addition to the windage loss and friction loss described above, load due to the tension of the yarns Y is further applied to each of the godet rollers 20a to 20e on which the yarns Y are wound. For example, in a case of the godet roller 20d, as shown in FIG. 4(b), the godet roller 20d receives (i) a tension T1 of the yarns Y on the upstream of the godet roller 20d in a yarn running direction (indicated by arrows in FIG. 2 and FIG. 4) which run from the inlet 12a toward the outlet 12b and (ii) a tension T2 of the yarns Y on the downstream of the godet roller 20d in the yarn running direction. To be more specific, the tension T1 acts in the direction opposite to the rotational direction of the godet roller 20d, whereas the tension T2 acts in the same direction as the rotational direction of the godet roller 20d. In other words, the godet roller 20d further receives load caused by a tension difference (T1-T2) between the tensions T1 and T2 of the yarns Y. On this account, each motor 30 generates a predetermined rotational torque corresponding to the load applied to each of the godet rollers 20a to 20e, in order to keep the rotation speed of each of the godet rollers 20a to 20e, to which load is applied due to the tension difference (T1-T2) in addition to the windage loss, friction loss, etc., to be constant at a predetermined speed. The rotational torque at this stage is termed a second rotational torque. For each of the godet rollers 20a to 20e, the control unit 60 acquires a second current (second predetermined value) output to the motor 30 in accordance with the second rotational torque and stores the acquired second current in the memory, based on the rotational angle of the rotor of the motor 30 detected by the rotational angle detection circuit 50 (step S5).

(Yarn Tension Calculation Process)

[0051] Subsequently, for each of the godet rollers 20a to 20e, the control unit 60 calculates a difference between the tension of the yarns on the upstream in the yarn running direction of the godet roller 20 and the tension of the yarns Y on the downstream in the yarn running direction of the godet roller 20 (hereinafter, this difference in tension may be simply referred to as a tension difference) based on a difference between the first current and the second current stored in the memory (step S6).

[0052] In a case of the godet roller 20d, for example, the first current is a current corresponding to the first rotational torque generated by the motor 30 in the godet roller 20d which receives load due to the windage loss, friction loss, etc. The second current is a current corresponding to the second rotational torque generated by the motor 30 in the godet roller 20d which receives load

due to the tension difference ($T_1 - T_2$) in addition to the windage loss, friction loss, etc. To put it differently, the difference between the first current and the second current corresponds to the difference between the first rotational torque and the second rotational torque, and therefore corresponds to the tension difference ($T_1 - T_2$). It is therefore possible to calculate, for each of the godet rollers 20a to 20e, a tension difference ($T_1 - T_2$) based on a difference between the first current and the second current.

[0053] Specific steps of the yarn tension calculation process are as follows: a conversion table for converting a difference between the first current and the second current to a tension difference is set in advance and stored in the memory of the control unit 60. The control unit 60 then acquires a tension difference of the yarns Y in each of the godet rollers 20a to 20e by converting a difference between the first current and the second current into a tension difference based on the conversion table.

[0054] The tension difference in the present embodiment is equivalent to a tension-related value related to a yarn wound onto a roller in the present invention.

(Second Failure Determination Process)

[0055] The control unit 60 executes a second failure determination process to determine whether a tension difference of the yarns Y in each of the godet rollers 20a to 20e acquired in the yarn tension calculation process is out of a second predetermined range (step S7). The second predetermined range is an allowable range of tension differences in each of the godet rollers 20a to 20e, when the tension of the yarns Y is appropriate. This range is, for example, set for each of the godet rollers 20a to 20e by an operator in advance.

(Second Notification Process)

[0056] When it is determined in the second failure determination process that a tension difference of the yarns Y wound onto a godet roller 20 is out of the second predetermined range (YES in S7), the control unit 60 executes a second notification process of notifying the operator that the tension of the yarns Y wound onto the godet roller 20 whose tension difference is out of the second predetermined range is erroneous (step S8). The notification is, in the same manner as in the first notification process, for example, done by producing warning sound or by a notification on a display or a warning lamp. The notification may be done in various ways as long as the operator is notified that the tension of the yarns Y wound onto the godet roller 20 is erroneous.

(Third Failure Determination Process)

[0057] Subsequently, the control unit 60 performs an adjustment process of adjusting the rotational torque

generated in the godet roller 20 by the motor 30 and the inverter 41 so that the tension differences of the yarns Y wound onto all godet rollers 20 fall within the second predetermined range (later-described step S11). However, if the yarns Y are broken at a part of the spun yarn take-up machine 1, the adjustment step cannot be done. For this reason, before executing the adjustment process, the control unit 60 executes, to begin with, a third failure determination process to determine whether a tension difference of the yarns Y on each of the godet rollers 20a to 20e is out of a third predetermined range (step S9). The third predetermined range is wider than the second predetermined range in the second failure determination process (S7), and is an allowable range of tension differences on each of the godet rollers 20a to 20e when the yarns Y are not broken. The third predetermined range is, for example, set for each of the godet rollers 20a to 20e by the operator in advance.

20 (Third Notification Process)

[0058] When it is determined in the third failure determination process that a tension difference of the yarns Y wound onto a godet roller 20 is out of the third predetermined range (YES in S9), the control unit 60 executes a third notification process of notifying the operator that the yarns Y are broken at a part of the spun yarn take-up machine 1 (step S10). The notification is, in the same manner as in the first notification process and the second notification process, for example, done by producing warning sound or by a notification on a display or a warning lamp. The notification may be done in various ways as long as the operator is notified that the tension of the yarns Y wound onto the godet roller 20 is erroneous. Preferably, the second notification process and the third notification process are distinguishable. For example, when warning sound is produced in the second notification process and the third notification process, the warning sound in the second notification process is preferably different from the warning sound in the third notification process. This allows the operator to easily understand whether the warning sound is produced in the second notification process or in the third notification process. After the third notification process, the control unit 60 stops the spun yarn drawing apparatus 3. As a matter of course, when a warning is visually produced on a display or a warning lamp, a way of displaying a warning is preferably different between the second notification process and the third notification process.

