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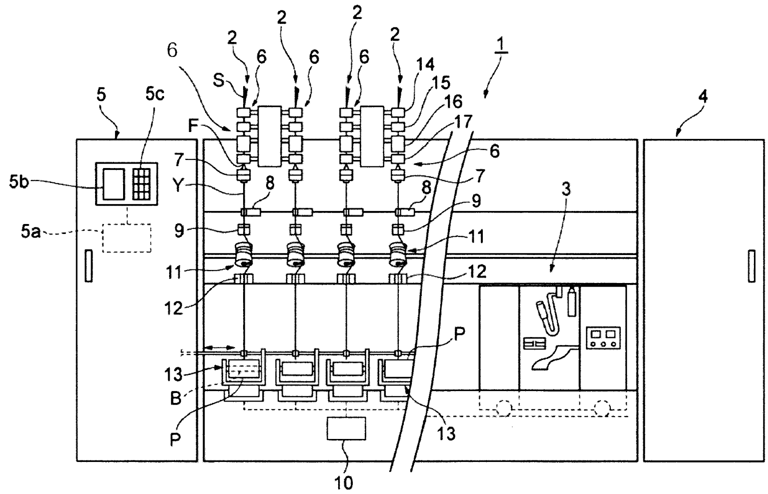
(54) **DRAFTING DEVICE AND SPINNING UNIT**

(57) A drafting device (6) includes a back roller pair (14), a third roller pair (15), a middle roller pair (16), and a front roller pair (17) that draft a fiber bundle (F). The drafting device (6) also includes a stepping motor that rotationally drives a back bottom roller (14a) of the back roller pair (14), a main control device (5a) that receives setting of a drafting condition about the fiber bundle (F), and a unit control device (10) that controls an operation of the stepping motor. The unit control device (10) adjusts the operation of the stepping motor such that the drafting performed by the roller pairs (14, 15, 16, 17) is within a range that satisfies the drafting condition received by the main control device (5a).

FIG.1



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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a drafting device and a spinning unit.

2. Description of the Related Art

[0002] A drafting device including a plurality of roller pairs that drafts a fiber bundle, a plurality of stepping motors that drives a driver roller of the roller pairs, and a control section that controls an operation of the stepping motors is known in the art (e.g., see Japanese Patent Application Laid-Open NO. 2016-94682).

SUMMARY OF THE INVENTION

[0003] In the above drafting device, when a drafting condition is set, it is demanded that a fiber bundle is drafted while satisfying the drafting condition. In addition, it is demanded that the drafting of the fiber bundle is performed stably.

[0004] One object of the present invention is to provide a drafting device that can stably draft a fiber bundle while satisfying a drafting condition and to provide a spinning unit that can improve yarn quality of a yarn wound into a package.

[0005] A drafting device according to one aspect of the present invention includes a plurality of roller pairs that draft a fiber bundle, each roller pair including a driver roller and a driven roller that rotates following the rotation of the driver roller; a stepping motor that rotationally drives the driver roller of at least one roller pair among the roller pairs; a receiving section that receives setting of a drafting condition relating to the fiber bundle to be drafted by the roller pairs; and a control section that controls an operation of the stepping motor. The control section adjusts the operation of the stepping motor such that the drafting performed by the roller pairs is within a range that satisfies the drafting condition received by the receiving section.

[0006] A spinning unit according to another aspect of the present invention includes the above drafting device; a spinning device that applies a twist to the fiber bundle to form a yarn; a winding device that winds the yarn to form a package; and a yarn monitoring device that monitors the yarn. According to the spinning unit, for the reasons explained above, the fiber bundle can be drafted stably while satisfying the drafting condition. As a result, a yarn quality of the yarn wound into the package can be improved.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007]

FIG. 1 is a front view of a spinning machine according to one embodiment.
FIG. 2 is a side view of a drafting device shown in FIG. 1.
FIG. 3 is a flowchart of a process procedure for adjusting an operation of a stepping motor.
FIG. 4A is a graph exemplifying quantity of unevenness of a thickness of a yarn detected in a spinning machine according to a comparative example.
FIG. 4B is a graph exemplifying quantity of unevenness of a thickness of a yarn detected in the spinning machine according to the present embodiment.
FIG. 5 is a flowchart of another process procedure for adjusting an operation of the stepping motor.
FIG. 6 is a flowchart of an electric current change determination process shown in FIG. 5.

DETAILED DESCRIPTION

[0008] Exemplary embodiments of the present invention are explained below in detail with reference to the accompanying drawings. Identical elements or corresponding elements are indicated by the same reference symbols in the drawings, and redundant explanation thereof is omitted in the following explanation.

[0009] As shown in FIG. 1, a spinning machine 1 includes a plurality of spinning units 2, a yarn joining cart 3, a not-shown doffing cart, a first-end frame 4, a second-end frame 5, and a plurality of unit control devices 10. The spinning units 2 are arranged side-by-side. Each of the spinning units 2 forms a yarn Y and winds the yarn Y into a package P. The yarn joining cart 3 performs a yarn joining operation in a certain spinning unit 2 in which the yarn Y is cut or becomes discontinuous for some reason. When the package P becomes fully wound in a certain spinning unit 2, the doffing cart doffs the fully wound package P and supplies a new empty bobbin B to that spinning unit 2.

[0010] Devices such as a collecting device for collecting fiber waste, yarn waste, and the like generated in the spinning units 2 are accommodated in the first-end frame 4. An air supplying section that supplies air to various elements of the spinning machine 1 after appropriately adjusting an air pressure of compressed air (air) supplied to the spinning machine 1, and a driving motor and the like that supplies driving power to various elements of the spinning units 2 are arranged in the second-end frame 5.

[0011] The second-end frame 5 is provided with a main control device 5a, a display screen 5b, and one or more input keys 5c. The main control device 5a centrally manages and controls various elements of the spinning machine 1. The display screen 5b displays information and the like about setting contents and / or a state of the spinning units 2. The operator can perform setting work of the spinning units 2 by performing an appropriate operation by using the input keys 5c.

[0012] One unit control device 10 is arranged for a predetermined number of the spinning units 2, and the unit control device 10 controls operations of those spinning units 2. For example, the unit control device 10 is constituted by a computer that includes CPU (Central Processing Unit), ROM (Read Only Memory), and the like. A computer program for controlling the spinning units 2 is stored in the ROM. The CPU executes the computer program stored in the ROM. The unit control device 10 is communicably connected to the main control device 5a. The operations of the various elements of the spinning units 2 are controlled based on an operating condition input into the main control device 5a.

[0013] Each of the spinning units 2 includes, sequentially from an upstream side in a traveling direction of the yarn Y, a drafting device 6, an air spinning device 7, a yarn monitoring device 8, a tension sensor 9, a yarn accumulating device 11, a waxing device 12, and a winding device 13.

[0014] The drafting device 6 drafts a sliver (fiber bundle) S. The drafting device 6 includes, sequentially from an upstream side in a traveling direction of the sliver S, a back roller pair (first roller pair) 14, a third roller pair (back roller pair or second roller pair) 15, a middle roller pair 16, and a front roller pair 17. The drafting device 6 will be explained in detail later. In the present embodiment, the roller pair indicated by the reference numeral 14 is referred to as the back roller pair, however, each of the roller pair 14 and the roller pair 15 may be referred to as the back roller pair. In this case, the back roller pair may be explained as including the first roller pair 14 and the second roller pair 15 sequentially from the upstream side.

[0015] The air spinning device 7 forms the yarn Y by applying twists by using a swirling air current to a fiber bundle F drafted by the drafting device 6. The yarn accumulating device 11 removes a slack of the yarn Y at a location between the air spinning device 7 and the winding device 13. The waxing device 12 applies wax to the yarn Y at a location between the yarn accumulating device 11 and the winding device 13. The winding device 13 winds the yarn Y around the bobbin B thereby forming the package P.

[0016] The yarn monitoring device 8 monitors (detects) a state of a traveling yarn Y at a location between the air spinning device 7 and the yarn accumulating device 11. The yarn monitoring device 8 acquires information about a yarn defect in the yarn Y and unevenness and the like in a thickness of the yarn Y. The yarn monitoring device 8 detects, as the yarn defect (abnormality) of the yarn Y, for example, an abnormality of the thickness (and / or amount of fiber) of the yarn Y and / or a foreign substance contained in the yarn Y. Also, the yarn monitoring device 8 detects a yarn breakage, namely, presence / absence of the yarn Y in a yarn path of the yarn Y. The yarn monitoring device 8 can monitor a state of the yarn Y by using an electrostatic capacitance sensor. When doing so, the yarn monitoring device 8 detects an amount of the fiber of the yarn Y. The yarn monitoring device 8 transmits a signal representing the detection result to the unit control device 10.

[0017] The tension sensor 9 measures, at a location between the air spinning device 7 and the yarn accumulating device 11, a tension of the traveling yarn Y, and transmits a tension measurement signal representing the measured tension to the unit control device 10. When the unit control device 10 determines, based on the detection result obtained in the yarn monitoring device 8 and / or the tension sensor 9, that an abnormality is present in the yarn Y, the operation of the spinning unit 2 is stopped. More particularly, when the unit control device 10 determines that there is abnormality, the formation of the yarn Y by the air spinning device 7 is suspended thereby cutting the yarn Y, and the winding of the yarn Y performed by the winding device 13 is suspended. Alternatively, the spinning unit 2 can include a cutter, and the yarn Y can be cut by this cutter. Also, the winding of the yarn Y performed by the winding device 13 is suspended in the event that the yarn Y is naturally cut due to an excessive tension, when the package P is fully wound, when the type (lot) of the yarn Y to be wound into the package P is changed, when the power of the spinning machine 1 is turned on, and the like.

