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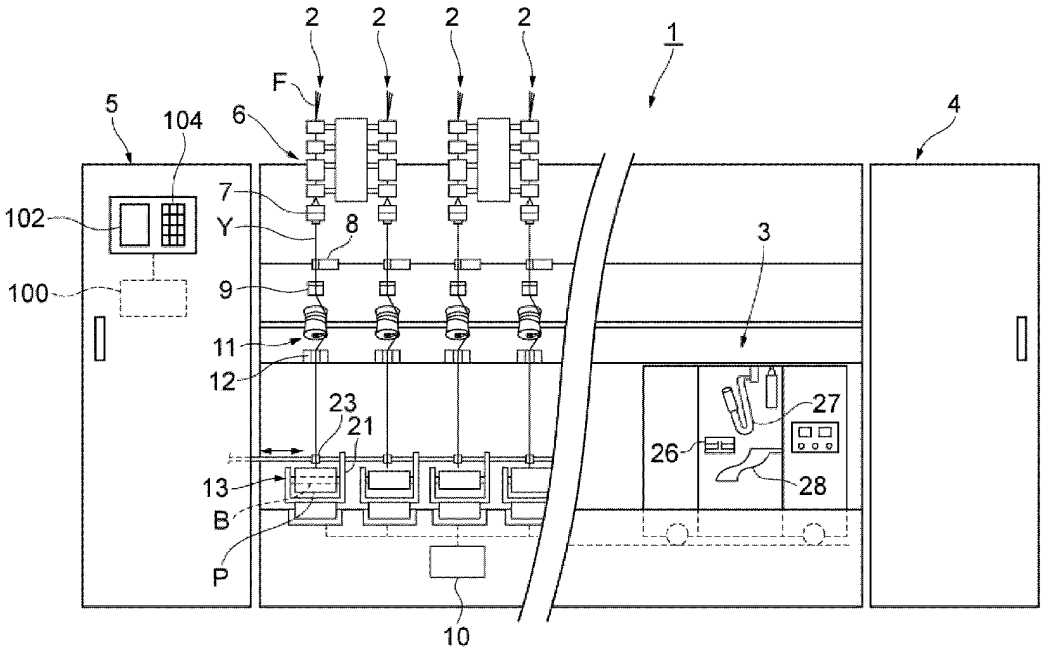
(54) SPINNING MACHINE AND SPINNING METHOD

(57) Spinning machine (1) including a draft device (6), a pneumatic spinning device (7), and a control section (10) adapted to, when splitting a fiber bundle (F), change a drafting ratio to a ratio different from a drafting ratio for a first drafting operation and cause a second drafting operation to be performed, and to stop the injection of air in the pneumatic spinning device (7) after the second drafting operation has been performed, whereby the control section (10) calculates the timing to stop the injection of air in the pneumatic spinning device (7) at the same time as or after at least one part of the fiber bundle (F) drafted in the second drafting operation has flown into the pneumatic spinning device (7).

FIG. 1



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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a spinning machine and a spinning method.

2. Description of the Related Art

[0002] As a conventional spinning machine, a spinning machine including a draft device adapted to draft a fiber bundle, and a pneumatic spinning device adapted to twist the fiber bundle drafted by the draft device by injecting air into a spinning chamber to produce a yarn is known (see e.g., Japanese Unexamined Patent Publication No. 2006-144136).

[0003] In this spinning machine, for example, when a yarn defect is detected and drafting operation performed by the draft device is accordingly stopped, a fiber bundle portion (ear tip) that is not twisted is formed at a yarn end of the yarn.

[0004] In the spinning machine described above, for example, when accumulating the yarn in a yarn accumulating device that uses a yarn accumulating roller, the fiber bundle portion may remain on the yarn accumulating roller if the length of the fiber bundle portion is too long. If the length of the fiber bundle portion is too short, the yarn end of the yarn may not be reliably caught from a package in a winding device when carrying out a yarn joining operation.

BRIEF SUMMARY OF THE INVENTION

[0005] It is an object of one aspect of the present invention to provide a spinning machine and a spinning method capable of adjusting dimension of a fiber bundle portion formed at a yarn end of a yarn.

[0006] A spinning machine according to one aspect of the present invention includes: a draft device including a plurality of rotatable roller pairs and adapted to draft a fiber bundle with the roller pairs; a pneumatic spinning device adapted to apply twists on the fiber bundle drafted by the draft device by injecting air to produce a yarn; a control section adapted to, when splitting the fiber bundle, change a drafting ratio to a ratio different from a drafting ratio for a first drafting operation of drafting the fiber bundle and cause a second drafting operation of drafting the fiber bundle to be performed in the draft device, and to stop the injection of air in the pneumatic spinning device after the second drafting operation is performed; and a calculating section adapted to calculate timing to stop the injection of air in the pneumatic spinning device based on a spinning condition, where, when splitting the fiber bundle, the control section stops the injection of air in the pneumatic spinning device based on the timing calculated by the calculating section.

[0007] In the spinning machine according to one aspect of the present invention, the injection of air in the pneumatic spinning device is stopped after the second drafting operation is performed in the draft device. The drafting ratio for the first drafting operation is different from the drafting ratio for the second drafting operation. Therefore, the state of the fiber bundle drafted by the second drafting operation is different from that of the fiber bundle drafted by the first drafting operation. When the ratio is increased to become higher than the drafting ratio for the first drafting operation and then the second drafting operation is performed, the fiber bundle drafted by the second drafting operation is stretched more than the fiber bundle drafted by the first drafting operation. Consequently, the fiber volume (the volume of fibers in a cross-sectional area orthogonal to the drafting direction) of the fiber bundle after the second drafting operation becomes smaller than that of the fiber bundle after the first drafting operation. When the ratio is reduced to become lower than the drafting ratio for the first drafting operation and then the second drafting operation is performed, the fiber bundle drafted by the second drafting operation becomes shorter than the fiber bundle drafted by the first drafting operation. Consequently, the fiber volume of the fiber bundle after the second drafting operation becomes larger than that of the fiber bundle after the first drafting operation. Thus, in the present spinning machine, the fiber volume of the fiber bundle can be adjusted by changing the drafting ratio for the first drafting operation and the drafting ratio of the second drafting operation. Therefore, in the spinning machine of the present invention, dimensions (thickness and/or length) of a fiber bundle portion (portion that is not twisted appropriately) that is formed at a yarn end of the yarn by the split (hereinafter also referred to as splitting operation) of the fiber bundle can be appropriately adjusted. The split of the fiber bundle can be said as split of a yarn.

[0008] The time until the fiber bundle drafted by the second drafting operation flows into the pneumatic spinning device differs according to the spinning condition, and the like. For example, when the injection of air in the pneumatic spinning device is stopped before the fiber bundle drafted by the second drafting operation flows into the pneumatic spinning device, the fiber bundle portion is formed in the fiber bundle in which the count is not changed. In this case, the adjustment of the dimension of the fiber bundle portion may not be carried out appropriately.

[0009] In the spinning machine according to one aspect of the present invention, the calculating section calculates the timing to stop the injection of air in the pneumatic spinning device based on the spinning condition. The control

section stops the injection of air in the pneumatic spinning device at the same time as or after at least one part of the fiber bundle drafted by the second drafting operation flows into the pneumatic spinning device based on the timing calculated by the calculating section. Thus, in the spinning machine, the fiber bundle portion is reliably formed in the fiber bundle drafted by the second drafting operation. Therefore, in the present spinning machine, the dimension of the fiber bundle portion can be automatically and appropriately adjusted according to the spinning condition.

[0010] In one embodiment, the draft device includes at least three roller pairs arranged along the draft path of the fiber bundle, the control section may cause the second drafting operation to be performed by changing a rotation speed of one or plurality of roller pairs other than a roller pair arranged on a most downstream side in the draft path, of the at least three roller pairs, and stop the injection of air in the pneumatic spinning device at the same time as or after at least one part of the fiber bundle flows into the pneumatic spinning device, the fiber bundle being located between a preceding roller pair which is a roller pair arranged on a most downstream side in the draft path, of the roller pairs in which the rotation speed is changed, and a following roller pair which is a roller pair arranged next to the preceding roller pair on a downstream side in the draft path, when the second drafting operation is performed (when the second drafting operation starts), the fiber bundle not being sandwiched by the following roller pair when the second drafting operation is performed (when the second drafting operation starts). In this configuration, the injection of air can be stopped at an appropriate timing. Thus, in the spinning machine, the twists can be avoided from being applied to all the fiber bundles drafted by the second drafting operation, and the fiber bundle portion is formed in the fiber bundle drafted by the second drafting operation. Therefore, in the present spinning machine, the dimension of the fiber bundle portion can be appropriately adjusted.