(Adjustment Step)

[0059] When it is determined in the third failure determination process that a tension difference of the yarns Y wound onto a godet roller 20 falls within the third predetermined range (NO in S9), the control unit 60 determines that the yarns Y are not broken at any part of the spun yarn take-up machine 1. The control unit 60 then

performs an adjustment process of adjusting the rotational torque generated in any of the godet rollers 20a to 20e by the motor 30 and the inverter 40 so that the tension differences of the yarns Y wound onto all godet rollers 20 fall within the second predetermined range (step S11). Thereafter, the control unit 60 goes back to the step S5 and executes the second rotational torque information acquisition process again.

[0060] When it is determined in the second failure determination process that tension differences of the yarns Y wound onto all godet rollers 20 fall within the second predetermined range (NO in S7), the control unit 60 determines whether the yarn winding apparatus 4 provided below the spun yarn drawing apparatus 3 has completed the winding of the yarns Y (step S12). The control unit 60 of the spun yarn drawing apparatus 3 is connected to the yarn winding apparatus 4.

[0061] When it is determined that the yarn winding apparatus 4 has not completed the winding of the yarns Y (NO in S12), the control unit 60 goes back to the step S5 and executes the second rotational torque information acquisition process again. When it is determined that the yarn winding apparatus 4 has completed the winding of the yarns Y (YES in S12), the spun yarn drawing apparatus 3 finishes the operation.

[0062] In the present embodiment, after in the step S4 the yarns Y spun out from the spinning apparatus 2 are wound onto each of the godet rollers 20a to 20e of the spun yarn drawing apparatus 3, production of the yarns Y by the spun yarn take-up machine 1 is performed, i.e., drawing by the spun yarn drawing apparatus 3 and production of packages P by the yarn winding apparatus 4 are performed. Therefore, in the present embodiment, tension differences of the yarns Y wound onto the godet rollers 20 are always measured and adjusted to suitable values in the process of producing the yarns Y.

(Effects)

[0063] The spun yarn drawing apparatus 3 of the present embodiment includes the godet rollers 20a to 20e each being capable of winding the running yarns Y onto a circumferential surface of the godet roller, the inverter 41 configured to output a current, the motor 30 configured to generate a rotational torque corresponding to the current output from the inverter 41 in the godet rollers 20a to 20e, the rotational angle detection circuit 50 configured to detect the rotational angle of the rotor of the motor 30, and the control unit 60 including the torque current calculation unit which is configured to calculate a current corresponding to the rotational torque based on the rotational angle of the rotor. The control unit 60 then executes: the first rotational torque information acquisition process of acquiring the first current corresponding to the first rotational torque generated in the godet roller 20 when no yarns Y are wound onto the godet roller 20 while the rotation speed of each of the godet rollers 20a to 20e is arranged to be constant at a prede-

termined speed; the second rotational torque information acquisition process of acquiring the second current corresponding to the second rotational torque generated in the godet roller 20 when the yarns Y are wound onto the godet roller 20 while the rotation speed of each of the godet rollers 20a to 20e is arranged to be constant at the predetermined speed; and the yarn tension calculation process of calculating a tension-related value related to the tension of the yarns Y wound onto each of the godet rollers 20a to 20e based on a difference between the first current and the second current.

[0064] According to the present embodiment, the tension-related value of the yarns Y can be calculated based on a difference between the first current and the second current which correspond to the first rotational torque and the second rotational torque, respectively. The first rotational torque is a rotational torque when the yarns Y are wound onto the godet rollers 20, whereas the second rotational torque is a rotational torque when the yarns Y are not wound onto the godet rollers 20. It is therefore unnecessary to provide a tension sensor to detect the tension of the yarns Y. In this way, it is possible in the spun yarn drawing apparatus 3 to always detect the tension of the yarns Y with ease, without deteriorating the quality of the yarns Y. Furthermore, because it is possible to calculate the tension-related value of the yarns Y based on the current flowing in the motor 30 when the rotational torque is generated in each of the godet rollers 20a to 20e, the tension of the yarns Y is easily detected as compared to a case where the tension of the yarns Y is directly detected. Furthermore, because the current corresponding to the rotational torque is acquired based on the rotational angle of the rotor of the motor 30, complicated control is not required and the tension of the yarns Y can be further easily detected.

[0065] In the spun yarn drawing apparatus 3 of the present embodiment, a tension-related value of the yarns Y is a tension difference between the tension of the yarns Y on the upstream of the godet rollers 20a to 20e in the yarn running direction and the tension of the yarns Y on the downstream of the godet rollers 20a to 20e in the yarn running direction. A tension difference between the tension of the yarns Y on the upstream of a godet roller 20 in the yarn running direction and the tension of the yarns Y on the downstream of the godet roller 20 in the yarn running direction is determined in advance based on the characteristics (e.g., the rotation speed and the magnitude of the rotational torque) of the godet roller 20 and the type of the yarns Y to be wound. According to the present embodiment, it is possible to easily determine whether the tension of the yarns Y is appropriate, by comparing a tension difference calculated in the yarn tension calculation process with a tension difference determined in advance.

[0066] In the spun yarn drawing apparatus 3 of the present embodiment, the control unit 60 further executes the first failure determination process of determining whether the first current acquired in the first rotational

torque information acquisition process is out of the first predetermined range and the first notification process of notifying that there is a failure in the spun yarn drawing apparatus 3 when it is determined in the first failure determination process that the first current is out of the first predetermined range. The first current is a current corresponding to the rotational torque of each of the godet rollers 20a to 20e when no yarns Y are wound onto the godet rollers 20. In the present embodiment, it is possible to detect a failure of the spun yarn drawing apparatus 3 based on the first current, before the yarns Y are wound. It is therefore possible to promptly detect a failure of the spun yarn drawing apparatus 3.