[0018] The drafting device 6 is explained in detail below. As shown in FIG. 2, the back roller pair 14 includes a back bottom roller 14a and a back top roller 14b that oppose each other across a traveling path R on which the sliver S travels. The third roller pair 15 includes a third bottom roller 15a and a third top roller 15b that oppose each other across the traveling path R. The middle roller pair 16 includes a middle bottom roller 16a and a middle top roller 16b that oppose each other across the traveling path R. An apron belt 18a is stretched over the middle bottom roller 16a. An apron belt 18b is stretched over the middle top roller 16b. The front roller pair 17 includes a front bottom roller 17a and a front top roller 17b that oppose each other across the traveling path R. The roller pairs 14, 15, 16, and 17 while drafting the sliver S, which is supplied from a not-shown can and guided thereto by a fiber bundle guide 77, send the sliver S from the upstream to the downstream.

[0019] The back bottom roller 14a is rotatably supported by a back roller housing 66. The third bottom roller 15a is rotatably supported by a third roller housing 67. The middle bottom roller 16a is rotatably supported by a middle roller housing 68. The front bottom roller 17a is rotatably supported by a front roller housing 69. The configuration for supporting the bottom rollers 14a, 15a, 16a, and 17a is not limited to this. For example, the middle bottom roller 16a and the front bottom roller 17a can be rotatably supported by one housing.

[0020] The drafting device 6 further includes a stepping motor (first stepping motor) M14 and a stepping motor (second stepping motor) M15. The stepping motor M14 rotationally drives the back bottom roller 14a. A belt B14 is stretched over a rotating shaft of the stepping motor M14 and a rotating shaft of the back bottom roller 14a. More specifically, a pulley P14b is attached to the rotating shaft of the stepping motor M14, and the belt B14 connects the pulley P14b and a pulley P14a attached to the rotating shaft of the back bottom roller 14a. A torque of the stepping motor M14 is transmitted to the back bottom roller 14a by the belt B14. The stepping motor M15 rotationally drives the third bottom roller 15a. A belt B15 is stretched over a rotating shaft of the stepping motor M15 and a rotating shaft of the third bottom roller 15a. More specifically, a pulley P15b is attached to the rotating shaft of the stepping motor M15, and the belt B15 connects the pulley P15b and a pulley P15a attached to the rotating shaft of the third bottom roller 15a. A torque of the stepping motor M15 is transmitted to the third bottom roller 15a by the belt B15.

[0021] The operation of the stepping motors M14 and M15 is controlled by the unit control device 10. That is, in the present embodiment, the unit control device 10 functions as a control section that controls the operation of the stepping motors M14 and M15. The stepping motors M14 and M15 are connected to the unit control device 10 via a respective not-shown driver. When a pulse signal is input into the driver from the unit control device 10, an electric current matching with the pulse signal is applied by the driver to the stepping motors M14 and M15. Each of the stepping motors M14 and M15 operate based on the applied electric current. In the present embodiment, the value of the electric current to be applied to each of the stepping motors M14 and M15 can be changed (adjusted) as desired.

[0022] The middle bottom roller 16a and the front bottom roller 17a rotate based on the driving power supplied from the second-end frame 5. The back bottom roller 14a is a driver roller that rotates based on the driving power of the stepping motor M14. The third bottom roller 15a is a driver roller that rotates based on the driving power of the stepping motor M15. The middle bottom roller 16a is a driver roller that rotates based on the driving power of a driving motor arranged in the second-end frame 5. The front bottom roller 17a is a driver roller that rotates based on the driving power of a different driving motor arranged in the second-end frame 5. The bottom rollers 14a, 15a, 16a, and 17a rotate at different rotational speeds such that more the roller is located downstream, faster the rotational speed thereof is.

[0023] Each of the back top roller 14b, the third top roller 15b, the middle top roller 16b, and the front top roller 17b are rotatably supported by a draft cradle 71. Each of the top rollers 14b, 15b, 16b, and 17b are driven rollers that are in contact with the respective bottom rollers 14a, 15a, 16a, and 17a, and thereby rotate following the rotation of the bottom rollers 14a, 15a, 16a, and 17a.

[0024] The draft cradle 71 is pivotable around a support shaft 72 between a position at which the top rollers 14b, 15b, 16b, and 17b contact the respective bottom rollers 14a, 15a, 16a, and 17a at a predetermined pressure and a position at which the top rollers 14b, 15b, 16b, and 17b are separated from the respective bottom rollers 14a, 15a, 16a, and 17a.

[0025] The pivoting of the draft cradle 71 is performed by operating a not-shown handle attached to the draft cradle 71. The draft cradle 71 rotatably supports the top rollers 14b, 15b, 16b, and 17b of the drafting devices 6 of each pair of adjacent spinning units 2. That is, one draft cradle 71 is shared by the drafting devices 6 of the pair of the adjacent spinning units 2.

[0026] Next, while referring to a flowchart shown in FIG. 3, among various control performed by the unit control device 10 on various elements of the spinning unit 2, a control for adjusting an operation of the stepping motor M14 is explained below. A control performed on one of the spinning units 2 will be explained below and the other spinning units 2 are controlled in a similar manner. At the time of start of the processing shown in FIG. 3, the operation of the spinning unit 2 is stopped.

[0027] First of all, the main control device 5a receives setting of a drafting condition relating to the fiber bundle F from the input keys 5c (Step S1). In the present embodiment, the main control device 5a (input keys 5c) functions as a receiving section that receives the setting of the drafting condition. In the present embodiment, the drafting device 6 also includes the main control device 5a that functions as the receiving section and the unit control device 10 that functions as the control section.

[0028] Upon receiving the setting of the drafting condition, the main control device 5a instructs each of the unit control devices 10 to draft the fiber bundle F according to the drafting condition. The drafting condition includes, for example, a spinning speed and a total draft ratio. The spinning speed is a speed at which the air spinning device 7 forms the yarn Y. The total draft ratio is a ratio of fiber amount or number of fibers of the fiber bundle F that has been processed by the front roller pair 17 to fiber amount or number of fibers of the sliver S before being guided to the back roller pair 14. The spinning machine 1 may be operated at different spinning speeds and draft ratio depending on a lot, and the stepping motor M14 may also be driven at different rotational speeds depending on the lot. That is, the stepping motor M14 may be driven at a frequency that is not expected.

[0029] Then, the unit control device 10 calculates, based on the drafting condition input into the main control device 5a, a frequency of the pulse signal to be input into the stepping motor M14 (Step S2). More particularly, the unit control device 10 calculates the rotational speed of the back bottom roller 14a based on the spinning speed and the total draft ratio included in the drafting condition. The unit control device 10 calculates a frequency of the pulse signal to be input into the stepping motor M14 based on the calculated rotational speed of the back bottom roller 14a.

[0030] Then, the unit control device 10 determines whether the frequency of the pulse signal calculated at Step S2 is within a predetermined range that contains a resonance frequency of the stepping motor M14 (Step S3). The predetermined range is a range of the frequency of the pulse signal in which the stepping motor M14 resonates when a pulse signal that falls within this range is input into the stepping motor M14. The resonance frequency of the stepping motor M14 depends on the specifications, the fixed state, and the like of the stepping motor M14. The resonance frequency of the stepping motor M14 is calculated, for example, by experiments or simulations.

[0031] When the unit control device 10 determines at Step S3 that the frequency of the pulse signal is within the predetermined range (Step S3: YES), the processing advances to Step S4. When the unit control device 10 determines at Step S3 that the frequency of the pulse signal is not within the predetermined range (Step S3: NO), the processing advances to Step S5.

[0032] At Step S4, the unit control device 10 sets an electric current value (magnitude of the electric current) to be applied to the stepping motor M14 to a first electric current value. At Step S5, the unit control device 10 sets the electric current value to be applied to the stepping motor M14 to a second electric current value. After executing Step S4 or S5, the unit control device 10 finishes the processing shown in FIG. 3. After completion of the processing shown in FIG. 3, the unit control device 10 applies an electric current of the set electric current value to the stepping motor M14 whereby the spinning unit 2 starts its operation.

[0033] The second electric current value is a value set at a normal time, that is, when the frequency of the pulse signal calculated at Step S2 is not within the predetermined range. The first electric current value is a value set at an adjustment time, that is, when the frequency of the pulse signal calculated at Step S2 is within the predetermined range. The first electric current value is higher than the second electric current value.

[0034] Both the first electric current value and the second electric current value are set equal to or higher than a lower limit value corresponding to the necessary torque required for the stepping motor M14. This lower limit value is, for example, equal to the minimum value of an electric current required for generating a necessary torque in the stepping motor M14, or equal to a value that is higher than the minimum value by a predetermined amount. In other words, the unit control device 10 changes the value of the electric current to be applied to the stepping motor M14 within a range that is equal to or higher than the lower limit value corresponding to the necessary torque required for the stepping motor M14. Thereby, the torque of the stepping motor M14 can be secured regardless of the electric current value that is to be set.

[0035] When the electric current value applied to the stepping motor M14 is set to any of the first electric current value and the second electric current value, the fiber bundle F drafted by the roller pairs 14, 15, 16, and 17 satisfies the drafting condition received by the main control device 5a. This is because the rotational speed of the stepping motor M14 does not depend on the value of the electric current applied to the stepping motor M14, but it is decided by the frequency of the pulse signal input into the stepping motor M14. In other words, the unit control device 10 changes the value of the electric current to be applied to the stepping motor M14 such that the drafting performed by the roller pairs 14, 15, 16, and 17 is within a range that satisfies the drafting condition received by the main control device 5a (i.e. a range defined by the drafting condition received by the main control device 5a).

[0036] In this manner, in the present embodiment, the unit control device 10 adjusts the operation of the stepping motor M14 such that the drafting performed by the roller pairs 14, 15, 16, and 17 is within a range that satisfies the drafting condition received by the main control device 5a. The term "within the range that satisfies the drafting condition" means that the yarn Y wound into the package P does not change before and after the adjustment of the operation of the stepping motor M14. More particularly, while the unit control device 10 sets an electric current value applied to the stepping motor M14 to the second electric current value at the normal time, that is, when the frequency of the pulse signal calculated at Step S2 is not within the predetermined range, the unit control device 10 sets the electric current value applied to the stepping motor M14 to the first electric current value at the adjustment time, that is, when the frequency of the pulse signal calculated at Step S2 is within the predetermined range, where the first electric current value is higher than the second electric current value. That is, the unit control device 10 adjusts the operation of the stepping motor M14 by increasing the electric current applied to the stepping motor M14.