[0011] In one embodiment, the control section may stop the injection of air in the pneumatic spinning device when at least one part of the fiber bundle drafted by the second drafting operation is discharged from the outlet of the spinning section of the pneumatic spinning device, based on the timing calculated by the calculating section. In this configuration, the injection of air can be stopped at an appropriate timing.

[0012] In one embodiment, the spinning machine includes a yarn detecting device disposed on the downstream side of the travelling path of the yarn with respect to the pneumatic spinning device and adapted to detect the yarn defect of the yarn, where the control section may stop the injection of air in the pneumatic spinning device when at least one part of the fiber bundle drafted by the second drafting operation passes the yarn detecting device, based on the timing calculated by the calculating section. In this configuration, the injection of air can be stopped at an appropriate timing.

[0013] In one embodiment, the spinning machine includes a pull-out device disposed on the downstream side of the travelling path of the yarn with respect to the spinning device and adapted to pull out the yarn produced in the pneumatic spinning device, where the control section may stop the injection of air in the pneumatic spinning device when at least one part of the fiber bundle drafted by the second drafting operation reaches the pull out device, based on the timing calculated by the calculating section. In this configuration, the injection of air can be stopped at an appropriate timing.

[0014] In one embodiment, a spinning machine includes a pull-out device adapted to pull out the yarn produced in the pneumatic spinning device, and a yarn detecting device arranged between the pneumatic spinning device and the pull-out device in a travelling path of the yarn and adapted to detect a yarn defect of the yarn, where the draft device includes at least a first roller pair, a second roller pair, a third roller pair, and a fourth roller pair in order from the downstream side toward the upstream side in a draft path of the fiber bundle; the control section changes a ratio of the drafting ratio of the third roller pair and the fourth roller pair in the second drafting operation from the first drafting operation; the calculating section calculates a time as timing based on a distance in the draft path between the first roller pair and the second roller pair, a distance in the draft path between the second roller pair and the third roller pair, a value obtained by dividing the pull-out speed at which the pull-out device pulls out the yarn, by the rotation speed of the second roller pair, a value obtained by dividing the rotation speed of the second roller pair by the rotation speed of the third roller pair, a value obtained by dividing the pull-out speed by the rotation speed of the first roller pair, a distance in the travelling path of the fiber bundle and the yarn between the pneumatic spinning device and the first roller pair, a distance in the travelling path of the fiber bundle and the yarn between the yarn detecting device and the first roller pair, or a distance in the travelling path of the fiber bundle and the yarn between the pull-out device and the first roller pair, and the pull-out speed; and the control section may stop the injection of air in the pneumatic spinning device when the time has elapsed from detection of a yarn defect of the yarn by the yarn detecting device. In this configuration, the time until the fiber bundle drafted by the second drafting operation is discharged from the pneumatic spinning device can be appropriately calculated. Thus, in the spinning machine, the fiber bundle portion is formed in the fiber bundle drafted by the second drafting operation without the fiber bundle portion being formed in the fiber bundle drafted by the first drafting operation and without the twist being applied to all the fiber bundles drafted by the second drafting operation. Therefore, in the present spinning machine, the dimension of the fiber bundle portion can be appropriately adjusted.

[0015] In one embodiment, the pull-out device may be a yarn accumulating device adapted to accumulate the yarn while pulling out the yarn. In this configuration, the yarn can be stably pulled out from the pneumatic spinning device while removing slack of the yarn Y.

[0016] In one embodiment, the control section may increase the drafting ratio to a ratio higher than the drafting ratio

for the first drafting operation and cause the second drafting operation to be performed in the draft device. In this configuration, the fiber bundle drafted by the second drafting operation is stretched more than the fiber bundle drafted by the first drafting operation. Consequently, the fiber volume of the fiber bundle after the second drafting operation becomes smaller than that of the fiber bundle after the first drafting operation. For example, when producing the yarn of low count (thick yarn), the fiber volume of the fiber bundle supplied to the pneumatic spinning device in a unit time is large. In this case, the fiber bundle may not be appropriately split and a fiber bundle portion formed at the yarn end of yarn may become thicker and longer. In the present spinning machine, as the fiber volume of the fiber bundle is reduced by the second drafting operation when the fiber bundle is to be split, the fiber bundle portion can be suppressed from becoming thicker and longer. Therefore, in the spinning machine, dimension of the fiber bundle portion formed at the yarn end of yarn can be appropriately adjusted.

[0017] In one embodiment, the control section may cause the draft device to perform the second drafting operation when a count of the yarn produced by the pneumatic spinning device is lower than or equal to Ne 15. When producing a yarn with a count of lower than or equal to Ne 15, the fiber volume of the fiber bundle is relatively large, where if splitting of the fiber bundle is performed with such a large volume, the fiber bundle portion tends to become thicker and longer. Thus, in the spinning machine, when yarn with a count of Ne 15 or lower is generated, the second drafting operation is performed, whereby the fiber bundle portion can be prevented from becoming thicker and longer, and dimension of the fiber bundle portion can be adjusted appropriately.

[0018] In one embodiment, the control section may reduce the drafting ratio to a ratio lower than the drafting ratio for the first drafting operation and cause the second drafting operation to be performed in the draft device. In this configuration, the fiber volume of the fiber bundle after the second drafting operation becomes larger than that of the fiber bundle after the first drafting operation. Therefore, a situation in which the thickness of the fiber bundle portion becomes too small when the fiber bundle is split, making it difficult for a yarn catching device to catch the corresponding yarn end in the following yarn joining operation can be avoided.

[0019] In one embodiment, the control section may cause the fiber bundle to be drafted in the second drafting operation at a drafting ratio such that a count of the yarn produced by the pneumatic spinning device falls within a range higher than or equal to Ne 15 and lower than or equal to Ne 45. In this manner, the fiber volume of the fiber bundle of when being split can be adjusted to an appropriate volume by drafting the fiber bundle into a fiber bundle such that the count of the yarn falls within the range higher than or equal to Ne 15 and lower than or equal to Ne 45. Thus, in the spinning machine, the fiber bundle portion can be prevented from becoming too thick, too thin, too long, or too short. Furthermore, a situation in which fibers are more likely to fly in the surroundings because the fiber bundle portion is excessively thick and long can be avoided, and a situation in which it is difficult for the yarn catching device to catch the corresponding yarn end because the fiber bundle portion is too thin can be avoided.

[0020] In one embodiment, the spinning machine may include a plurality of spinning units, where each spinning unit including at least three roller pairs and a pneumatic spinning device, at least one roller pair of the at least three roller pairs being arranged to be independently rotationally drive for each spinning unit, and the control section may cause the second drafting operation to be performed by changing the rotation speed of the roller pair that is independently rotationally driven. According to such a configuration, the drafting ratio can be changed in the second drafting operation using the roller pair independently rotationally driven for each spinning unit. Thus, the second drafting operation can be performed at desired timing for each spinning unit.

[0021] In one embodiment, the spinning machine further includes a winding device adapted to wind the yarn produced by the pneumatic spinning device around a bobbin to form a package, where the control section has an adjustment mode of adjusting a dimension of a fiber bundle portion formed at a yarn end of the yarn by split of the fiber bundle, implementation/non-implementation of the adjustment mode is switchable between time of full wound in which a defined amount of yarn is wound into the package by the winding device and a normal time other than the time of full wound, the fiber bundle is split in the adjustment mode at the normal time, and the fiber bundle is not split in the adjustment mode at the time of full wound. The adjustment mode is a mode of stopping the injection of air in the pneumatic spinning device at the same time as or after at least one part of the fiber bundle drafted by the second drafting operation flows into the pneumatic spinning device based on the timing calculated by the calculating section.

[0022] In one embodiment, at the time of full wound, the control section stops rotation of the back roller pair which is a roller pair arranged most upstream in a drafting direction, of the plurality of roller pairs and continues the injection of air in the pneumatic spinning device until at least a time of a same length as the timing calculated by the calculating section has elapsed from when the rotation of the back roller pair is stopped.

[0023] A spinning method according to one aspect of the present invention is a spinning method performed in a spinning machine including a draft device including a plurality of rotatable roller pairs and adapted to draft a fiber bundle with the roller pairs, a pneumatic spinning device adapted to apply twists on the fiber bundle drafted by the draft device by injecting air to produce a yarn, and a control section adapted to, when splitting the fiber bundle, change a drafting ratio to a ratio different from a drafting ratio for a first drafting operation of drafting the fiber bundle and cause a second drafting operation of drafting the fiber bundle to be performed in the draft device, and to stop the injection of air in the pneumatic spinning

device after the second drafting operation is performed, the method including the steps of: calculating timing to stop the injection of air in the pneumatic spinning device based on a spinning condition; and stopping the injection of air in the pneumatic spinning device at the same time as or after at least one part of the fiber bundle drafted by the second drafting operation flows into the pneumatic spinning device based on the timing when splitting the fiber bundle.