[0067] In the spun yarn drawing apparatus 3 of the present embodiment, the control unit 60 further executes: the second failure determination process of determining whether the tension difference (tension-related value) calculated in the yarn tension calculation process is out of the second predetermined range; the second notification process of notifying that there is a failure in the tension of the yarns Y wound on the godet roller 20 when it is determined in the second failure determination process that the tension difference is out of the second predetermined range; and the adjustment process of adjusting the rotational torque generated in the godet roller 20 by the motor 30. According to the present embodiment, the operator is able to reliably know whether the tension of the yarns Y wound on each of the godet rollers 20a to 20e is normal or not. Furthermore, the tension of the yarns Y wound on the godet roller 20 is maintained to be always appropriate, and hence the quality of the yarns Y is maintained to be constant in the spun yarn drawing apparatus 3.

[0068] In the spun yarn drawing apparatus 3 of the present embodiment, the control unit 60 further executes the third failure determination process of determining whether the tension difference (tension-related value) calculated in the yarn tension calculation process is out of the third predetermined range and the third notification process of notifying that the yarns Y are broken when it is determined in the third failure determination process that the tension difference is out of the third predetermined range. According to the present embodiment, the operator is able to reliably and promptly know that the yarns Y are broken.

[0069] In the spun yarn drawing apparatus 3 of the present embodiment, the conversion table is set in advance to convert a difference between the first current and the second current into a tension difference (tension-related value) of the yarns Y, and the control unit 60 calculates a tension difference based on the conversion table in the yarn tension calculation process. According to the present embodiment, because a tension difference is calculated based on the conversion table set in advance, a complicated calculation process is unnecessary, and the tension of yarns can be further easily detected.

[0070] A preferred embodiment of the present inven-

tion has been described. It should be noted that the present invention is not limited to the above-described embodiment, and various changes, substitutions, and alterations can be made herein without departing from the spirit and scope of the invention as defined by the appended claims. The following will describe modifications of the above-described embodiment. The members identical with those in the embodiment above will be denoted by the same reference numerals, and the explanations thereof are not repeated.

(Modifications)

[0071] In the embodiment above, the first predetermined value and the second predetermined value are the first current and the second current output to the motor 30, respectively. Alternatively, the first predetermined value and the second predetermined value may be voltages, rotational torques, or other types of values. In any case, the first predetermined value and the second predetermined value are stored in a memory in the control unit 60.

[0072] In the embodiment above, the rollers are the godet rollers 20a to 20e accommodated in the thermal insulation box 12 of the spun yarn drawing apparatus 3, and each of these godet rollers 20a to 20e has the arrangement of the present invention. Alternatively, only one or some of the godet rollers 20a to 20e may have the arrangement of the present invention. In this case, for the godet roller not having the arrangement of the present invention, the control unit 60 does not execute the processes such as the first rotational torque information acquisition process, the second rotational torque information acquisition process, the yarn tension calculation process, the first to third failure determination processes, the first to third notification processes, and the adjustment process. The number of the godet rollers may not be plural, and may be one. In this case, the one godet roller has the arrangement of the present invention.

[0073] In the embodiment above, the control unit 60 acquires the first current (first predetermined value) and the second current (second predetermined value) for each of the godet rollers 20a to 20e. Alternatively, the control unit 60 may acquire the first current and the second current for only one of the godet rollers 20a to 20e. In this case, the first current and the second current of the other godet rollers are acquired in a relative manner with reference to the first current and the second current of the one godet roller acquired by actual measurement, and these currents are stored in a memory. For example, to begin with, the control unit 60 acquires, for the godet roller 20a, the first current output to the motor 30 in accordance with the first rotational torque, and stores the acquired first current in the memory. Subsequently, the control unit 60 acquires, for each of the other godet rollers 20b to 20e, the first current output to the motor 30 in accordance with the first rotational torque in a relative manner with reference to the first current of the godet

roller 20a stored in the memory, and stores the acquired first currents in the memory. The second current is acquired in a similar manner. It is therefore possible to easily and rapidly execute the first rotational torque information acquisition process and the second rotational torque information acquisition process, as compared to a case where the first predetermined value and the second predetermined value are independently acquired for each of the godet rollers 20a to 20e.

[0074] In the embodiment above, the first predetermined range, the second predetermined range, and the third predetermined range are set for each of the godet rollers 20a to 20e. Alternatively, the first predetermined range, the second predetermined range, and the third predetermined range may be set for only one of the godet rollers 20a to 20e. In this case, the upper limits and the lower limits of the first predetermined range, the second predetermined range, and the third predetermined range of the other godet rollers are set in a relative manner, with reference to the upper limits and the lower limits of the first predetermined range, the second predetermined range, and the third predetermined range of the one godet roller.

[0075] In the embodiment above, the textile machine is the spun yarn drawing apparatus 3. Alternatively, for example, the textile machine may be a draw texturing machine. In such a case, the roller is feed rollers. The feed rollers, for example, include a drive roller and a driven roller. As the drive roller is rotationally driven while yarns are sandwiched between the drive roller and the driven roller, the yarns are fed in the yarn running direction. Therefore, to be more specific, the roller is a drive roller among the feed rollers. The rollers may be godet rollers in the spun yarn take-up machine 1, which are not of the spun yarn drawing apparatus 3.

[0076] In the embodiment above, the motor 30 is a permanent magnet synchronous motor. Alternatively, the motor 30 may be a DC brush motor. In this case, a current supplied to the motor 30 must be a direct current. The inverter 41 is therefore a DC inverter. In this case, both the rotational torque and the rotation speed of the godet roller 20 are determined by the magnitude of the current controlled by the DC inverter 41. Therefore the control unit 60 does not perform the vector control, and controls a current generating a magnetic field at the rotor and a current generating the rotational torque in an integrated manner.