[0037] The advantageous effect of the spinning machine 1 according to the above embodiment is explained below. FIG. 4A is a graph exemplifying quantity of unevenness of a thickness of the yarn Y detected in a spinning machine according to a comparative example. FIG. 4B is a graph exemplifying quantity of unevenness of a thickness of the yarn Y detected in the spinning machine 1 according to the embodiment. The spinning machine according to the comparative example differs from the spinning machine 1 according to the embodiment only in that no control for adjusting the operation of the stepping motor M14 is performed. That is, in the spinning machine according to the comparative example, the electric current value applied to the stepping motor M14 is set to the second electric current value in either case of determining at Step S3 that the frequency of the pulse signal is within the predetermined range or that the frequency of the pulse signal is not within the predetermined range.

[0038] As shown in FIG. 4A, during the operation of the spinning machine according to the comparative example, the quantity of the unevenness of the thickness of the yarn Y detected by the yarn monitoring device 8 has become equal to or greater than a reference value A in some of the spinning units 2. In contrast, as shown in FIG. 4B, during the operation of the spinning machine 1 according to the embodiment, the quantity of the unevenness of the thickness of the yarn Y detected by the yarn monitoring device 8 is lower than the reference value A in all spinning units 2. From this fact, it is apparent that an increase of the quantity of the unevenness of the thickness of the yarn Y can be reduced by adjusting the operation of the stepping motor M14 like in the spinning machine 1 according to the embodiment. Note that, in the spinning machine 1 according to the embodiment, it is sufficient that the increase of the quantity of the unevenness of the thickness of the yarn Y is reduced, and it is not necessary that the quantity of the unevenness of the thickness of the yarn Y detected by the yarn monitoring device 8 is lower than the reference value A in all the spinning units 2.

[0039] Furthermore, during the operation of the spinning machine according to the comparative example, a periodic unevenness, that has a frequency corresponding to the resonance frequency of the stepping motor M14 (for example, a frequency that is approximately the same as the resonance frequency) was detected by the yarn monitoring device 8 in some of the spinning units 2. In contrast, during the operation of the spinning machine 1 according to the embodiment, such periodic unevenness was not detected by the yarn monitoring device 8. From this fact, it is apparent that the occurrence of such periodic unevenness can be reduced by adjusting the operation of the stepping motor M14 like in the spinning machine 1 according to the embodiment. In other words, the unit control device 10 adjusts the operation of the stepping motor M14 such that periodic unevenness having the frequency corresponding to the resonance frequency of the stepping motor M14 is not detected by the yarn monitoring device 8. Note that, in the present embodiment, it is sufficient that the occurrence of the periodic unevenness is reduced, and it is not necessary that the occurrence of all the periodic unevenness is prevented.

[0040] As explained above, in the comparative example, because the stepping motor M14 resonates by the pulse signal input into the stepping motor M14, the quantity of the unevenness of the thickness of the yarn Y increases, and the periodic unevenness occurs. In contrast, as explained above, the increase of the quantity of the unevenness of the thickness of the yarn Y and the occurrence of the periodic unevenness can be reduced by adjusting the operation of the stepping motor M14 like in the spinning machine 1 according to the embodiment. This is because the waveform of the electric current applied to the stepping motor M14 changes when the electric current applied to the stepping motor M14 is increased.

[0041] As mentioned above, in the drafting device in which the driver roller is driven by the stepping motor, it is necessary to change the pulleys depending on the set total draft ratio, so that there is a constraint on the drafting condition that can be set in the drafting device. However, in the present embodiment, the fiber bundle can be drafted stably by adjusting the operation of the stepping motor. That is, in the drafting device 6, the operation of the stepping motor M14 is adjusted such that the drafting performed by the roller pairs 14, 15, 16, and 17 is within a range that satisfies the drafting condition received by the main control device 5a. With this arrangement, while satisfying the drafting condition, the fiber bundle F can be drafted stably.

[0042] In the drafting device 6, the unit control device 10 adjusts the operation of the stepping motor M14 by changing the magnitude of the electric current applied to the stepping motor M14. With this arrangement, by adjusting the magnitude of the electric current applied to the stepping motor M14, the fiber bundle F can be drafted stably while satisfying the drafting condition.

[0043] In the drafting device 6, the unit control device 10 increases the electric current applied to the stepping motor M14 to adjust the operation of the stepping motor M14. With this arrangement, the amount of the electric current applied to the stepping motor M14 when the operation is not adjusted can be reduced and the power consumption can be reduced.

[0044] In the drafting device 6, the unit control device 10 adjusts the operation of the stepping motor M14 by changing the magnitude of the electric current (electric current value) applied to the stepping motor M14 within a range that is equal to or higher than the lower limit value corresponding to the necessary torque required for the stepping motor M14. With this arrangement, the fiber bundle F can be drafted stably while securing the torque of the stepping motor M14.

[0045] In the drafting device 6, based on the drafting condition received by the main control device 5a, the unit control device 10 calculates the frequency of the pulse signal to be input into the stepping motor M14, and when the calculated frequency is within the predetermined range including the resonance frequency of the stepping motor M14, adjusts the operation of the stepping motor M14. With this arrangement, situations where stable drafting of the fiber bundle F is hindered due to resonance of the stepping motor M14 can be avoided reliably so that stable drafting of the fiber bundle F can be realized reliably.

[0046] In the drafting device 6, the unit control device 10 adjusts the operation of the stepping motor M14, which drives the back bottom roller 14a, within a range in which the drafting performed by the roller pairs 14, 15, 16, and 17 satisfies the drafting condition received by the main control device 5a. In the present embodiment, the back bottom roller 14a is driven by the stepping motor M14 arranged in each drafting device 6, and the driving motors that respectively drive each of the middle bottom rollers 16a and the front bottom rollers 17a are arranged in the second-end frame 5. Because each of the drafting devices 6 is provided with the stepping motor M14, drafting unevenness due to the resonance of the stepping motor M14 easily appears in the fiber bundle F. However, because the operation of the stepping motor M14 is adjusted, the fiber bundle F can be drafted more stably.

[0047] When the stepping motor M14 resonates, and if the frequency of the vibration of the stepping motor M14 matches with a resonance frequency of the front bottom roller 17a, periodic unevenness having the frequency corresponding to the resonance frequency of the front bottom roller 17a may increase. In contrast, in the drafting device 6, the occurrence of such periodic unevenness can be prevented.

[0048] In the drafting device 6, the back bottom roller 14a and the middle bottom roller 15a that are arranged upstream are rotationally driven at a lower speed than the front bottom roller 17a. Generally, the stepping motor easily resonates in a low-speed range. In the drafting device 6, as explained above, because the operation of the stepping motor M14 and / or the stepping motor M15 is adjusted, the fiber bundle F can be drafted stably within a wide range of the total draft ratio while preventing the resonance.

[0049] In the spinning unit 2 that includes the drafting device 6, by the above-mentioned reasons, the fiber bundle F can be drafted stably while satisfying the drafting condition. As a result, a yarn quality of the yarn Y wound into the package P can be improved.

[0050] In the spinning unit 2, the unit control device 10 adjusts the operation of the stepping motor M14 so that the periodic unevenness having the frequency corresponding to the resonance frequency of the stepping motor M14 is not detected by the yarn monitoring device 8. As a result, a yarn quality of the yarn Y wound into the package P can be improved more reliably.

[0051] Exemplary embodiments of the present invention are explained above; however, the present invention is not limited to those embodiments. For example, the unit control device 10 can adjust the operation of the stepping motor M14 by performing a processing shown in FIGS. 5 and 6. In this variation, while the spinning unit 2 is operating, the processing shown in FIG. 5 is started.

[0052] In the processing shown in FIG. 5, first of all, the unit control device 10 determines whether a periodic unevenness alarm is output (Step S11). When the unit control device 10 determines that the periodic unevenness alarm is output (Step S11: YES), the processing advances to Step S12. When the unit control device 10 determines that the periodic unevenness alarm is not output (Step S11: NO), the processing shown in FIG. 5 is terminated. The periodic unevenness alarm is an alarm that is output to the unit control device 10 when the periodic unevenness, in which the quantity of the unevenness of the yarn Y changes periodically, is detected by the yarn monitoring device 8.

[0053] At Step S12, the unit control device 10 executes an electric current change determination process shown in FIG. 6. First of all, the unit control device 10 determines whether a length of the periodic unevenness detected by the yarn monitoring device 8 (length for one repeat unit) corresponds to a predetermined length (Step S21). When the unit control device 10 determines that the length of the periodic unevenness corresponds to the predetermined length (Step S21: YES), the processing advances to Step S22. When the unit control device 10 determines that the length of the periodic unevenness does not correspond to the predetermined length (Step S21: NO), the processing advances to Step S24.

[0054] The length of the periodic unevenness is calculated by dividing the spinning speed by a frequency of the periodic unevenness. The predetermined length is a value used to determine whether the periodic unevenness is caused by the back bottom roller 14a. The predetermined length L is calculated by using following Equation (1) in which TDR is a total draft ratio, PL is a circumferential length of the back bottom roller 14a, and θ is a step angle, PN is a number of phases, and RR is a reduction ratio of the stepping motor M14. At Step S21, the unit control device 10 may determine that the length of the periodic unevenness corresponds to the predetermined length, not only when the length of the periodic unevenness exactly corresponds to the predetermined length, but also when the length of the periodic unevenness slightly deviates from the predetermined length.

$$L = TDR \times PL \div (360 \div (\theta \times PN) \times RR) \quad \ldots \quad (1)$$

[0055] At Step S22, the unit control device 10 determines whether it is possible to change the electric current value applied to the stepping motor M14. More particularly, the unit control device 10 determines that it is possible to change the electric current if a driver connected to the stepping motor M14 has a channel for changing the electric current value applied to the stepping motor M14, and determines that it is not possible to change the electric current if the driver does not have such a channel. When the unit control device 10 determines that it is possible to change the electric current value (Step S22: YES), the processing advances to Step S23. When the unit control device 10 determines that it is not possible to change the electric current value (Step S22: NO), the processing advances to Step S24.