[0024] In the spinning method according to one aspect of the present invention, the injection of air in the pneumatic spinning device is stopped after the second drafting operation is performed in the draft device. The state of the fiber bundle drafted by the second drafting operation is different from that of the fiber bundle drafted by the first drafting operation. When the ratio is increased to become higher than the drafting ratio for the first drafting operation and then the second drafting operation is performed, the fiber bundle drafted by the second drafting operation is stretched more than the fiber bundle drafted by the first drafting operation. Consequently, the fiber volume (the volume of fibers in a cross-sectional area orthogonal to the drafting direction) of the fiber bundle after the second drafting operation becomes smaller than that of the fiber bundle after the first drafting operation. When the ratio is reduced to become lower than the drafting ratio for the first drafting operation and then the second drafting operation is performed, the fiber bundle drafted by the second drafting operation becomes shorter than the fiber bundle drafted by the first drafting operation. Consequently, the fiber volume of the fiber bundle after the second drafting operation becomes larger than that of the fiber bundle after the first drafting operation. In this manner, in the spinning method, the fiber volume of the fiber bundle can be adjusted by changing the drafting ratio for the first drafting operation and the drafting ratio for the second drafting operation. Therefore, in the spinning method, dimensions (thickness and/or length) of a fiber bundle portion (portion that is not twisted appropriately) that is formed in a yarn end of yarn by the splitting operation can be appropriately adjusted.

[0025] In the spinning method according to one aspect of the present invention, the timing to stop the injection of air in the pneumatic spinning device is calculated based on the spinning condition, and the injection of air in the pneumatic spinning device is stopped at the same time as or after at least one part of the fiber bundle drafted by the second drafting operation flows into the pneumatic spinning device based on the timing. Thus, in the spinning method, the fiber bundle portion is reliably formed in the fiber bundle drafted by the second drafting operation. Therefore, in the spinning method, the dimension of the fiber bundle portion can be appropriately adjusted.

[0026] According to one aspect of the present invention, the dimension of the fiber bundle portion formed at the yarn end of the yarn can be adjusted.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027]

FIG. 1 is a front view of a spinning machine according to one embodiment;
FIG. 2 is a side view of a spinning unit of the spinning machine in FIG. 1;
FIG. 3 is a longitudinal cross-sectional view of a pneumatic spinning device of the spinning unit in FIG. 2;
FIG. 4 is a longitudinal cross-sectional view of the pneumatic spinning device during movement from a spinning position to a receded position;
FIG. 5 is a longitudinal cross-sectional view of the pneumatic spinning device at the receded position;
FIG. 6 is a view according to one embodiment, illustrating a fiber volume of a yarn and timing to stop air injection in the pneumatic spinning device; and
FIG. 7 is a view according to an alternative embodiment, illustrating a timing chart of the operations of a draft device and the pneumatic spinning device when the package is fully wound.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0028] Preferred embodiments of the present invention will be hereinafter described in detail with reference to the accompanied drawings. The same or corresponding components are denoted with the same reference numerals in the description of the drawings, and the redundant description will be omitted.

[0029] As illustrated in FIG. 1, a spinning machine 1 includes a plurality of spinning units 2, a yarn joining cart 3, a doffing cart (not illustrated), a first end frame 4, and a second end frame 5. The plurality of spinning units 2 are arranged in a row. Each of the spinning units 2 is adapted to produce a yarn Y and to wind the yarn Y around a package P. The yarn joining cart 3 is adapted to perform a yarn joining operation in a spinning unit 2 after the yarn Y is cut, or is broken for some reason in such a spinning unit 2. The doffing cart is adapted to doff the package P and to supply a new bobbin B to the spinning unit 2 when the package P is fully wound in a spinning unit 2.

[0030] The first end frame 4 accommodates, for example, a collecting device adapted to collect fiber waste, yarn waste, and the like generated in the spinning units 2. The second end frame 5 accommodates an air supplying section adapted to adjust air pressure of compressed air (air) to be supplied to the spinning machine 1 and to supply the air to each section of the spinning machine 1, a drive motor adapted to supply power to each section of the spinning unit 2,

and the like. The second end frame 5 is provided with a machine control device 100, a display screen 102, and an input key 104. The machine control device 100 is adapted to intensively manage and control each section of the spinning machine 1. The display screen 102 is capable of displaying information relating to set contents and/or status of the spinning unit 2, or the like. An operator can make the settings of the spinning units 2 by performing appropriate operations with the input keys 104.

[0031] As illustrated in FIGS. 1 and 2, each spinning unit 2 includes, in the order from the upstream side in a travelling direction of the yarn Y, a draft device 6, a pneumatic spinning device 7, a yarn monitoring device (yarn detecting device) 8, a tension sensor 9, a yarn accumulating device (pull-out device) 11, a waxing device 12, and a winding device 13. A unit controller (control section, calculating section) 10 is provided for every predetermined number of the spinning units 2 and is adapted to control operations of the spinning units 2. The unit controller 10 may be provided individually to each spinning unit 2.

[0032] The draft device 6 is adapted to draft a fiber bundle (sliver) F. The draft device 6 includes, in the order from the upstream side in a travelling direction of the fiber bundle F, a back roller pair (fourth roller pair) 14, a third roller pair (third roller pair) 15, a middle roller pair (second roller pair) 16, and a front roller pair (first roller pair) 17. In other words, in the draft device 6, the four draft roller pairs 14 to 17 are arranged in the order of the front roller pair 17, the middle roller pair 16, the third roller pair 15, and the back roller pair 14 from the downstream side toward the upstream side in a draft path of the fiber bundle F.

[0033] The back roller pair 14 has a top roller 14a and a bottom roller 14b. The third roller pair 15 has a top roller 15a and a bottom roller 15b. The middle roller pair 16 has a top roller 16a and a bottom roller 16b. The front roller pair 17 has a top roller 17a and a bottom roller 17b. The bottom rollers 14b, 15b, 16b, and 17b are rotationally driven by a drive motor provided on the second end frame 5 or a drive motor provided on each spinning unit 2. In the present embodiment, the bottom rollers 14b and 15b are rotationally driven by a drive motor provided on each spinning unit 2. The bottom rollers 16b and 17b are rotationally driven by a drive motor provided on the second end frame 5. An apron belt 18a is wound around the top roller 16a of the middle roller pair 16. An apron belt 18b is wound around the bottom roller 16b of the middle roller pair 16.

[0034] The pneumatic spinning device 7 is adapted to twist the fiber bundle F drafted by the draft device 6 with a whirling airflow to produce the yarn Y. As illustrated in FIG. 3, the pneumatic spinning device 7 injects air to the fiber bundle F drafted by the draft device 6 to apply twists to the fiber bundle and produce the yarn Y at a spinning position. The spinning position is a position of the pneumatic spinning device 7 where the pneumatic spinning device 7 is disposed close to the draft device 6 (specifically, the front roller pair 17) during spinning when the fiber bundle F is supplied from the draft device 6 to the pneumatic spinning device 7. The pneumatic spinning device 7 includes a nozzle block 70 and a hollow guide shaft body 80. The hollow guide shaft body 80 is inserted into the nozzle block 70 from the downstream side. An internal space formed by the nozzle block 70 and the hollow guide shaft body 80 is a spinning chamber 73.

[0035] The nozzle block 70 includes a fiber guiding portion 71 and a whirling flow generating portion 72. In the fiber guiding portion 71, a guide hole 71a is provided for guiding the fiber bundle F supplied from the draft device 6 to the spinning chamber 73. The fiber guiding portion 71 is provided with a needle 75. A tip 75a of the needle 75 is located in the spinning chamber 73. The needle 75 has a function of suppressing a twist from being propagated to the upstream of the spinning chamber 73. In the whirling flow generating portion 72, a plurality of nozzles 74 communicating with the spinning chamber 73 are formed. The plurality of nozzles 74 are arranged such that the whirling flow is generated in the spinning chamber 73 when air is injected. In the whirling flow generating portion 72, a hole portion 72a, into which the hollow guide shaft body 80 is inserted, is formed. The hole portion 72a is formed to a shape of truncated cone that tapers off toward the upstream side, and is communicated with the spinning chamber 73.