[0077] In the embodiment above, the control unit 60 converts a difference between the first current and the second current into a tension difference of the yarns Y at the godet roller 20, based on the conversion table which is set in advance. Alternatively, a mathematical expression for converting a difference between the first current and the second current into a tension difference of the yarns Y may be set in advance. In this case, the tension difference of the yarns Y is calculated by inputting the difference between the first current and the second current into the mathematical expression.

[0078] In the embodiment above, a tension-related value related to the tension of yarns wound onto a roller is a tension difference between the tension of the yarns Y on the upstream of the godet roller 20 in the yarn running direction and the tension of the yarns Y on the downstream of the godet roller 20 in the yarn running direction. Alternatively, for example, the tension-related value may directly indicate the tension of the yarns Y wound onto the godet roller 20, or may indicate the ratio of the tension of the yarns Y on the upstream of the godet roller 20 in the yarn running direction to the tension of the yarns Y on the downstream of the godet roller 20 in the yarn running direction. The user is allowed to suitably select one of these types of tension-related values.

[0079] In the embodiment above, in the yarn tension calculation process, the control unit 60 calculates a tension-related value of the yarns Y based on a difference between the first current and the second current. Alternatively, the control unit 60 may calculate a tension-related value of the yarns Y based on the ratio of the first current to the second current. Alternatively, the control unit 60 may calculate a tension-related value of the yarns Y by performing a predetermined calculation process for the first current and the second current.

[0080] The rotational angle detection circuit 50 is provided in the embodiment above. Alternatively, in place of the rotational angle detection circuit, a position sensor such as an optical encoder or a resolver for detecting the position of the rotor of the motor 30 or a sensor configured to detect the positions of magnetic poles of the rotor of the motor 30 may be provided. In this case, the sensor is connected to the motor 30 and the motor controller 40 and the location information of the rotor of the motor 30 detected by the sensor is sent to the control unit 60.

[0081] In the embodiment above, the control unit 60 stops the spun yarn drawing apparatus 3 after executing the first notification process and the third notification process. Alternatively, the control unit 60 may stop the spun yarn drawing apparatus 3 while the first notification process and the third notification process are being executed, or may stop the spun yarn drawing apparatus 3 at the same time as the execution of the first notification process and the third notification process.

[0082] In the embodiment above, the third failure determination process is executed after the second notification process. Alternatively, the third failure determination process may be executed prior to the second failure determination process. In this case, the control unit 60 executes the third failure determination process after the yarn tension calculation process. When it is determined in the third failure determination process that the tension differences of the yarns Y wound onto all godet rollers 20 fall within the third predetermined range, the control unit 60 further executes the second failure determination process. Also in this case, the third predetermined range is wider than the second predetermined range in the second failure determination process.

[0083] The third failure determination process may not

be executed. In this case, when it is determined in the second failure determination process that the tension difference of the yarns Y wound onto any of the godet rollers 20 is out of the second predetermined range, the control unit 60 executes the second notification process and the adjustment process. The control unit 60 may execute only one of the second notification process and the adjustment process. For example, when the adjustment process is not executed, the control unit 60 stops the spun yarn drawing apparatus 3 after executing the second notification process.

[0084] Alternatively, only the third failure determination process may be executed. In this case, when it is determined in the third failure determination process that tension differences of the yarns Y wound onto all godet rollers 20 fall within the third predetermined range, the control unit 60 determines whether the yarn winding apparatus 4 provided below the spun yarn drawing apparatus 3 has completed the winding of the yarns Y. In the case, above, furthermore, the tension difference of the yarns Y calculated in the yarn tension calculation process is, for example, checked by the operator. When the tension difference of the yarns Y falls within the third predetermined range but is not an appropriate value, the control unit 60 stops the spun yarn drawing apparatus 3 based on a signal input by the operator.

Claims

1. A textile machine (3) comprising:

a roller (20) which is capable of winding a running yarn (Y) onto a circumferential surface of the roller (20) ;
a rotational driving unit which is configured to generate a rotational torque in the roller (20);
a torque information acquisition unit which is configured to acquire a value corresponding to the rotational torque; and
a control unit (60),
the control unit (60) executing:

a first rotational torque information acquisition process of arranging rotation speed of the roller (20) to be constant at a predetermined speed, and acquiring, by the torque information acquisition unit, a first predetermined value corresponding to a first rotational torque generated in the roller (20) when no yarn (Y) is wound on the roller (20);
a second rotational torque information acquisition process of arranging the rotation speed of the roller (20) to be constant at the predetermined speed, and acquiring, by the torque information acquisition unit, a second predetermined value corresponding to a second rotational torque generated in the

roller (20) when the yarn (Y) is wound on the roller (20); and
a yarn tension calculation process of calculating a tension-related value related to the tension of the yarn (Y) wound onto the roller (20), based on the first predetermined value and the second predetermined value.

2. The textile machine (3) according to claim 1, wherein, the tension-related value is a tension difference between the tension (T1) of the yarn (Y) on the upstream of the roller (20) in a yarn running direction in which the yarn (Y) runs and the tension (T2) of the yarn (Y) on the downstream of the roller (20) in the yarn running direction.

3. The textile machine (3) according to claim 1 or 2, wherein,
the rotational driving unit includes an output unit (40) configured to output a current and a motor (30) configured to generate a rotational torque corresponding to the current output from the output unit (40), and the control unit (60)
acquires a first current as the first predetermined value in the first rotational torque information acquisition process,
acquires a second current as the second predetermined value in the second rotational torque information acquisition process, and
calculates the tension-related value based on the first current and the second current in the yarn tension calculation process.