[0056] At Step S23, the unit control device 10 stores information which indicates that it is possible to change the electric current value in a memory. At Step S24, the unit control device 10 stores information which indicates that it is not possible to change the electric current value in a memory. After the unit control device 10 has executed Step S23 or Step S24, the processing shown in FIG. 6 is terminated and the processing advances to Step S13 shown in FIG. 5.

[0057] At Step S13, the unit control device 10 checks the memory and determines whether it is possible to change the electric current value. When the unit control device 10 determines that it is possible to change the electric current value (Step S13: YES), the processing advances to Step S14. When the unit control device 10 determines that it is not possible to change the electric current value (Step S13: NO), the processing shown in FIG. 5 is terminated.

[0058] At Step S14, the unit control device 10 determines whether the operation of the spinning unit 2 is stopped. When the unit control device 10 determines that the operation of the spinning unit 2 is stopped (Step S14: YES), the processing advances to Step S15. When the unit control device 10 determines that the operation of the spinning unit 2 is not stopped (Step S14: NO), Step S14 is executed again, and the unit control device 10 waits until the operation of the spinning unit 2 stops. In this manner, when the unit control device 10 determines, based on the detection result obtained in the yarn monitoring device 8 and / or the tension sensor 9, that an abnormality is present, the operation of the spinning unit 2 is stopped.

[0059] At Step S15, the unit control device 10 changes an electric current value to be applied to the stepping motor M14. At Step S15, the unit control device 10 changes the electric current value, for example, from the second electric current value to the first electric current value. Then, the unit control device 10 causes the spinning unit 2 to resume the operation (Step S16). Then, the unit control device 10 terminates the processing shown in FIG. 5. The processing shown in FIGS. 5 and 6 may be performed repeatedly.

[0060] As explained above, in this variation, when an abnormality in the yarn Y is detected by the yarn monitoring device 8, the unit control device 10 adjusts the operation of the stepping motor M14 by changing the electric current value applied to the stepping motor M14. The unit control device 10 adjusts the operation of the stepping motor M14 while the winding of the yarn Y by the winding device 13 is suspended (that is, while the operation of the spinning unit 2 is stopped). The unit control device 10 adjusts the operation of the stepping motor M14 depending on the length of the periodic unevenness detected by the yarn monitoring device 8. That is, the unit control device 10 adjusts the operation of the stepping motor M14 by performing a feedback control based on the unevenness in the thickness of the yarn Y detected by the yarn monitoring device 8. Even in the above variation, like in the above embodiment, the fiber bundle F can be drafted stably while satisfying the drafting condition.

[0061] In the above variation, when the operation of the stepping motor M14 is adjusted in a certain spinning unit 2, the operation of the stepping motors M14 of the other spinning units 2 can also be adjusted in a similar manner. For example, when the operation of the stepping motor M14 is adjusted in one or a predetermined number of the spinning units 2, the operation of the stepping motors M14 of all the other spinning units 2 can also be adjusted in a similar manner. Because, when a phenomenon occurs in a certain spinning unit 2, the same phenomenon may also occur in the other spinning units 2. With this arrangement, the fiber bundle F can be drafted stably while satisfying the drafting condition in a plurality of the spinning units 2.

[0062] In the above variation, the operation of the stepping motor M14 is adjusted when the length of the periodic unevenness detected by the yarn monitoring device 8 corresponds to the predetermined length. However, the operation of the stepping motor M14 can be adjusted when a predetermined peak is detected in the unevenness of the thickness of the yarn Y detected by the yarn monitoring device 8. The "a predetermined peak is detected in the unevenness of the thickness of the yarn Y" means, for example, as explained above with reference to FIG. 4A, that the quantity of unevenness of the thickness of the yarn Y detected by the yarn monitoring device 8 is the reference value A or more. Even in this case, like in the above embodiment, the fiber bundle F can be drafted stably while satisfying the drafting condition.

[0063] In the above variation, the operation of the stepping motor M14 is adjusted by the unit control device 10 when the winding of the yarn Y by the winding device 13 has been suspended. However, the operation of the stepping motor M14 can be adjusted by the unit control device 10 when the yarn Y is being wound by the winding device 13.

[0064] As other variations, the operations of both the stepping motors M14 and M15 can be adjusted such that the drafting performed by the roller pairs 14, 15, 16, and 17 is within a range that satisfies the drafting condition received by the main control device 5a. For example, in the above embodiment, at normal times, while the electric current value applied to each of the stepping motors M14 and M15 is set to the second electric current value, at the time of performing the adjustment, the electric current value applied to each of the stepping motors M14 and M15 can be set to the first electric current value that is higher than the second electric current value. In this case, the fiber bundle F can be drafted more stably. As a further variation, the operation of only the stepping motor M15 can be adjusted. In other words, the operation of the stepping motor M14 need not be adjusted.

[0065] The first electric current value can be lower than the second electric current value. That is, the operation of the stepping motor M14 can be adjusted by decreasing the amount of the electric current applied to the stepping motor M14.

Even in this case, the first electric current value and the second electric current value can be set to values that are equal to or higher than the lower limit value corresponding to the necessary torque required for the stepping motor M14. Even when the value of the electric current value applied to the stepping motor M14 is set to any of the first electric current value and the second electric current value, the drafting performed by the roller pairs 14, 15, 16, and 17 satisfies the drafting condition received by the main control device 5a. Even in the above variation, like in the above embodiment, the fiber bundle F can be drafted stably while satisfying the drafting condition.

[0066] Instead of changing the electric current value to be applied to the stepping motor M14, the operation of the stepping motor M14 can be adjusted by changing an excitation mode of the stepping motor M14. For example, the operation of the stepping motor M14 can be adjusted by changing the excitation mode of the stepping motor M14 to an excitation mode having a smaller step angle. Even with such a control, like in the above embodiment, the increase in the quantity of unevenness of the thickness of the yarn Y and the occurrence of the periodic unevenness can be prevented.

[0067] Instead of changing the electric current value to be applied to the stepping motor M14, the operation of the stepping motor M14 can be adjusted by varying a frequency (carrier frequency) of a pulse signal to be input into the stepping motor M14. For example, the operation of the stepping motor M14 can be adjusted by decreasing the frequency of the pulse signal of the stepping motor M14. Even with such a control, like in the above embodiment, the increase in the quantity of the unevenness of the thickness of the yarn Y and the occurrence of the periodic unevenness can be prevented.

[0068] The above control can be used in combination. The operation of the stepping motor M14 can be adjusted by changing at least one among the electric current value applied to the stepping motor M14, the excitation mode of the stepping motor M14, and the frequency of the pulse signal input into the stepping motor M14. That is, the operation of the stepping motor M14 can be adjusted by changing one or more control parameters (electric current value, excitation mode, and carrier frequency) of the stepping motor M14. The operation of the stepping motor M15 can be adjusted in the similar manner.

[0069] In the above embodiment, the operation of the stepping motor M14 is controlled by the unit control device 10. However, a control section that controls the operation of the stepping motor M14 can be arranged in the drafting device 6 and this control section can control the operation of the stepping motor M14. In the above embodiment, the main control device 5a functions as a receiving section that receives the setting of the drafting condition; however, the setting of the drafting condition can be received by a section other than the main control device 5a. The receiving section can be a touch screen, a keyboard, push buttons, or the like. If the spinning machine 1 is configured so as to be able to communicate with an external device, such as a portable terminal, it is allowable that the receiving section receives information, as the setting of the drafting condition, from the external device.

[0070] In a configuration in which the stepping motor M15 is omitted and the stepping motor M14 rotationally drives both the back bottom roller 14a and the third bottom roller 15a, the operation of the stepping motor M14 can be adjusted like in the above embodiment. Even in this case, like in the above embodiment, the fiber bundle F can be drafted stably while satisfying the drafting condition.

[0071] In the above embodiment, the electric current value applied to the stepping motor M14 is changed between the first electric current value and the second electric current value; however, the electric current value can be changed between three or more electric current values.

[0072] In the above embodiment, each of the front bottom roller 17a and the middle bottom roller 16a is driven by a respective driving motor arranged in the second-end frame 5; however, a stepping motor (s) that drives one or both of the front bottom roller 17a and the middle bottom roller 16a can be provided in each of the drafting devices 6. In this case, the operation of the stepping motor can be adjusted by the unit control device 10.

[0073] When the front bottom roller 17a is driven by the stepping motor, the unit control device 10 can adjust the operation of the stepping motor such that the drafting is within a range that satisfies the drafting condition received by the main control device 5a. Specifically, the unit control device 10 adjusts the operation of the stepping motor by changing at least one among the magnitude of the electric current applied to the stepping motor, the excitation mode of the stepping motor, and the frequency of the pulse signal input into the stepping motor.

[0074] When the middle bottom roller 16a is driven by the stepping motor, the unit control device 10 can adjust the operation of the stepping motor such that the drafting is within a range that satisfies the drafting condition received by the main control device 5a. Specifically, the unit control device 10 adjusts the operation of the stepping motor by changing at least one among the magnitude of the electric current applied to the stepping motor, the excitation mode of the stepping motor, and the frequency of the pulse signal input into the stepping motor.