[0036] The hollow guide shaft body 80 can be inserted into the hole portion 72a of the whirling flow generating portion 72. An upper end portion 80a of the hollow guide shaft body 80 is formed to a shape of truncated cone that tapers off toward the upstream side. In the hollow guide shaft body 80, a channel 81 extending along the central axis of the hollow guide shaft body 80 is formed. The upstream side of the channel 81 is communicated with the spinning chamber 73, and the channel 81 is formed so as to widen toward an outlet 83 on the downstream side. A collecting portion 77 is communicated with the spinning chamber 73 through a gap formed between the upper end portion 80a of the hollow guide shaft body 80 and the hole portion 72a of the whirling flow generating portion 72. In the present embodiment, the spinning chamber 73 and the channel 81 are collectively referred to as a spinning section. The fiber bundle F is changed to the yarn Y in the spinning section. The produced yarn Y is discharged from the outlet 83 through the channel 81. Fibers that have not formed the yarn Y are collected in the collecting portion 77.

[0037] The pneumatic spinning device 7 is movably (rotatably) supported by a support shaft (not illustrated). As illustrated in FIGS. 4 and 5, the pneumatic spinning device 7 is movable to a receded position, which is more distant from the draft device 6 than the spinning position. The hollow guide shaft body 80 is further movable from the nozzle block 70 at the receded position. When the pneumatic spinning device 7 is moved from the spinning position to the receded position, as illustrated in FIG. 4, the nozzle block 70 and the hollow guide shaft body 80 are integrally separated from the draft device 6. Subsequently, as illustrated in FIG. 5, only the nozzle block 70 is stopped at a predetermined

position. The hollow guide shaft body 80 continues to be moved, and is separated from the nozzle block 70. Subsequently, the hollow guide shaft body 80 separated from the nozzle block 70 is stopped at a predetermined position.

[0038] As illustrated in FIGS. 1 and 2, the yarn monitoring device 8 monitors information on a travelling yarn Y at between the pneumatic spinning device 7 and the yarn accumulating device 11 to detect the presence or absence of a yarn defect on the basis of the monitored information. When detecting the yarn defect, the yarn monitoring device 8 transmits a yarn defect detection signal to the unit controller 10. The yarn monitoring device 8 detects a thickness abnormality of the yarn Y and/or a foreign substance included in the yarn Y, for example, as the yarn defect. The yarn monitoring device 8 also detects yarn breakage or the like. The tension sensor 9 is adapted to measure tension of the travelling yarn Y between the pneumatic spinning device 7 and the yarn accumulating device 11, and to transmit a tension measurement signal to the unit controller 10. When the unit controller 10 determines presence of an abnormality based on a detection result of the yarn monitoring device 8 and/or the tension sensor 9, the yarn Y is cut (split) in the spinning unit 2.

[0039] The waxing device 12 is adapted to apply wax to the yarn Y between the yarn accumulating device 11 and the winding device 13.

[0040] The yarn accumulating device 11 is adapted to accumulate the yarn Y between the pneumatic spinning device 7 and the winding device 13. The yarn accumulating device 11 has a function of stably pulling out the yarn Y from the pneumatic spinning device 7, a function of preventing the yarn Y from slackening by accumulating the yarn Y fed from the pneumatic spinning device 7 at the time of the yarn joining operation or the like by the yarn joining cart 3, and a function of preventing variation in the tension of the yarn Y on the downstream side of the yarn accumulating device 11 from being propagated to the pneumatic spinning device 7.

[0041] The winding device 13 is adapted to wind the yarn Y around a bobbin B to form a package P. The winding device 13 includes a cradle arm 21, a winding drum 22, and a traverse guide 23. The cradle arm 21 rotatably supports the bobbin B.

[0042] After the yarn Y is cut, or is broken for some reason in a spinning unit 2, the yarn joining cart 3 travels to such a spinning unit 2 to perform the yarn joining operation. The yarn joining cart 3 includes a yarn joining device 26, a suction pipe (yarn catching device) 27, and a suction mouth (yarn catching device) 28. The suction pipe 27 is swingably supported by a support shaft 31, and is adapted to catch the yarn Y from the pneumatic spinning device 7 and to guide the caught yarn Y to the yarn joining device 26. When having caught the yarn end of the yarn Y, the suction pipe 27 cuts off the fiber bundle portion Y1 formed at the yarn end, and guides the yarn end of the yarn Y, from which the fiber bundle portion Y1 has been cut off, to the yarn joining device 26. The suction mouth 28 is swingably supported by a support shaft 32, and is adapted to catch the yarn Y from the winding device 13 and to guide the caught yarn Y to the yarn joining device 26. When having caught the yarn end of the yarn Y, the suction mouth 28 cuts off the fiber bundle portion Y1 formed at the yarn end, and guides the yarn end of the yarn Y, from which the fiber bundle portion Y1 has been cut off, to the yarn joining device 26. The yarn joining device 26 is adapted to join the guided yarns Y together. The yarn joining device 26 is a splicer using the compressed air, a knotter adapted to join the yarns Y together in a mechanical manner, or the like. When the yarn joining cart 3 performs the yarn joining operation, the package P is rotated in an unwinding direction (reversely rotated).

[0043] The operation (spinning method) related to adjusting the length of the fiber bundle portion Y1 formed at the yarn end of yarn Y will now be described. The fiber bundle portion Y1 refers to a region where twist is not applied at the yarn end of yarn Y continuing to the package P, as illustrated in FIG. 5. The operation of forming the fiber bundle portion Y1 is performed, for example, when a yarn defect is detected and spinning is stopped accordingly, or when the package P is in a fully wound state and the spinning is terminated accordingly.

[0044] When splitting the fiber bundle F, the unit controller 10 changes a drafting ratio to a ratio different from the drafting ratio for a first drafting operation of drafting the fiber bundle F so as to achieve a count of the yarn Y produced by the pneumatic spinning device 7 and causes a second drafting operation of drafting the fiber bundle F to be performed in the draft device 6, and furthermore, causes the injection of air in the pneumatic spinning device 7 to be stopped after the second drafting operation is performed.

[0045] The unit controller 10 calculates timing to stop the injection of air in the pneumatic spinning device 7 based on a spinning condition. The spinning condition may include spinning speed, drafting ratio, draft gauge, and the like. When splitting the fiber bundle F, the unit controller 10 stops the injection of air in the pneumatic spinning device 7 at the same time as or after at least one part of the fiber bundle F drafted by the second drafting operation flows into the pneumatic spinning device 7 based on the timing described above.

[0046] In the present embodiment, the unit controller 10 changes the rotation speed of the back roller pair 14 and causes the second drafting operation to be performed. In other words, the unit controller 10 changes the rotation speed of the draft roller pair other than the front roller pair 17 and causes the second drafting operation to be performed. The unit controller 10 stops the injection of air in the pneumatic spinning device 7 after at least one part of "the fiber bundle F located between a preceding roller pair, which is the roller pair arranged on the most downstream side in the draft path of the roller pair (one or a plurality of roller pairs 14, 15, 16) in which the rotation speed is changed, and a following

roller pair, which is the roller pair (one of the roller pairs 14, 16, 17) arranged one roller pair downstream of the preceding roller pair at the time point the second drafting operation is performed (at the time point the second drafting operation starts), the fiber bundle F not having been sandwiched by the following roller pair at the time point the second drafting operation is performed (at the time point the second drafting operation starts)" flows into the pneumatic spinning device 7. For example, when the roller pair in which the rotation speed is changed is the back roller pair 14, the injection of air in the pneumatic spinning device 7 is stopped after at least one part of the fiber bundle F that is located between the back roller pair 14 and the third roller pair 15 and that has not been sandwiched by the third roller pair 15 at the time point the second drafting operation starts flows into the pneumatic spinning device 7.

[0047] The unit controller 10 calculates a time T from when receiving the yarn defect detection signal transmitted from the yarn monitoring device 8 until stopping the injection of air in the pneumatic spinning device 7 as the timing to stop the injection of air in the pneumatic spinning device 7. In the present embodiment, a case of changing the rotation speed of the back roller pair 14 (bottom roller 14b) will be described for the second drafting operation. In this case, the unit controller 10 calculates the time T[msec] based on the following equation (1).

$$T = \{(D1 \times M \times I/Fe) + (D2 \times M/Fe) + D3\}/(S/60) + c \quad \ldots(1)$$

D1 [mm] is a distance in the draft path between the third roller pair 15 and the middle roller pair 16 (distance between centers of the third roller pair 15 and the middle roller pair 16). D1 is also referred to as a draft gauge of the third roller pair 15 and the middle roller pair 16.

[0048] M is a main drafting ratio. M is a value (spinning speed/middle roller rotation speed) obtained by dividing the spinning speed [m/min] by the rotation speed [m/min] of the middle roller pair 16. In the present embodiment, the spinning speed corresponds to the pull-out speed at which the yarn accumulating device 11 pulls out the yarn Y.