4. The textile machine (3) according to claim 3, wherein, the torque information acquisition unit includes a rotational angle detection unit (50) configured to detect a rotational angle of a rotor of the motor (30) and a torque current calculation unit configured to calculate a current corresponding to the rotational torque based on the rotational angle.

5. The textile machine (3) according to any one of claims 1 to 4, wherein,
the control unit (60) further executes:

a first failure determination process of determining whether the first predetermined value acquired in the first rotational torque information acquisition process is out of a first predetermined range; and
a first notification process of notifying that there is a failure in the textile machine (3), when it is determined in the first failure determination process that the first predetermined value is out of the predetermined range.

6. The textile machine (3) according to any one of claims 1 to 5, wherein,

the control unit (60) further executes:

a second failure determination process of determining whether the tension-related value calculated in the yarn tension calculation process is out of a second predetermined range; and
a second notification process of notifying that there is a failure in the tension of the yarn (Y) wound onto the roller (20), when it is determined in the second failure determination process that the tension-related value is out of the second predetermined range.

7. The textile machine (3) according to any one of claims 1 to 6, wherein,
the control unit (60) further executes:

a second failure determination process of determining whether the tension-related value calculated in the yarn tension calculation process is out of a second predetermined range; and
an adjustment process of adjusting the rotational torque generated in the roller (20) by the rotational driving unit, when it is determined in the second failure determination process that the tension-related value is out of the second predetermined range.

8. The textile machine (3) according to any one of claims 1 to 7, wherein,
the control unit (60) further executes:

a third failure determination process of determining whether the tension-related value calculated in the yarn tension calculation process is out of a third predetermined range; and
a third notification process of notifying that the yarn (Y) is broken, when it is determined in the third failure determination process that the tension-related value is out of the third predetermined range.

9. The textile machine (3) according to any one of claims 1 to 8, wherein,
conversion information is set in advance to convert the first predetermined value and the second predetermined value into the tension-related value, and the control unit (60) calculates the tension-related value based on the conversion information in the yarn tension calculation process.

10. A yarn tension detection method for detecting the tension of a running yarn (Y) which runs in a textile machine (3) and is wound onto a roller (20) capable of winding the yarn (Y) onto a circumferential surface of the roller (20), the textile machine (3) comprising:

a rotational driving unit generating a rotational

torque in the roller (20); and

a torque information acquisition unit acquiring a value corresponding to the rotational torque, the method comprising:

a first rotational torque information acquisition step of arranging rotation speed of the roller (20) to be constant at a predetermined speed, and acquiring, by the torque information acquisition unit, a first predetermined value corresponding to a first rotational torque generated in the roller (20) when no yarn (Y) is wound on the roller (20);
a second rotational torque information acquisition step of arranging the rotation speed of the roller (20) to be constant at the predetermined speed, and acquiring, by the torque information acquisition unit, a second predetermined value corresponding to a second rotational torque generated in the roller (20) when the yarn (Y) is wound on the roller (20); and
a yarn tension calculation step of calculating a tension-related value related to the tension of the yarn (Y) wound onto the roller (20), based on the first predetermined value and the second predetermined value.