[0075] The unit control device 10 can change the magnitude of the electric current to be applied to the stepping motor M14 and / or the stepping motor M15 by selecting the magnitude of the electric current to be applied to each phase of the stepping motor M14 and / or the stepping motor M15. In such a configuration, because a difference on the electric current can be made small among the phases at a predetermined frequency, the fiber bundle F can be drafted stably.

[0076] In the above embodiment, the yarn Y is formed by applying twists to the fiber bundle F using a swirling air current by the air spinning device 7; however, the yarn Y can be formed by using a pair of air jetting nozzles that apply a twist to the fiber bundle in respectively opposite directions.

[0077] In the above embodiment, the yarn Y is pulled from the air spinning device 7 by the yarn accumulating device 11; however, the yarn Y can be pulled from the air spinning device 7 by using a delivery roller and a nip roller. In a configuration in which the yarn Y is pulled from the air spinning device 7 by using the delivery roller and the nip roller, the yarn accumulating device 11 can be replaced with a slack tube that absorbs slack of the yarn Y by using a suction airflow, and / or a mechanical compensator, or the like.

[0078] A drafting device according to one aspect of the present invention includes a plurality of roller pairs that draft a fiber bundle, each roller pair including a driver roller and a driven roller that rotates following the rotation of the driver roller; a stepping motor that rotationally drives the driver roller of at least one roller pair among the roller pairs; a receiving section that receives setting of a drafting condition relating to the fiber bundle to be drafted by the roller pairs; and a control section that controls an operation of the stepping motor. The control section adjusts the operation of the stepping motor such that the drafting performed by the roller pairs is within a range that satisfies the drafting condition received by the receiving section.

[0079] With this arrangement, while satisfying the drafting condition, the fiber bundle can be drafted stably. For example, even when the receiving section receives any draft ratio within a wide range of a total draft ratio, the fiber bundle can be drafted stably without changing a pulley attached to a rotating shaft of the stepping motor and / or a rotating shaft of the driver roller. In the conventional art, it is necessary to change the pulley when changing the total draft ratio. This was a complicated work for the operator.

[0080] In the above drafting device, the control section can adjust the operation of the stepping motor by changing at least one among a magnitude of an electric current applied to the stepping motor, an excitation mode of the stepping motor, and a frequency of a pulse signal input into the stepping motor. With this configuration, the fiber bundle can be drafted stably without the drafting condition being changed.

[0081] In the above drafting device, the control section can adjust the operation of the stepping motor by increasing the electric current applied to the stepping motor. With this configuration, the amount of the electric current applied to the stepping motor when the operation of the stepping motor is not adjusted can be reduced and the power consumption can be reduced.

[0082] In the above drafting device, the control section can adjust the operation of the stepping motor by changing the magnitude of the electric current applied to the stepping motor within a range of a value that is equal to or higher than a lower limit value corresponding to a necessary torque required for the stepping motor. With this configuration, the fiber bundle can be drafted stably while securing the torque of the stepping motor.

[0083] In the above drafting device, the control section adjusts the operation of the stepping motor by maintaining the magnitude of the electric current applied to the stepping motor and changing the frequency of the pulse signal input into the stepping motor. With this configuration, even when the operation of the stepping motor is adjusted, the power consumption does not increase thereby realizing an energy-saving drafting device.

[0084] In the above drafting device, the control section can calculate, based on the drafting condition received by the receiving section, the frequency of the pulse signal to be input into the stepping motor, and can adjust the operation of the stepping motor when the calculated frequency is within a predetermined range including a resonance frequency of the stepping motor. With this configuration, situations where stable drafting of the fiber bundle is hindered due to resonance of the stepping motor can be avoided more reliably thereby realizing the stable drafting of the fiber bundle more reliably.

[0085] In the above drafting device, the roller pairs can include a back roller pair, a middle roller pair, and a front roller pair sequentially from an upstream side in a traveling direction of the fiber bundle. The control section can adjust the operation of the stepping motor that rotationally drives the driver roller of the back roller pair such that the drafting performed by the roller pairs is within the range that satisfies the drafting condition received by the receiving section. With this arrangement, in a configuration in which the stepping motor rotationally drives the driver roller of the back roller pair, the fiber bundle can be drafted stably.

[0086] The above drafting device can include a pulley attached to a rotating shaft of the stepping motor; and a belt that connects a rotating shaft of the driver roller to the pulley. Even when an instruction to change the drafting condition is received by the receiving section, the fiber bundle can be drafted by using the roller pairs without changing the pulley. With this arrangement, the fiber bundle can be drafted without being restricted by the pulley. As a result, the flexibility in the drafting operation performed by the drafting device increases.

[0087] In the above drafting device, the back roller pair can include a first roller pair and a second roller pair sequentially from the upstream side in the traveling direction, and the stepping motor can include a first stepping motor that rotationally drives the driver roller of the first roller pair and a second stepping motor that rotationally drives the driver roller of the second roller pair. The control section can adjust the operation of one or both of the first stepping motor and the second stepping motor such that the drafting performed by the roller pairs is within the range that satisfies the drafting condition received by the receiving section. With this configuration, the fiber bundle can be drafted more stably.

[0088] In the above drafting device, the first stepping motor and the second stepping motor can be stepping motors of the same type. With this configuration, because the same type of the driver can be used in both the first stepping motor and the second stepping motor, it is unnecessary to tune the driver individually thereby simplifying the configuration of the drafting device.

[0089] A spinning unit according to another aspect of the present invention includes the above drafting device; a spinning device that applies a twist to the fiber bundle to form a yarn; a winding device that winds the yarn to form a package; and a yarn monitoring device that monitors the yarn. According to the spinning unit, for the reasons explained above, the fiber bundle can be drafted stably while satisfying the drafting condition. As a result, a yarn quality of the yarn wound into the package can be improved.

[0090] In the above spinning unit, the control section can adjust the operation of the stepping motor such that periodic unevenness having a frequency corresponding to a resonance frequency of the stepping motor is not detected by the yarn monitoring device. With this configuration, the yarn quality of the yarn wound into the package can be improved more reliably.

[0091] In the above spinning unit, the control section can adjust the operation of the stepping motor when abnormality in the yarn is detected by the yarn monitoring device. With this configuration, the yarn quality of the yarn wound into the package can be improved more reliably.

[0092] In the above spinning unit, the control section can adjust the operation of the stepping motor when, as the abnormality, a predetermined peak in unevenness of a thickness of the yarn is detected by the yarn monitoring device. With this configuration, the yarn quality of the yarn wound into the package can be improved more reliably.

[0093] In the above spinning unit, the control section can adjust the operation of the stepping motor when winding of the yarn by the winding device is in suspended state. With this configuration, the yarn being wound can be prevented from being affected by adjustment of the operation of the stepping motor. Accordingly, the yarn quality of the yarn wound into the package can be improved more reliably.

[0094] In the above spinning unit, the control section can adjust the operation of the stepping motor by a feedback control based on the unevenness of the thickness of the yarn detected by the yarn monitoring device. With this configuration, because the operation of the stepping motor can be adjusted more appropriately, the yarn quality of the yarn wound into the package can be improved more reliably.

[0095] In the above explanation, the meaning of "a plurality of" also includes "a predetermined number of".

[0096] According to an aspect 1, a drafting device comprises:

a plurality of roller pairs adapted to draft a fiber bundle each roller pair including a driver roller and a driven roller adapted to rotate following rotation of the driver roller;
a stepping motor adapted to rotationally drive the driver roller of at least one roller pair among the roller pairs;
a receiving section adapted to receive setting of a drafting condition relating to the fiber bundle to be drafted by the roller pairs; and
a control section adapted to control an operation of the stepping motor by changing at least one among a magnitude of an electric current applied to the stepping motor, an excitation mode of the stepping motor, and a frequency of a pulse signal input into the stepping motor such that drafting performed by the roller pairs is within a range that satisfies the drafting condition received by the receiving section.

[0097] According to an aspect 2, in the drafting device of aspect 1, the control section is adapted to adjust the operation of the stepping motor by increasing the electric current applied to the stepping motor.

[0098] According to an aspect 3, in the drafting device of aspect 1 or 2, the control section is adapted to adjust the operation of the stepping motor by changing the magnitude of the electric current applied to the stepping motor within a range of a value that is equal to or higher than a lower limit value corresponding to a necessary torque required for the stepping motor.

[0099] According to an aspect 4, in the drafting device of aspect 1, the control section is adapted to adjust the operation of the stepping motor by maintaining the magnitude of the electric current applied to the stepping motor and changing the frequency of the pulse signal input into the stepping motor.

[0100] According to an aspect 5, in the drafting device of one of aspects 1 to 4, the control section is adapted to calculate, based on the drafting condition received by the receiving section, the frequency of the pulse signal to be input into the stepping motor, and adjust the operation of the stepping motor when the calculated frequency is within a predetermined range including a resonance frequency of the stepping motor.

[0101] According to an aspect 6, in the drafting device of one of aspects 1 to 5, the roller pairs include a back roller pair, a middle roller pair, and a front roller pair sequentially from an upstream side in a traveling direction of the fiber bundle, and the control section is adapted to adjust the operation of the stepping motor that rotationally drives the driver roller of the back roller pair such that the drafting performed by the roller pairs is within the range that satisfies the drafting condition received by the receiving section.

[0102] According to an aspect 7, the drafting device of one of aspects 1 to 6, comprises: a pulley attached to a rotating shaft of the stepping motor; and a belt adapted to connect a rotating shaft of the driver roller to the pulley, wherein even when an instruction to change the drafting condition is received by the receiving section, the fiber bundle is drafted by using the roller pairs without changing the pulley.

[0103] According to an aspect 8, in the drafting device of aspect 6 or 7, the back roller pair includes a first roller pair and a second roller pair sequentially from the upstream side in the traveling direction, the stepping motor includes a first stepping motor adapted to rotationally drive the driver roller of the first roller pair and a second stepping motor adapted to rotationally drive the driver roller of the second roller pair, and the control section is adapted to adjust the operation of one or both of the first stepping motor and the second stepping motor such that the drafting performed by the roller pairs is within the range that satisfies the drafting condition received by the receiving section.