[0049] I is an intermediate drafting ratio. I is a value (middle roller rotation speed/third roller rotation speed) obtained by dividing the rotation speed [m/min] of the middle roller pair 16 by the rotation speed [m/min] of the third roller pair 15.

[0050] Fe is a feed ratio. Fe is a value (spinning speed/front roller rotation speed) obtained by dividing the spinning speed [m/min] by the rotation speed [m/min] of the front roller pair 17.

[0051] D2[mm] is a distance in the draft path between the middle roller pair 16 and the front roller pair 17 (distance between centers of the middle roller pair 16 and the front roller pair 17). D2 is also referred to as a draft gauge of the middle roller pair 16 and the front roller pair 17.

[0052] D3 [mm] is a distance in the travelling path of the fiber bundle F and the yarn Y between the outlet 83 of the hollow guide shaft body 80 and the front roller pair 17.

[0053] S[m/min] is a spinning speed.

[0054] c is a constant set based on an environment of the spinning machine 1. c is, for example, a constant set in view of the communication environment (signal delay) between the yarn monitoring device 8 and the unit controller 10, deaerating delay in the pneumatic spinning device 7, and the like. c is, for example, "-10". "60" is a numerical value for converting the unit of the time T to [msec].

[0055] The time T corresponds to a time (first time) from when the yarn defect is detected in the yarn monitoring device 8 (when the yarn defect signal is received by the unit controller 10) until one part (head) of the fiber bundle F (fiber bundle F drafted by the second drafting operation) between the back roller pair 14 and the third roller pair 15 is discharged from the outlet 83 of the pneumatic spinning device 7.

[0056] The unit controller 10 calculates the time T based on the information (spinning condition, etc.) set in advance in a storage section (not illustrated). Specifically, in the case where the spinning condition (production lot) is input with the input keys 104 of the machine control device 100, the unit controller 10 calculates the time T based on the spinning condition.

[0057] In the present embodiment, a method of adjusting the length of the fiber bundle portion Y1 when spinning the yarn Y with a low count (e.g., lower than Ne 15), will be described with reference to FIG. 6. In Fig.6, a chain dashed line indicates a fiber volume of the yarn Y, and a solid line indicates the timing of control of the draft device 6 and the pneumatic spinning device 7 by the unit controller 10. A vertical axis of FIG. 6 indicates increase and decrease of the fiber volume of the yarn Y. A horizontal axis of FIG. 6 indicates elapse of time.

[0058] When a yarn defect is detected by the yarn monitoring device 8 during spinning, the yarn defect detection signal is transmitted to the unit controller 10. In FIG. 6, a portion indicated by surrounding the chain dashed line with a chain line indicates that the yarn defect (thickness abnormality of the yarn Y) occurs. When having received the yarn defect detection signal, the unit controller 10 controls the operation of the draft device 6. Specifically, when having received the yarn defect detection signal at the time point of time T1, the unit controller 10 increases the drafting ratio to a ratio higher than the drafting ratio for the first drafting operation of drafting the fiber bundle F to achieve the count of the yarn Y to be produced by the pneumatic spinning device 7, and causes the second drafting operation of drafting the fiber

bundle F to be performed. In other words, when having received the yarn defect detection signal, the unit controller 10 changes a total drafting ratio of the draft device 6.

[0059] Specifically, the unit controller 10 changes the total drafting ratio of the draft device 6 such that the count becomes finer than the count of the yarn Y that is currently being spun. Specifically, the unit controller 10 changes the drafting ratio (brake drafting ratio) between the back roller pair 14 and the third roller pair 15. For example, when spinning the yarn Y with a count of Ne 10, the unit controller 10 changes the drafting ratio to a drafting ratio for spinning the yarn Y with a count of Ne 35. Specifically, the unit controller 10 changes the rotation speed (increases the rotation speed) of the back roller pair 14 and maintains the rotation speed of the draft roller pairs 15, 16, 17 other than the back roller pair 14 (maintains the rotation speed of at least the front roller pair 17) to change the brake drafting ratio, thus having the total drafting ratio to, for example, 3.5 times the yarn Y with the count of Ne 10. The total drafting ratio in the draft device 6 is thereby changed, and the fiber bundle F is drafted into a fiber bundle F for spinning the yarn Y with a count of Ne 35.

[0060] The unit controller 10 sets a drafting ratio for performing the second drafting operation in the draft device 6 based on information that is set in advance in the storage section. The storage section stores therein yarn counts and drafting ratios for the second drafting operation corresponding to the respective counts. The drafting ratio for the second drafting operation is set such that the count of the yarn Y produced by the pneumatic spinning device 7 falls within a range higher than or equal to Ne 15 and lower than or equal to Ne 45. In other words, in the second drafting operation, the unit controller 10 causes the fiber bundle F to be drafted at a drafting ratio such that the count of the yarn Y produced by the pneumatic spinning device 7 falls within the range higher than or equal to Ne 15 and lower than or equal to Ne 45. The count of the yarn Y is more preferably set to fall within a range higher than or equal to Ne 30 and lower than or equal to Ne 40. For example, in the case where the spinning condition is input with the input keys 104, the unit controller 10 acquires from the storage section a drafting ratio for the second drafting operation corresponding to the count of the yarn Y (count of the yarn Y to produce) input as one of the spinning conditions. The drafting ratio for the second drafting operation may be set by, for example, operator's input with the input keys 104.

[0061] Then, after changing the total drafting ratio, the unit controller 10 causes the draft device 6 to draft the fiber bundle F for a predetermined time (perform the second drafting operation), and then controls the draft device 6 such that rotation of the back roller pair 14 stops (perform the splitting operation). The predetermined time is the time T described above from when the yarn defect detection signal transmitted from the yarn monitoring device 8 is received until when the fiber bundle F of finer count is discharged from the pneumatic spinning device 7. In other words, after the fiber bundle F of finer count flows into the pneumatic spinning device 7 and then is discharged from the pneumatic spinning device 7, the unit controller 10 controls the draft device 6 such that rotation of the back roller pair 14 stops. Because the front roller pair 17 is connected to the drive source different from that of the back roller pair 14, the front roller pair 17 continues to be driven. Consequently, the fiber bundle F is split between the back roller pair 14 and the front roller pair 17.

[0062] Furthermore, the unit controller 10 controls the pneumatic spinning device 7 to stop the injection of air from the plurality of nozzles 74. Specifically, the unit controller 10 stops the injection of air by the plurality of nozzles 74 on the basis of the time T calculated based on the equation (1) described above. That is, the unit controller 10 stops the injection of air by the plurality of nozzles 74 so that twists are not applied to all the fiber bundles F subjected to the second drafting operation. Specifically, as illustrated in FIG. 6, when having received the yarn defect detection signal at time T1, the unit controller 10 stops the injection of air by the plurality of nozzles 74 at time T2 after elapse of time T. Thus, as illustrated in FIG. 6, the air is not injected to all the fiber bundles F, in which the fiber volume has reduced by the second drafting operation, whereby the twists can be prevented from being applied to all the fiber bundles F by the second drafting operation.

[0063] The unit controller 10 then controls the pneumatic spinning device 7 so as to cause the pneumatic spinning device 7 to start moving from the spinning position to the receded position. According to such operations, the yarn Y is split, and the fiber bundle portion Y1 is formed at the yarn end of the yarn Y.

[0064] A case of interrupting the spinning when the yarn defect is detected by the yarn monitoring device 8 has been described above, but similar operations are also performed in a case of terminating the spinning when determined that a package P is in a fully wound state. In this case, the length of the fiber bundle portion Y1 is preferably reduced to prevent a knot from breaking when the package P is hung on a warper in the next step.

[0065] As described above, the spinning machine 1 according to the present embodiment causes the second drafting operation to be performed in the draft device 6, and then stops the injection of air in the pneumatic spinning device 7 The fiber bundle F drafted by the second drafting operation is stretched more than the fiber bundle F drafted by the first drafting operation. Thus, the fiber volume of the fiber bundle F after the second drafting operation becomes smaller than that of the fiber bundle F after the first drafting operation. For example, when producing the yarn Y with low count (coarse count yarn), the fiber volume of the fiber bundle F to be supplied to the pneumatic spinning device 7 is large. In this case, the fiber bundle F may not be appropriately split when the fiber bundle F is split, and the fiber bundle portion (portion that has not been appropriately applied with twists) Y1 formed at the yarn end of the yarn Y may become longer. In the spinning machine 1, as the fiber volume of the fiber bundle F is reduced by the second drafting operation when

the fiber bundle F is to be split, the fiber bundle portion Y1 can be suppressed from becoming longer when the fiber bundle F is split. Thus, in the spinning machine 1, the length of the fiber bundle portion Y1 formed at the yarn end of the yarn Y can be adjusted appropriately.