FIG.1

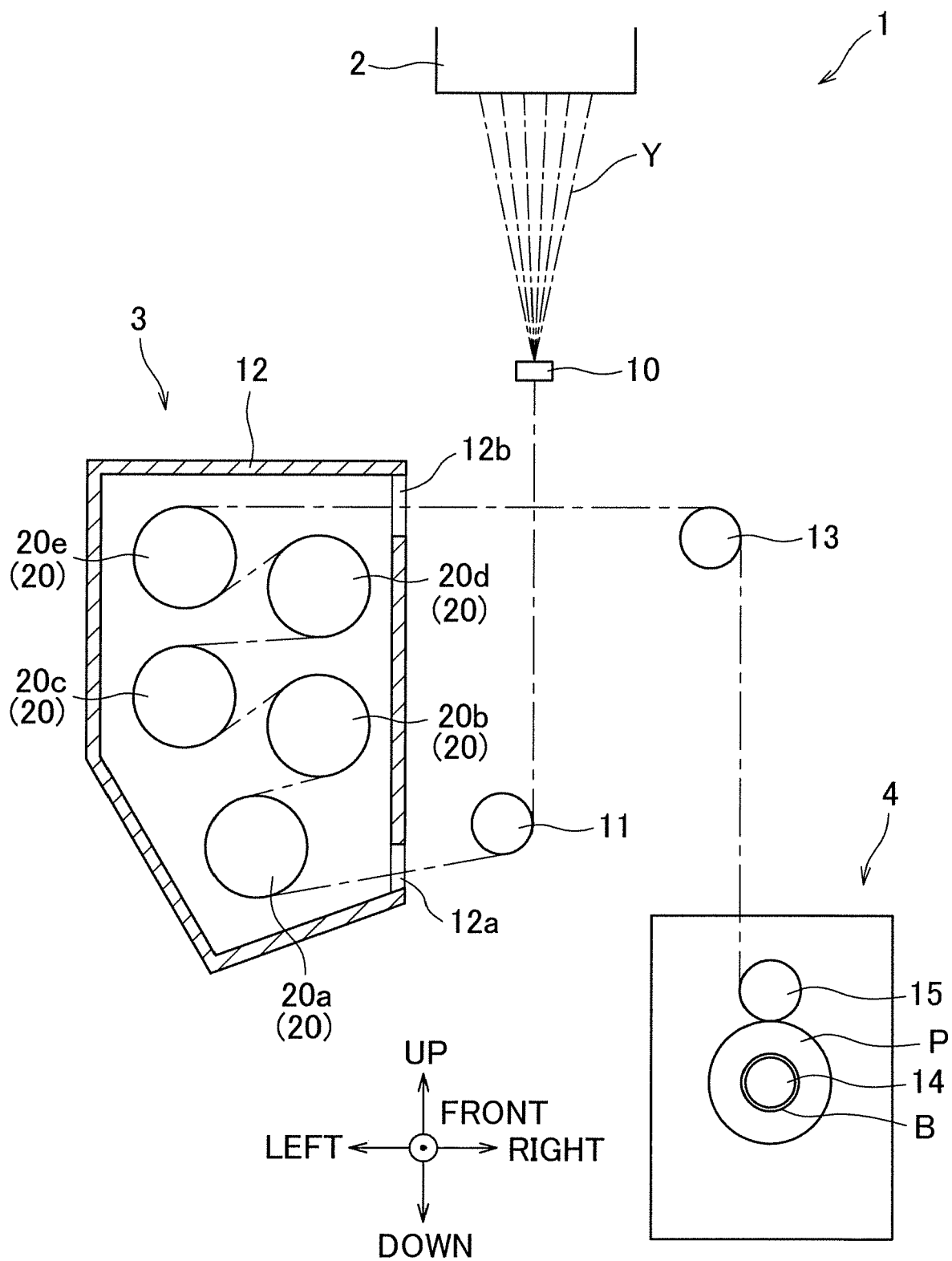


FIG.2

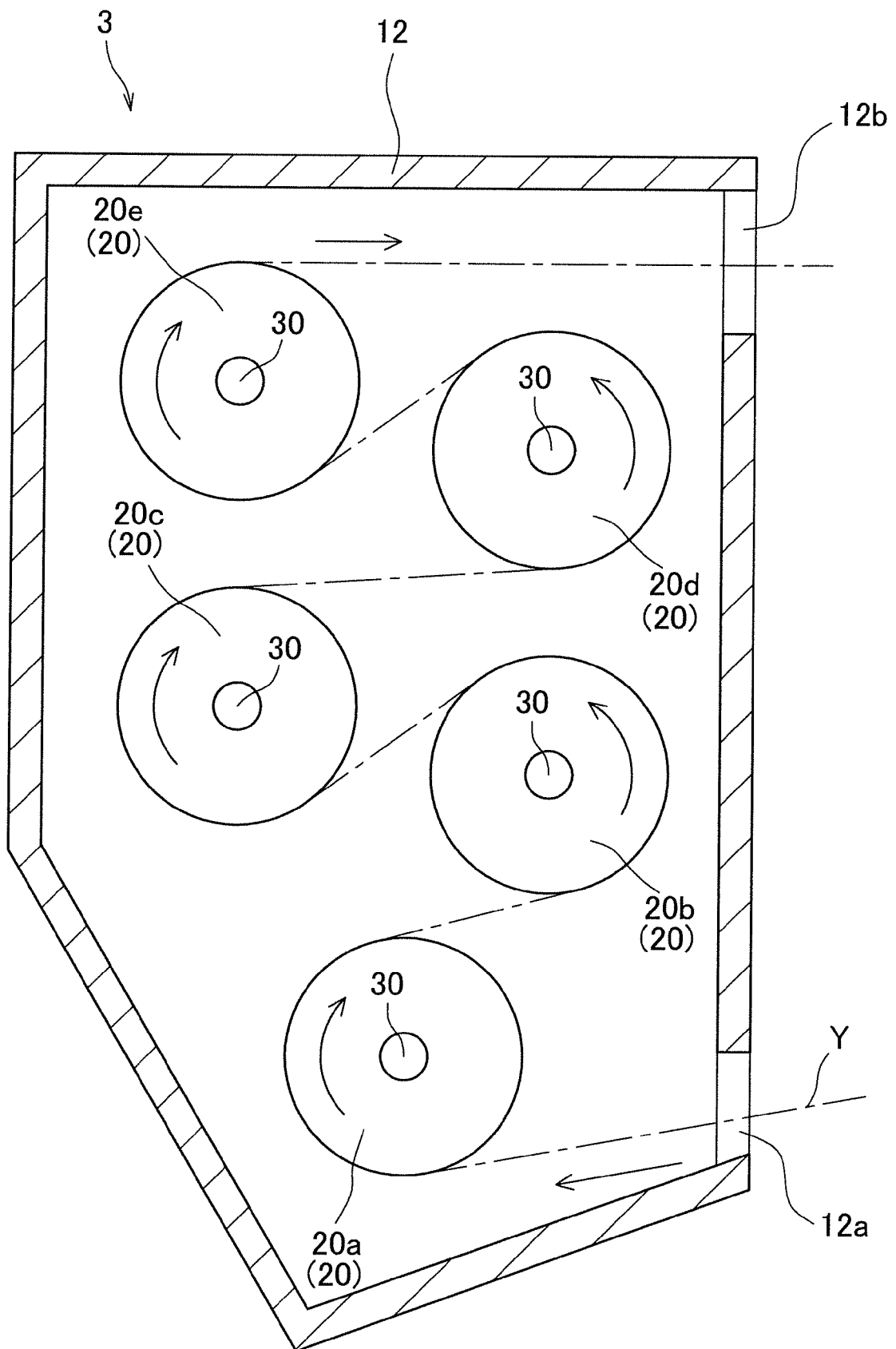


FIG.3

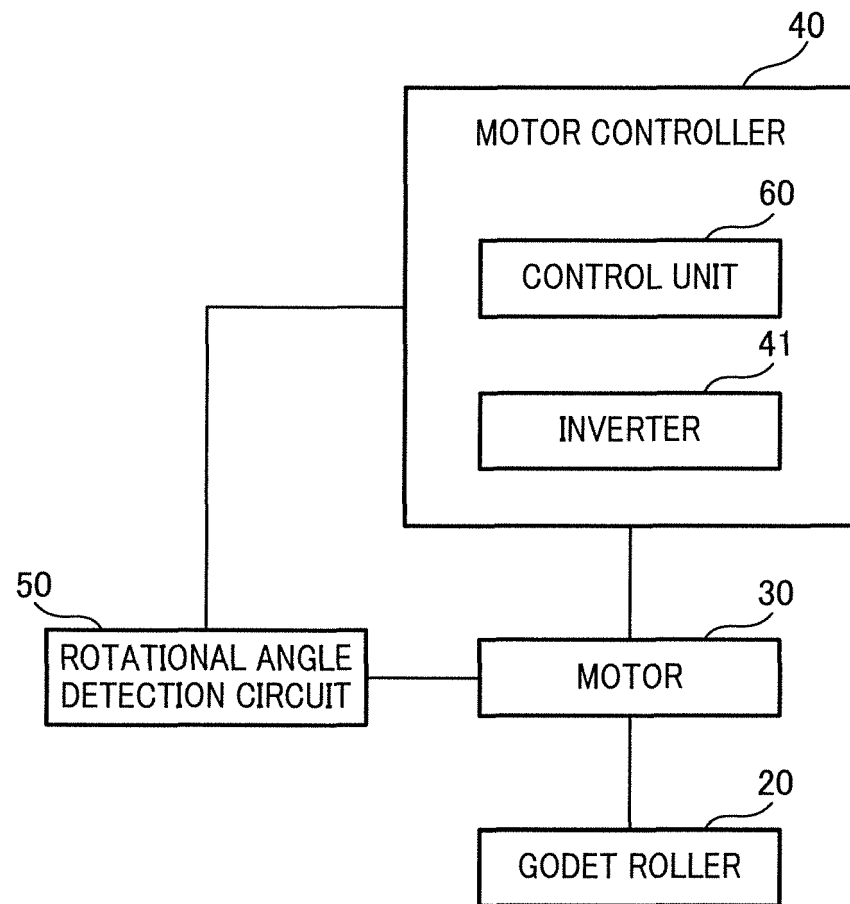


FIG.4

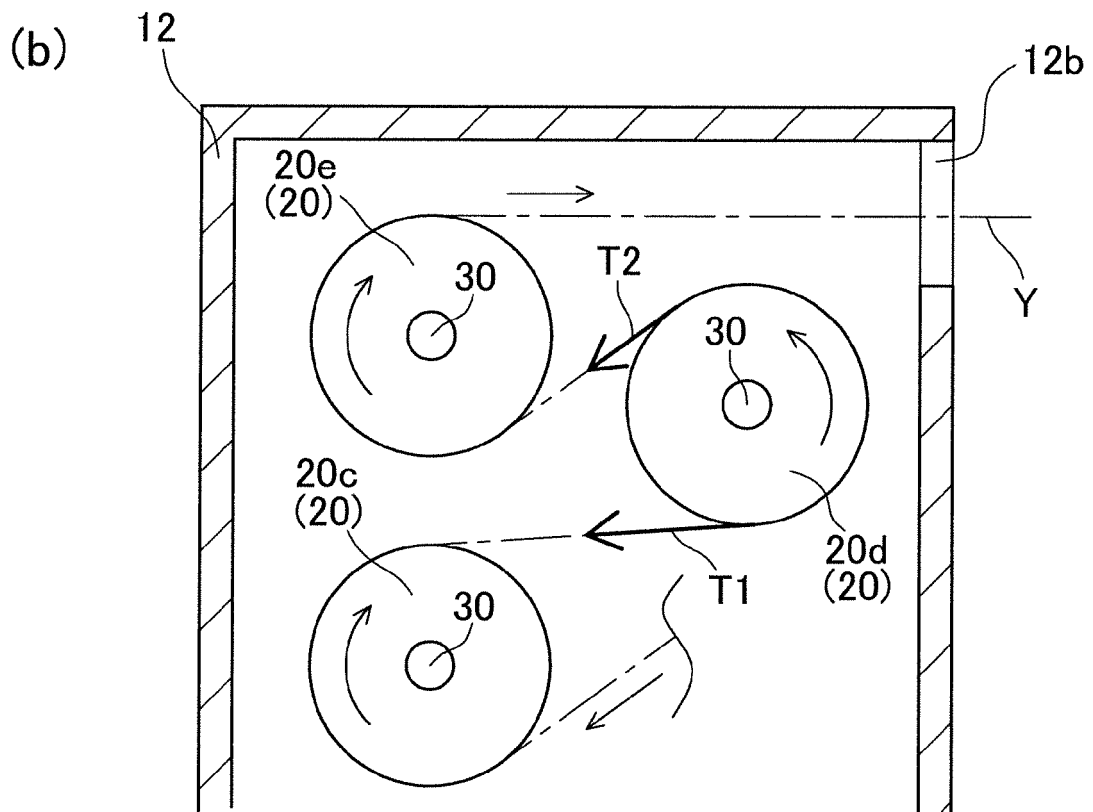