[0104] According to an aspect 9, in the drafting device of aspect 8, the first stepping motor and the second stepping motor are stepping motors of the same type.

[0105] According to an aspect 10, a spinning unit comprises the drafting device of one of aspects 1 to 9; a spinning device adapted to apply a twist to the fiber bundle to form a yarn; a winding device adapted to wind the yarn to form a package; and a yarn monitoring device adapted to monitor the yarn.

[0106] According to an aspect 11, in the spinning unit of aspect 10, the control section is adapted to adjust the operation of the stepping motor such that periodic unevenness having a frequency corresponding to a resonance frequency of the stepping motor is not detected by the yarn monitoring device.

[0107] According to an aspect 12, in the spinning unit of aspect 10 or 11, the control section is adapted to adjust the operation of the stepping motor when abnormality in the yarn is detected by the yarn monitoring device.

[0108] According to an aspect 13, in the spinning unit of aspect 12, the control section is adapted to adjust the operation of the stepping motor when, as the abnormality, a predetermined peak in unevenness of a thickness of the yarn is detected by the yarn monitoring device.

[0109] According to an aspect 14, in the spinning unit of one of aspects 10 to 13, the control section is adapted to adjust the operation of the stepping motor when winding of the yarn by the winding device is in suspended state.

[0110] According to an aspect 15, in the spinning unit of one of aspects 10 to 14, the control section is adapted to adjust the operation of the stepping motor by a feedback control based on the unevenness of the thickness of the yarn detected by the yarn monitoring device.

Claims

1. A drafting device (6) comprising:

a plurality of roller pairs (14, 15, 16, 17) adapted to draft a fiber bundle (S), each roller pair (14, 15, 16, 17) including a driver roller (14a, 15a, 16a, 17a) and a driven roller (14b, 15b, 16b, 17b) adapted to rotate following rotation of the driver roller (14a, 15a, 16a, 17a);
a stepping motor (M14, M15) adapted to rotationally drive the driver roller (14a, 15a) of at least one roller pair (14, 15) among the roller pairs (14, 15, 16, 17);
a receiving section (5a) adapted to receive setting of a drafting condition relating to the fiber bundle (S) to be drafted by the roller pairs (14, 15, 16, 17); and
a control section (10) adapted to control an operation of the stepping motor (M14, M15) by changing at least one among a magnitude of an electric current applied to the stepping motor (M14, M15), an excitation mode of the stepping motor (M14, M15), and a frequency of a pulse signal input into the stepping motor (M14, M15) such that drafting performed by the roller pairs (14, 15, 16, 17) is within a range that satisfies the drafting condition received by the receiving section (5a), wherein
the roller pairs (14, 15, 16, 17) include a back roller pair (14, 15), a middle roller pair (16), and a front roller pair (17) sequentially from an upstream side in a traveling direction of the fiber bundle (S), and
the control section (10) is adapted to adjust the operation of the stepping motor (M14, M15) that rotationally drives the driver roller (14a, 15a) of the back roller pair (14, 15) such that the drafting performed by the roller pairs (14, 15, 16, 17) is within the range that satisfies the drafting condition received by the receiving section (5a),
the back roller pair (14) includes a first roller pair (14) and a second roller pair (15) sequentially from the upstream side in the traveling direction,
the stepping motor (M14, M15) includes a first stepping motor (M14) adapted to rotationally drive the driver roller (14a) of the first roller pair (14) and a second stepping motor (M15) adapted to rotationally drive the driver roller (15a) of the second roller pair (15), and
the control section (10) is adapted to adjust the operation of one or both of the first stepping motor (M14) and the second stepping motor (M15) such that the drafting performed by the roller pairs (14, 15, 16, 17) is within the range that satisfies the drafting condition received by the receiving section (5a).

2. The drafting device (6) as claimed in Claim 1, wherein the control section (10) is adapted to adjust the operation of the stepping motor (M14, M15) by increasing the electric current applied to the stepping motor (M14, M15).

3. The drafting device (6) as claimed in Claim 1 or 2, wherein the control section (10) is adapted to adjust the operation of the stepping motor (M14, M15) by changing the magnitude of the electric current applied to the stepping motor (M14, M15) within a range of a value that is equal to or higher than a lower limit value corresponding to a necessary torque required for the stepping motor (M14, M15).

4. The drafting device (6) as claimed in Claim 1, wherein the control section (10) is adapted to adjust the operation of the stepping motor (M14, M15) by maintaining the magnitude of the electric current applied to the stepping motor (M14, M15) and changing the frequency of the pulse signal input into the stepping motor (M14, M15).

5. The drafting device (6) as claimed in one of Claims 1 to 4, wherein the control section (10) is adapted to calculate, based on the drafting condition received by the receiving section (5a), the frequency of the pulse signal to be input into the stepping motor (M14, M15), and
adjust the operation of the stepping motor (M14, M15) when the calculated frequency is within a predetermined range including a resonance frequency of the stepping motor (M14, M15).

6. The drafting device (6) as claimed in one of Claims 1 to 5, comprising:

   a pulley (P14b, P15b) attached to a rotating shaft of the stepping motor (M14, M15); and
   a belt (B14, B15) adapted to connect a rotating shaft of the driver roller (14a, 15a) to the pulley (P14b, P15b), wherein
   even when an instruction to change the drafting condition is received by the receiving section (5a), the fiber bundle (S) is drafted by using the roller pairs (14, 15, 16, 17) without changing the pulley (P14b, P15b).

7. The drafting device (6) as claimed in one of Claims 1 to 6, wherein the first stepping motor (M14) and the second stepping motor (M15) are stepping motors of the same type.

8. A spinning unit (2) comprising:

   the drafting device (6) as claimed in one of Claims 1 to 7;
   a spinning device (7) adapted to apply a twist to the fiber bundle (F) to form a yarn (Y);
   a winding device (13) adapted to wind the yarn (Y) to form a package (P); and
   a yarn monitoring device (8) adapted to monitor the yarn (Y) .

9. The spinning unit (2) as claimed in Claim 8, wherein the control section (10) is adapted to adjust the operation of the stepping motor (M14, M15) such that periodic unevenness having a frequency corresponding to a resonance frequency of the stepping motor (M14, M15) is not detected by the yarn monitoring device (8) .

10. The spinning unit (2) as claimed in Claim 8 or 9, wherein the control section (10) is adapted to adjust the operation of the stepping motor (M14, M15) when abnormality in the yarn (Y) is detected by the yarn monitoring device (8).

11. The spinning unit (2) as claimed in Claim 10, wherein the control section (10) is adapted to adjust the operation of the stepping motor (M14, M15) when, as the abnormality, a predetermined peak in unevenness of a thickness of the yarn (Y) is detected by the yarn monitoring device (8).

12. The spinning unit (2) as claimed in one of Claims 8 to 11, wherein the control section (10) is adapted to adjust the operation of the stepping motor (M14, M15) when winding of the yarn (Y) by the winding device (13) is in suspended state.

13. The spinning unit (2) as claimed in one of Claims 8 to 12, wherein the control section (10) is adapted to adjust the operation of the stepping motor (M14, M15) by a feedback control based on the unevenness of the thickness of the yarn (Y) detected by the yarn monitoring device (8).