[0066] Furthermore, as the fiber bundle portion Y1 can be prevented from becoming longer, fibers can be reduced from flying in the surroundings of the front roller pair 17, and attaching to the front roller pair 17, and the like.

[0067] The time until the fiber bundle F drafted by the second drafting operation flows into the pneumatic spinning device 7 differs according to the spinning condition and the like. For example, when the injection of air in the pneumatic spinning device 7 is stopped before the fiber bundle F drafted by the second drafting operation flows into the pneumatic spinning device 7, the fiber bundle portion Y1 is formed in the fiber bundle F in which the count is not changed. In this case, the adjustment of the dimension of the fiber bundle portion Y1 may not be carried out appropriately.

[0068] In the spinning machine 1 according to the present embodiment, the unit controller 10 calculates the timing to stop the injection of air in the pneumatic spinning device 7 based on the spinning condition. The unit controller 10 stops the injection of air in the pneumatic spinning device 7 after at least one part of the fiber bundle F drafted by the second drafting operation flows into the pneumatic spinning device 7 based on the calculated timing. Thus, in the spinning machine 1, the fiber bundle portion Y1 is reliably formed in the fiber bundle F drafted by the second drafting operation. Thus, in the spinning machine 1, the dimension of the fiber bundle portion Y1 can be appropriately adjusted.

[0069] The spinning machine 1 according to the present embodiment includes the yarn accumulating device 11 adapted to pull out the yarn produced in the pneumatic spinning device 7, and the yarn monitoring device 8 arranged between the pneumatic spinning device 7 and the yarn accumulating device 11 in the travelling path of the yarn Y to detect the yarn defect of the yarn Y. The draft device 6 includes the front roller pair 17, the middle roller pair 16, the third roller pair 15, and the back roller pair 14 in this order from the downstream side toward the upstream side in the draft path of the fiber bundle F.

[0070] In the spinning machine 1 according to the present embodiment, the unit controller 10 calculates a time from when receiving the yarn defect detection signal transmitted from the yarn monitoring device 8 until when stopping the injection of air in the pneumatic spinning device 7. In the present embodiment, the unit controller 10 calculates the time T from the equation (1) mentioned above. In this configuration, the time until the fiber bundle F drafted by the second drafting operation is discharged from the pneumatic spinning device 7 can be appropriately calculated. Therefore, in the spinning machine 1, the fiber bundle portion Y1 is formed in the fiber bundle F drafted by the second drafting operation without the fiber bundle portion Y1 being formed in the fiber bundle F drafted by the first drafting operation and without twists being applied to all the fiber bundles F drafted by the second drafting operation. Thus, in the spinning machine 1, the dimension of the fiber bundle portion Y1 can be appropriately adjusted.

[0071] In the spinning machine 1 according to the present embodiment, the unit controller 10 causes the fiber bundle F to be drafted in the second drafting operation at a drafting ratio such that the count of the yarn Y produced by the pneumatic spinning device 7 falls within a range higher than or equal to Ne 15 and lower than or equal to Ne 45. In this manner, the fiber volume of the fiber bundle F when being split can be adjusted to an appropriate volume by drafting the fiber bundle F into a fiber bundle such that the count of the yarn Y falls within the range higher than or equal to Ne 15 and lower than or equal to Ne 45. Therefore, in the spinning machine 1, the fiber bundle portion Y1 can be prevented from becoming too thick, too thin, too long, or too short. Furthermore, a situation in which fibers are more likely to fly in the surroundings because the fiber bundle portion Y1 is excessively thick and long can be avoided, and a situation in which it is difficult for the suction type catching device such as the suction pipe 27 and the suction mouth 28 to catch the corresponding yarn end because the fiber bundle portion Y1 is too thin can be avoided.

[0072] In the spinning machine 1 according to the present embodiment, the unit controller 10 causes the draft device 6 to perform the second drafting operation when the count of the yarn Y produced by the pneumatic spinning device 7 is lower than Ne 15. When producing the yarn Y with a count lower than Ne 15, the fiber volume of the fiber bundle F is relatively large. Thus, in the spinning machine 1, the fiber bundle portion Y1 can be prevented from becoming longer, and the length of the fiber bundle portion Y1 can be appropriately adjusted by causing the second drafting operation to be performed when producing the yarn Y with a count lower than Ne 15.

[0073] An embodiment of the present invention has been described, but the present invention is not necessarily limited to the above-described embodiment, and various changes can be made within a scope not deviating from the gist of the invention.

[0074] In the embodiment described above, a mode in which, in the spinning machine 1, the total drafting ratio of the draft device 6 is changed such that the count becomes finer than the count of the yarn Y that is currently being spun has been described as by way of example. However, in the spinning machine, the total drafting ratio of the draft device 6 may be changed such that the count becomes coarser than the count of the yarn Y that is currently being spun. Specifically, the unit controller 10 reduces the drafting ratio to a ratio lower than the drafting ratio for the first drafting operation and causes the second drafting operation to be performed in the draft device 6, and then causes the splitting operations to be performed.

[0075] Thus, the unit controller 10 of the present invention has an adjustment mode (yarn end control mode) of

"changing the drafting ratio to a ratio different from the drafting ratio for the first drafting operation of drafting the fiber bundle F to achieve the count of the yarn Y to be produced in the pneumatic spinning device 7 and causing the second drafting operation of drafting the fiber bundle F to be performed in the draft device 6, calculating stop timing of the injection so that the injection of air in the pneumatic spinning device 7 can be stopped at the same time as or after at least one part of the fiber bundle F drafted by the second drafting operation flows into the pneumatic spinning device 7, and stopping the injection based on the calculated stop timing".

[0076] The drafting ratio for the first drafting operation is different from the drafting ratio for the second drafting operation. Therefore, the state of the fiber bundle F drafted by the second drafting operation is different from that of the fiber bundle F drafted by the first drafting operation. When the drafting ratio is increased to become higher than the drafting ratio for the first drafting operation and then the second drafting operation is performed, the fiber bundle F drafted by the second drafting operation is stretched more than the fiber bundle F drafted by the first drafting operation. Thus, the fiber volume of the fiber bundle F after the second drafting operation becomes smaller than that of the fiber bundle F after the first drafting operation. When the ratio is reduced to become lower than the drafting ratio for the first drafting operation and then the second drafting operation is performed, the fiber bundle F drafted by the second drafting operation becomes shorter than the fiber bundle F drafted by the first drafting operation. Consequently, the fiber volume of the fiber bundle F after the second drafting operation becomes larger than that of the fiber bundle F after the first drafting operation. In this manner, in the spinning machine 1, the fiber volume of the fiber bundle F can be adjusted by changing the drafting ratio for the first drafting operation and the drafting ratio for the second drafting operation.

[0077] Therefore, the spinning machine 1 can appropriately adjust the dimension of the fiber bundle portion Y1 formed at the yarn end of the yarn Y by the adjustment mode. Thus, in the spinning machine 1, even when yarn Y is produced at a count not desirable for the split of the fiber bundle F, this adjustment enables the yarn to be split in an appropriate count in the splitting operation.

[0078] The count of the yarn Y that can be produced with the drafting ratio for the second drafting operation, that is, the count of the yarn Y that is preferable for splitting can be set based on the quality and the operating performance. The quality herein is the amount of fly waste in the fiber bundle portion Y1. The operating performance herein is the ratio of successful yarn end finding in the yarn joining cart 3. The quality above tends to deteriorate as the count decreases (as yarn Y becomes thicker), and tends to improve as the count increases (yarn Y becomes thinner). In other words, the amount of fly waste increases as the count decreases, and decreases as the count increases. The operating performance above tends to become higher as the count decreases, and tends to become lower as the count increases. In other words, the ratio of successful yarn end finding becomes higher as the count decreases, and becomes lower as the count increases. From the viewpoint of balance between the quality and the operating performance, the count is preferably 15 to 45, for example. However, the count is not limited to 15 to 45.

[0079] The count above may be freely set by a user, depending on which of the quality and the operating performance to emphasize. The user may set in advance a predetermined count range (e.g., other than a range of "Ne o to Ne o", more specifically, other than Ne 15 to Ne 45, for example) when performing the yarn end control described above and a target splitting count (e.g., Ne o, more specifically, Ne 30, for example) to be achieved by the second drafting operation by operating an operation unit (e.g., input keys 104, touch panel to be described later, etc.). When the yarn defect is detected, for example, during spinning in the predetermined count range, the unit controller 10 may cause the second drafting operation to be performed at a drafting ratio corresponding to the target splitting count, and then may cause the splitting operation to be performed.