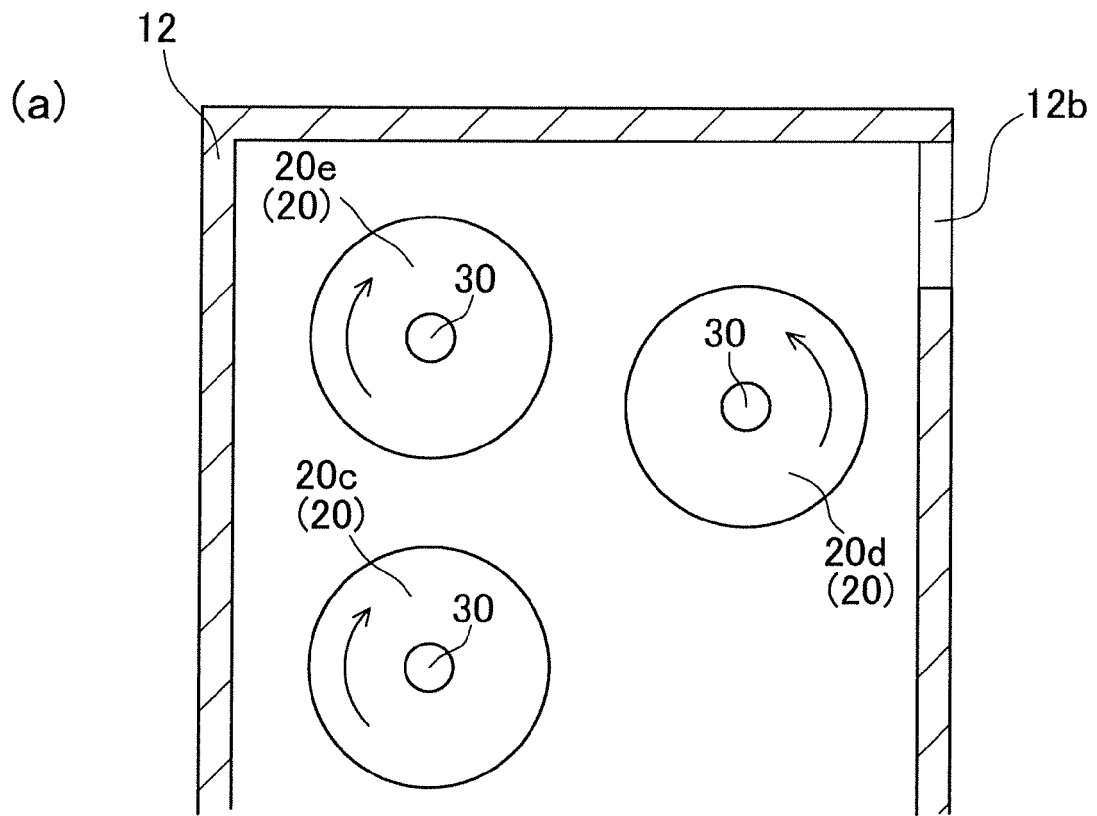
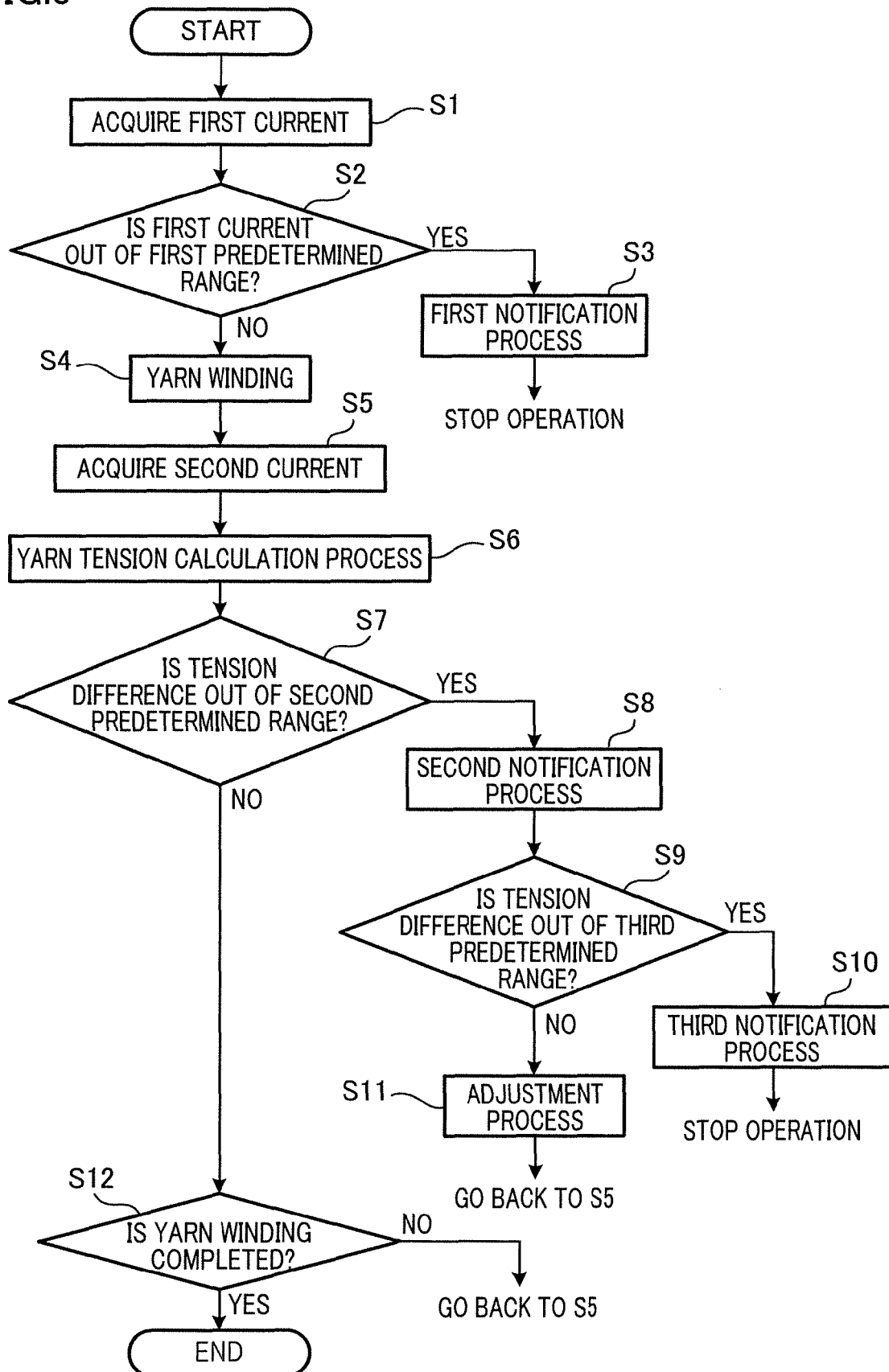


FIG.5





EUROPEAN SEARCH REPORT

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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 29 June 2021	Examiner Lemmen, René
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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