FIG.1

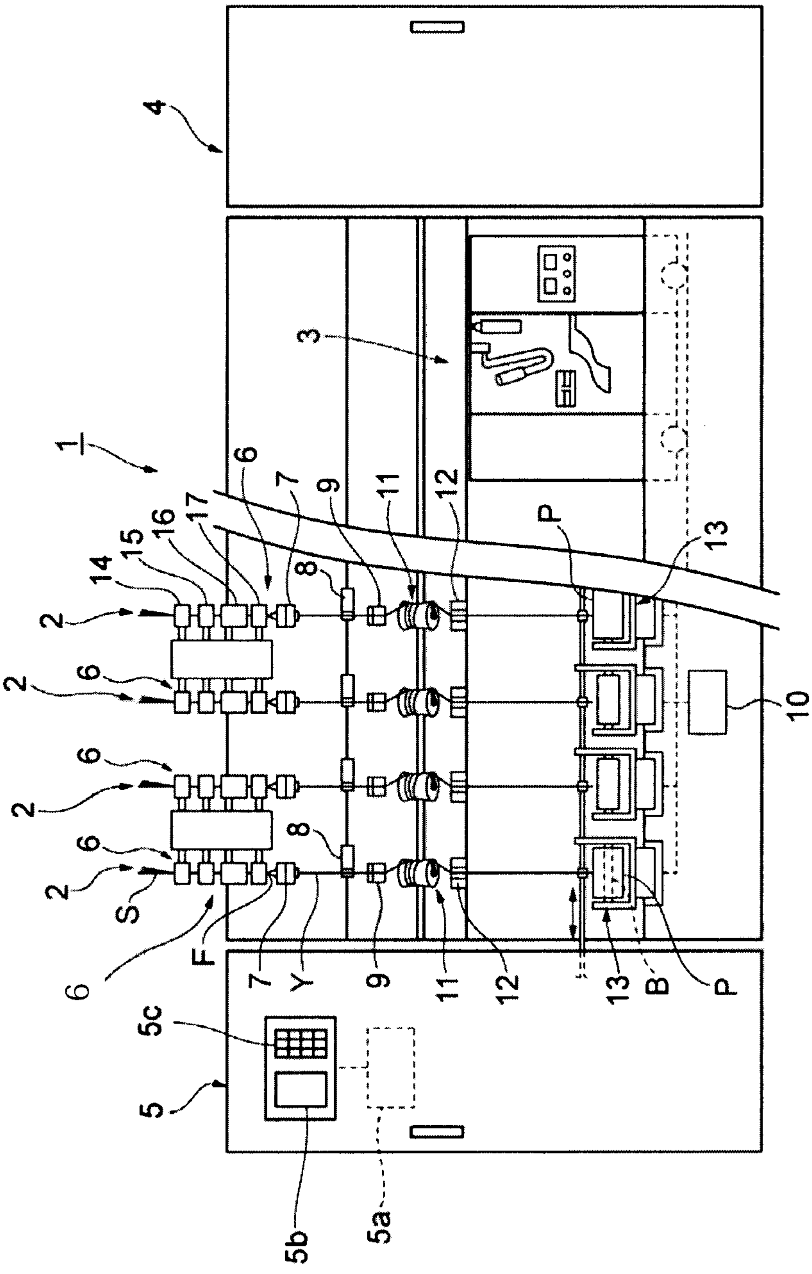


FIG.2

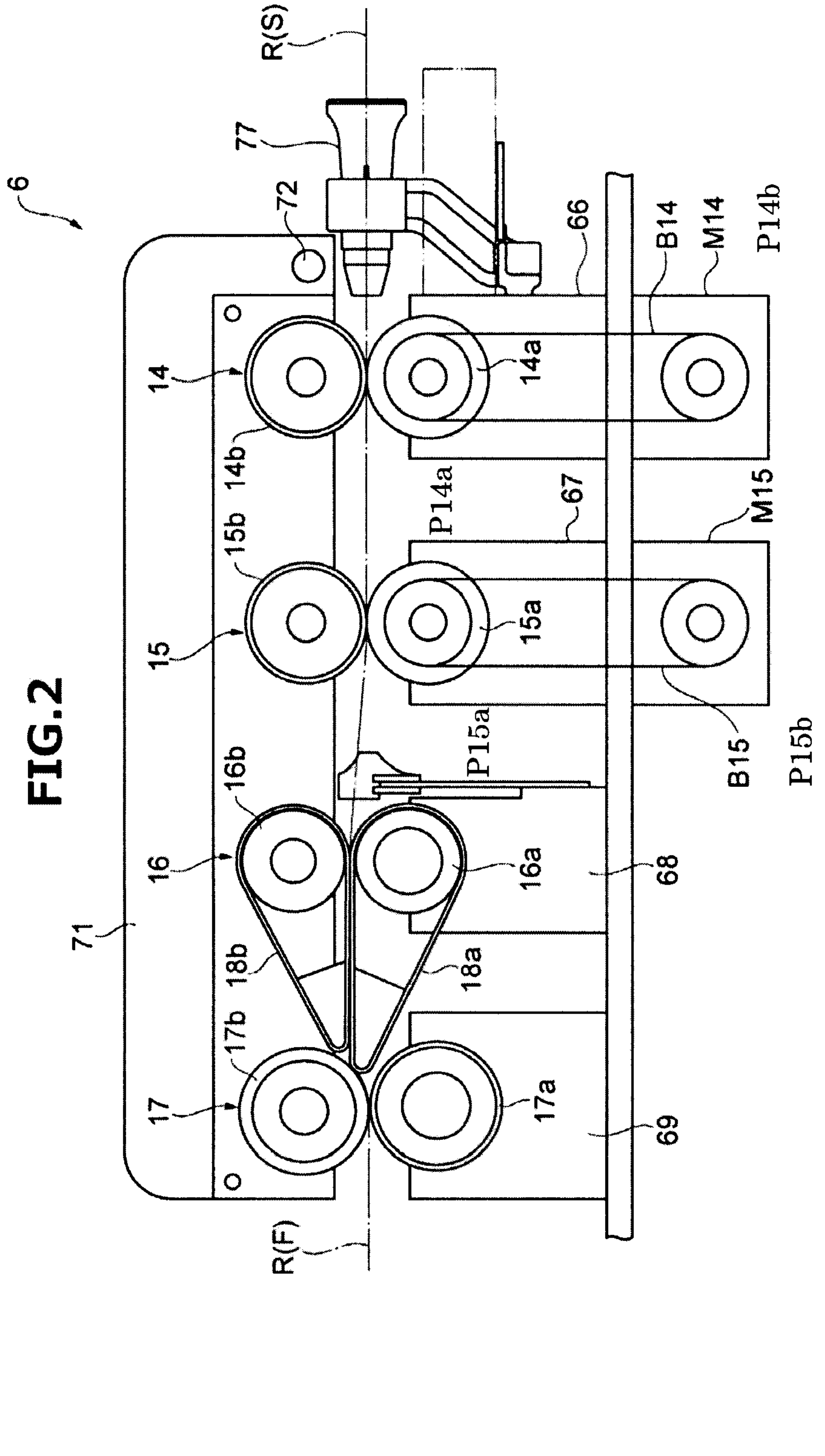

6
R(S)
77
72
66
B14
M14
P14b
14
14a
14b
P14a
67
M15
15b
15
15a
P15a
B15
P15b
16b
16
16a
68
71
18b
18a
17b
17
17a
69
R(F)

FIG.3

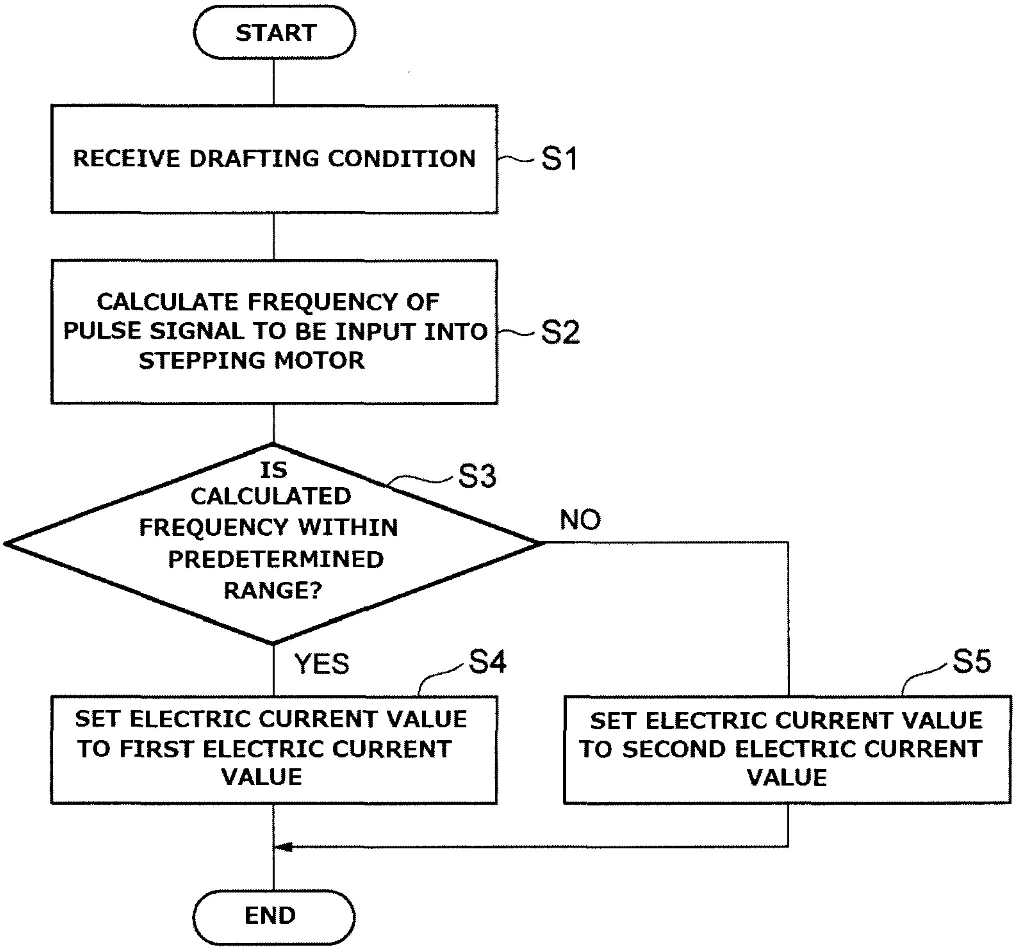

START
RECEIVE DRAFTING CONDITION
S1
CALCULATE FREQUENCY OF PULSE SIGNAL TO BE INPUT INTO STEPPING MOTOR
S2
IS CALCULATED FREQUENCY WITHIN PREDETERMINED RANGE?
S3
NO
YES
S4
SET ELECTRIC CURRENT VALUE TO FIRST ELECTRIC CURRENT VALUE
S5
SET ELECTRIC CURRENT VALUE TO SECOND ELECTRIC CURRENT VALUE
END