[0080] In the embodiment described above, a mode in which the bottom rollers 14b and 15b are rotationally driven by the drive motor provided to each spinning unit 2, and the bottom rollers 16b and 17b are rotationally driven by the drive motor provided to the second end frame 5 has been described by way of example. In such configuration, a mode of performing the second drafting operation by changing the drafting ratio of the back roller pair 14 and the third roller pair 15 of the draft device 6 has been described by way of example. However, the bottom rollers 14b, 15b, 16b, and 17b may be configured to be rotationally driven by a drive motor provided to each spinning unit 2. In this configuration, the second drafting operation may be performed by changing the drafting ratio of any roller pair among the back roller pair 14, the third roller pair 15, and the middle roller pair 16. In other words, the second drafting operation is preferably performed by changing the rotation speed of the draft roller pair independently rotationally driven for every spinning unit 2.

[0081] Specifically, for example, the unit controller 10 changes the drafting ratio of the third roller pair 15 and the middle roller pair 16. Specifically, the unit controller 10 changes the rotation speed of the third roller pair 15, and changes the intermediate drafting ratio (drafting ratio between the third roller pair 15 and the middle roller pair 16) to change the total drafting ratio. In such a configuration, the unit controller 10 calculates the time T[msec] based on the following equation (2).

$$T = \{(D2 \times M/Fe\} + D3\}/(S/60) + c \quad \ldots(2)$$

[0082] Furthermore, for example, the unit controller 10 changes the drafting ratio of the middle roller pair 16 and the front roller pair 17. Specifically, the unit controller 10 changes the rotation speed of the middle roller pair 16, and changes the drafting ratio (drafting ratio between the middle roller pair 16 and the front roller pair 17) to change the total drafting ratio. In such a configuration, the unit controller 10 calculates the time T[msec] based on the following equation (3).

$$T = D3/(S/60) + c \quad \ldots(3)$$

[0083] Therefore, in the unit controller 10, the time until the fiber bundle F drafted by the second drafting operation is discharged from the pneumatic spinning device 7 can be appropriately calculated. Therefore, in the spinning machine 1, the twists can be avoided from being applied to all the fiber bundles F drafted by the second drafting operation, and thus the fiber bundle portion Y1 is formed in the fiber bundle F drafted by the second drafting operation. Thus, in the spinning machine 1, the dimension of the fiber bundle portion can be appropriately adjusted.

[0084] Furthermore, in the equations (1), (2), and (3) described above, D3 may be "a distance in the travelling path of the fiber bundle F and the yarn Y between the inlet of the spinning chamber 73 (inlet of the spinning section) and the front roller pair 17" instead of "a distance in the travelling path of the fiber bundle F and the yarn Y between the outlet 83 of the hollow guide shaft body 80 (outlet of the spinning section) and the front roller pair 17". In this case, the time until the fiber bundle F drafted by the second drafting operation flows into the pneumatic spinning device 7 can be appropriately calculated in the unit controller 10. Therefore, the injection of air in the pneumatic spinning device 7 can be stopped at the same time that at least one part (head portion) of the fiber bundle drafted by the second drafting operation flows into the pneumatic spinning device 7. In this case as well, in the spinning machine 1, the twists can be avoided from being applied to all the fiber bundles F drafted by the second drafting operation, and thus the fiber bundle portion Y1 is formed in the fiber bundle F drafted by the second drafting operation. Thus, in the spinning machine 1, the dimension of the fiber bundle portion can be appropriately adjusted. D3 may be "a distance in the travelling path of the fiber bundle F and the yarn Y between the pneumatic spinning device 7 (arbitrary position in the pneumatic spinning device 7) and the front roller pair 17". The arbitrary position in the pneumatic spinning device 7 is not limited to the inlet and the outlet of the spinning section described above, and may be an intermediate point of the spinning section, for example, a changing point where the fiber bundle F changes to yarn Y.

[0085] Furthermore, in the equations (1), (2), and (3), D3 may be "a distance in the travelling path of the fiber bundle F and the yarn Y between the yarn monitoring device 8 and the front roller pair 17". In this case, a time (second time) until the fiber bundle F drafted by the second drafting operation passes the yarn monitoring device 8 can be appropriately calculated in the unit controller 10. Therefore, the injection of air in the pneumatic spinning device 7 can be stopped at the same time that at least one part (head portion) of the fiber bundle drafted by the second drafting operation passes the yarn monitoring device 8 or before the at least one part of the fiber bundle passes the yarn monitoring device 8. In this case as well, in the spinning machine 1, the twists can be avoided from being applied to all the fiber bundles F drafted by the second drafting operation, and thus the fiber bundle portion Y1 is formed in the fiber bundle F drafted by the second drafting operation. Thus, in the spinning machine 1, the dimension of the fiber bundle portion can be appropriately adjusted.

[0086] Furthermore, in the equations (1), (2), and (3), D3 may be "a distance in the travelling path of the fiber bundle F and the yarn Y between the yarn accumulating device 11 and the front roller pair 17". In this case, a time (third time) until the fiber bundle F drafted by the second drafting operation reaches the yarn accumulating device 11 can be appropriately calculated in the unit controller 10. Therefore, the injection of air in the pneumatic spinning device 7 can be stopped before at least one part (head portion) of the fiber bundle drafted by the second drafting operation reaches the yarn accumulating device 11. In this case as well, in the spinning machine 1, the twists can be avoided from being applied to all the fiber bundles F drafted by the second drafting operation, and thus the fiber bundle portion Y1 is formed in the fiber bundle F drafted by the second drafting operation. Thus, in the spinning machine 1, the dimension of the fiber bundle portion can be appropriately adjusted.

[0087] In the embodiment described above, the unit controller 10 calculates a time (length of time from a certain time point to another time point) T based on the equations (1), (2), and (3) as the timing (time point) of stopping the injection of air in the pneumatic spinning device 7. In the embodiment described above, an example in which a starting time point of the time T is a time point when the unit controller 10 received the yarn defect detection signal has been described. However, the starting time point (starting point) of the time T is not limited to the time point when the unit controller 10 received the yarn defect detection signal, and may be a time point other than the time point when the unit controller 10 received the yarn defect detection signal. For example, the starting time point of the time T may be a time point when the unit controller 10 transmitted a command to the draft device 6 to perform the second drafting operation. For example, the starting time point of the time T may be a time point when the second drafting operation started in the draft device 6. The starting time point of the second drafting operation can be detected by a sensor, for example, a rotation speed

sensor. The starting time point of the time T can be changed by, for example, adjusting the value of the constant c in the equations (1), (2), and (3) .

[0088] In the embodiment described above, a mode in which the draft device 6 includes the back roller pair 14, the third roller pair 15, the middle roller pair 16, and the front roller pair 17 has been described by way of example. However, the draft device merely needs to include at least three roller pairs. In this configuration, the unit controller 10 changes the rotation speed of one or a plurality of roller pairs of the at least three roller pairs other than the roller pair arranged on the most downstream side in the draft path and causes the second drafting operation to be performed.

[0089] In the embodiment described above, an example in which the operator performs appropriate operations such as making settings with the input keys 104 has been described, but using the display screen 102 as a touch panel display, the operator may operate the touch panel in place of the input keys 104 or in addition to the input keys 104.

[0090] In addition to the embodiments described above, the spinning machine 1 may further include an injection device and a suction device. The injection device injects air to a region between the draft device 6 and the pneumatic spinning device 7 after the pneumatic spinning device 7 starts moving from the spinning position to the receded position. The injection device is disposed to inject air so as to traverse a fiber passage (path through which the fiber bundle F travels) in the region. The injection device is preferably disposed so as to inject air along a direction perpendicular to the fiber passage. The injection device is controlled by the unit controller 10 so as to inject air at a desired timing. The suction device is disposed so as to be opposed to the injection device with the region therebetween, and sucks fibers remaining in the region and its vicinity. For example, the injection device is located on the top roller 17a side with respect to the region, and the suction device is located on the bottom roller 17b side with respect to the region. The positions of the injection device and the suction device may be interchanged.

[0091] In the embodiment described above, the count of the yarn Y is expressed in Number English (Ne: English count), but the count of the yarn Y may be expressed in other units.

[0092] In the embodiment described above, a mode in which the unit controller 10 functions as the control section and the calculating section has been described by way of example. However, each of the control section and the calculating section may be configured with an independent device.

[0093] The control section may be referred to as a command section.

[0094] The following can be said when each of the control section and the calculating section is configured with an independent device. In other words, the control section may be configured to have a first control section including the command section and a second control section including the calculating section. The first control section may be, for example, the unit controller 10, and the second control section may be, for example, the machine control device 100.