FIG.4A

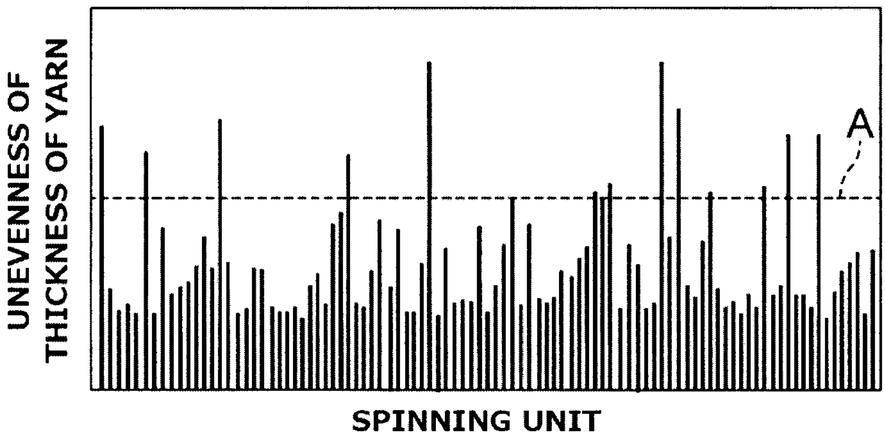

UNEVENNESS OF
THICKNESS OF YARN
A
SPINNING UNIT

FIG.4B

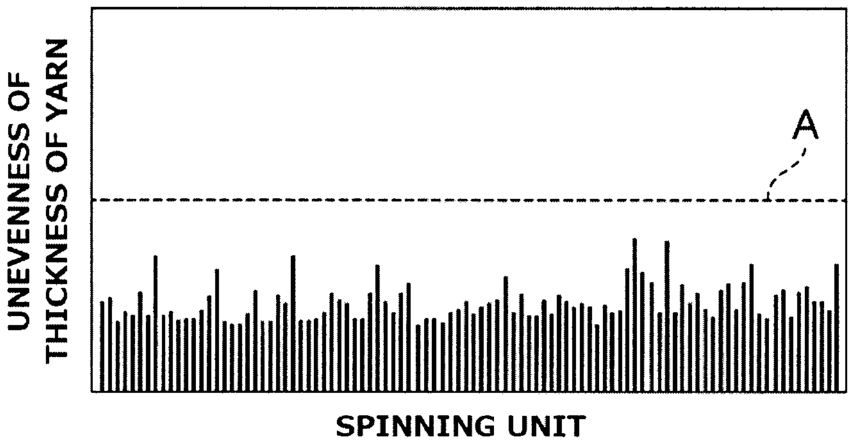

UNEVENNESS OF
THICKNESS OF YARN
A
SPINNING UNIT

FIG.5

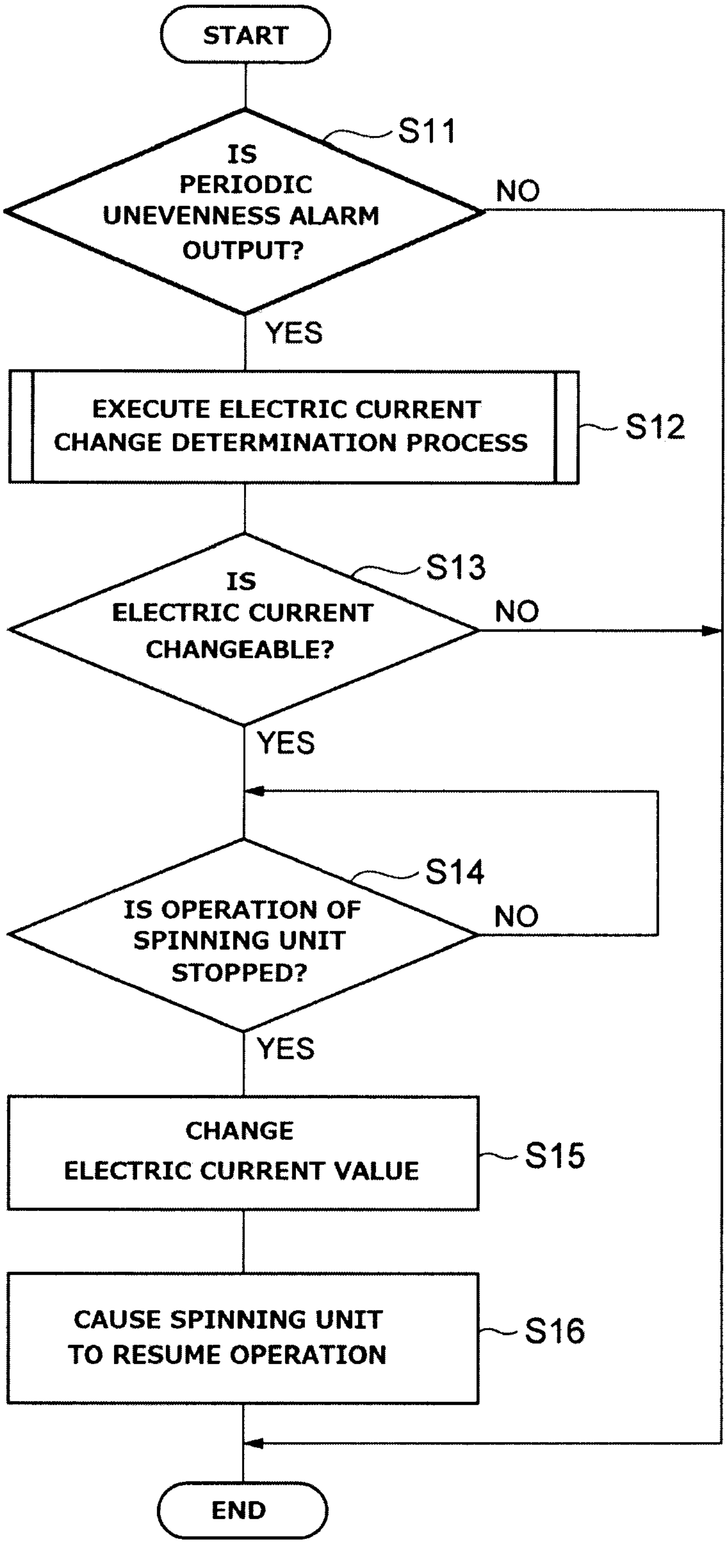
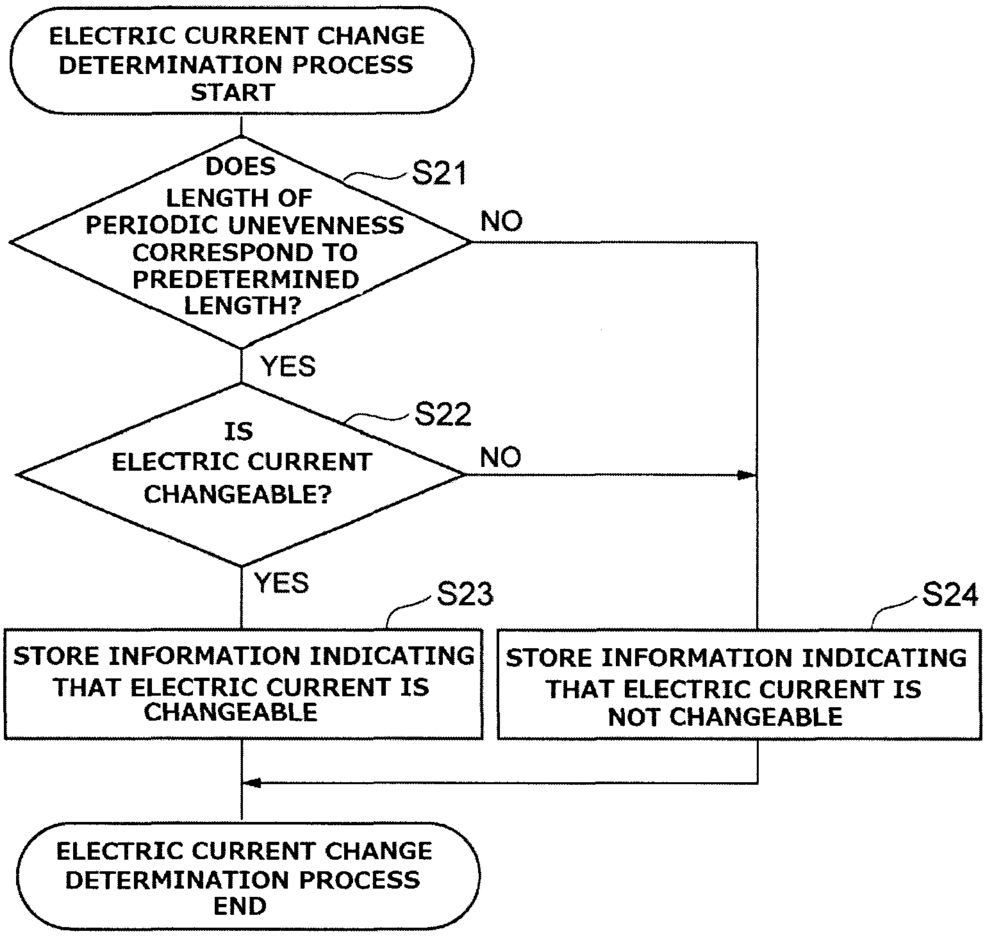

START
IS PERIODIC UNEVENNESS ALARM OUTPUT?
S11
NO
YES
EXECUTE ELECTRIC CURRENT CHANGE DETERMINATION PROCESS
S12
IS ELECTRIC CURRENT CHANGEABLE?
S13
NO
YES
IS OPERATION OF SPINNING UNIT STOPPED?
S14
NO
YES
CHANGE ELECTRIC CURRENT VALUE
S15
CAUSE SPINNING UNIT TO RESUME OPERATION
S16
END

FIG.6


ELECTRIC CURRENT CHANGE DETERMINATION PROCESS START
DOES LENGTH OF PERIODIC UNEVENNESS CORRESPOND TO PREDETERMINED LENGTH?
S21
NO
YES
IS ELECTRIC CURRENT CHANGEABLE?
S22
NO
YES
S23
STORE INFORMATION INDICATING THAT ELECTRIC CURRENT IS CHANGEABLE
S24
STORE INFORMATION INDICATING THAT ELECTRIC CURRENT IS NOT CHANGEABLE
ELECTRIC CURRENT CHANGE DETERMINATION PROCESS END

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EUROPEAN SEARCH REPORT

Application Number
EP 20 16 9588

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X A	JP 2009 243006 A (MURATA MACHINERY LTD) 22 October 2009 (2009-10-22) * paragraph [0012] * * paragraph [0017] - paragraph [0041] * * figures 1, 2 *	1-4,6-8, 10-13 5,9	INV. D01H5/26 D01H5/32
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A	CN 103 741 280 A (MA JIANHUI; DONG WEIGUO) 23 April 2014 (2014-04-23) * the whole document *	1-13	
A	EP 1 757 719 A2 (SAURER GMBH & CO KG [DE]) 28 February 2007 (2007-02-28) * paragraph [0022] * * paragraph [0028] *	1-13	

TECHNICAL FIELDS SEARCHED (IPC)

D01H
H02P
D01G
B65H

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	17 June 2020	Hausding, Jan

CATEGORY OF CITED DOCUMENTS

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17-06-2020

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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