[0095] Furthermore, in the Claims, description is made with respect to the control section and the calculating section that the control section changes, when splitting the fiber bundle, the drafting ratio to a ratio different from the drafting ratio for the first drafting operation of drafting the fiber bundle and causes the second drafting operation of drafting the fiber bundle to be performed in the draft device, and stops the injection of air in the pneumatic spinning device after causing the second drafting operation to be performed.

[0096] The calculating section has been described as being configured to calculate the timing to stop the injection of air in the pneumatic spinning device based on the spinning condition, and the control section has been described as being configured to, when splitting the fiber bundle, stop the injection of air in the pneumatic spinning device based on the timing calculated by the calculating section.

[0097] The description of the Claim can be said as below.

[0098] The spinning machine includes the control section (command section) and the calculating section.

[0099] The calculating section calculates the timing to stop the injection of air in the pneumatic spinning device when splitting the fiber bundle based on the spinning condition.

[0100] The control section (command section) changes, when splitting the fiber bundle, the drafting ratio to a ratio different from the drafting ratio for the first drafting operation of drafting the fiber bundle (first drafting operation, which is the drafting operation for spinning the yarn, the first drafting operation, which is the current drafting operation) and causes the draft device to perform the second drafting operation of drafting the fiber bundle, and causes the pneumatic spinning device to stop the injection of air in the pneumatic spinning device after the second drafting operation is performed based on the timing calculated by the calculating section.

[0101] The yarn joining device 26 may be a piecer using a seed yarn.

[0102] The pneumatic spinning device 7 may prevent the twists of the fiber bundle from being transmitted to the upstream side of the pneumatic spinning device by a downstream end of the fiber guiding portion, in place of the needle 75. Instead of the configuration described above, the pneumatic spinning device may include a pair of air-jet nozzles adapted to apply twists on the fiber bundle in directions opposite to each other. The spinning machine may be an open-end spinning machine.

[0103] In each spinning unit 2, the yarn accumulating device 11 has a function of pulling out the yarn Y from the pneumatic spinning device 7, but the yarn Y may be pulled out from the pneumatic spinning device 7 by a delivery roller and a nip roller. When pulling out the yarn Y from the pneumatic spinning device 7 by the delivery roller and the nip

roller, a slack tube or a mechanical compensator, for example, adapted to absorb slack of the yarn Y using suction airflow may be provided instead of the yarn accumulating device 11.

[0104] In the spinning machine 1, the respective devices are disposed such that yarn Y supplied from the upper side is wound on the lower side in the height direction. However, the respective devices may be disposed such that yarn supplied from the lower side is wound on the upper side.

[0105] In the spinning machine 1, at least one of the bottom rollers in the draft device 6, and the traverse guide 23 are driven by power from the second end frame 5 (that is, in common with the plurality of spinning units 2). However, the respective sections (e.g., draft device, pneumatic spinning device, winding device, etc.) of each spinning unit 2 may be independently driven for every spinning unit 2.

[0106] In the travelling direction of the yarn Y, the tension sensor 9 may be arranged on the upstream side of the yarn monitoring device 8. The unit controller 10 may be provided for every spinning unit 2. In the spinning unit 2, the waxing device 12, the tension sensor 9, and the yarn monitoring device 8 may be omitted.

[0107] In FIG. 1, the spinning machine 1 is illustrated to wind a cheese-shaped package P, but may wind a cone-shaped package. In the case of the cone-shaped package, slack of yarn is generated by traversing the yarn, but this slack can be absorbed by the yarn accumulating device 11. The materials and shapes of the respective components are not limited to those described above, and various materials and shapes may be adopted.

[0108] In the embodiment described above, description has been made that the adjustment mode is performed to appropriately adjust the dimension of the fiber bundle portion Y1 formed at the yarn end of the yarn Y even at the time of full wound. However, the adjustment mode may not be performed at the time of full wound.

[0109] In other words, the unit controller 10 has an adjustment mode of, when splitting the fiber bundle F, controlling the operations of the draft device 6 and the pneumatic spinning device 7, and adjusting the dimension of the fiber bundle portion Y1 formed at the yarn end of the yarn Y by the split of the fiber bundle F. The details of the adjustment mode are the same as the content of the embodiment described above. In the present alternative embodiment, the unit controller 10 can switch between implementation/non-implementation of the adjustment mode at the time of full wound in which a defined amount of yarn Y is wound into the package P by the winding device 13 and the normal time other than the time of full wound. The unit controller 10 splits the fiber bundle F in the adjustment mode at the normal time. The unit controller 10 does not split the fiber bundle F in the adjustment mode at the time of full wound. The time of full wound can also be referred to as time of doffing.

[0110] At the normal time, the unit controller 10 selects "implementation" of performing the adjustment mode, and splits the fiber bundle F in the adjustment mode. The normal time is, for example, when the yarn defect is detected and the spinning is to be stopped. The unit controller 10 splits the fiber bundle F in the adjustment mode as the normal time when the yarn monitoring device 8 detects the yarn defect. Furthermore, the normal time may be, for example, the time when the tension sensor 9 detects abnormality in the tension. When the tension sensor 9 detects abnormality in the tension, the unit controller 10 may splits the fiber bundle F in the adjustment mode as the normal time.

[0111] The operation of adjusting the length of the fiber bundle portion Y1 in the adjustment mode is preferably differed according to the count (thickness) of the yarn Y to be spun. For example, the adjustment content of the adjustment mode is preferably differed among the case that the count of the yarn to be spun is a low count (e.g., lower than Ne15), the case that the count of the yarn to be spun is a middle count (e.g., higher than or equal to Ne15 and lower than or equal to Ne45), and the case that the count of the yarn to be spun is a high count (e.g., higher than Ne45). In the case of low count, the adjustment mode of carrying out the second drafting operation in which the total drafting ratio is greater than the first drafting operation is preferably performed. In the case of high count, the adjustment mode of carrying out the second drafting operation in which the total drafting ratio is smaller than the first drafting operation is preferably performed. In the case of the middle count, the second drafting operation may not be performed.

[0112] Next, a description will be made on the operation at the time of full wound. In other words, an operation in which the unit controller 10 selects "non-implementation" of performing the adjustment mode and does not split the fiber bundle F in the adjustment mode will be described with reference to FIG. 7.

[0113] When the package P formed in the winding device 13 is fully wound, the unit controller 10 controls the operation of the draft device 6. The unit controller 10 determines that the package P is fully wound (full tube) based on the length of the yarn Y wound into the package P. When determining that the package P is fully wound, the unit controller 10 stops the rotation of the back roller pair 14 of the draft device 6 (drafting operation by the draft device 6) to split the fiber bundle F and continues the injection of air in the pneumatic spinning device 7 until at least one part of the split fiber bundle F flows into the pneumatic spinning device 7 while the drafting operation (first drafting operation) of drafting the fiber bundle F to achieve the count of the yarn Y produced by the pneumatic spinning device 7 is being performed. As the front roller pair 17 is connected to a drive source (drive source shared with the front roller pair 17 of the other spinning units 2) different from that of the back roller pair 14, the front roller pair 17 continues to be driven. Consequently, the fiber bundle F is split between the back roller pair 14 and the front roller pair 17.

[0114] The unit controller 10 controls the pneumatic spinning device 7 such that injection of air from the plurality of nozzles 74 is stopped. Specifically, the unit controller 10 calculates the time T until at least one part of the split fiber

bundle F flows into the pneumatic spinning device 7, and stops the injection of air in the pneumatic spinning device 7 based on the time T. The time T is a time calculated based on the equation (1) described above. The unit controller 10 continues the injection of air in the pneumatic spinning device 7 until at least the time T has elapsed from when the rotation (drafting operation by the draft device 6) of the back roller pair 14 is stopped. In FIG. 7, the time T corresponds to a time between the timing K of stopping the drafting operation by the draft device 6 and first timing L of stopping the injection of air.

[0115] Thereafter, the unit controller 10 controls the pneumatic spinning device 7 so as to cause the pneumatic spinning device 7 to start moving from the spinning position to the receded position. Timing N in FIG. 7 is timing (second timing) to cause the pneumatic spinning device 7 to start moving from the spinning position to the receded position. According to the above operations, the fiber bundle F is split without forming the fiber bundle portion Y1 at the yarn end of the yarn Y.

[0116] In the spinning machine 1 according to the present alternative embodiment, the unit controller 10 has an adjustment mode of adjusting the dimension of the fiber bundle portion Y1 formed at the yarn end of the yarn Y by the split of the fiber bundle F. Therefore, in the spinning machine 1, the dimension of the fiber bundle portion Y1 can be appropriately adjusted. Furthermore, in the spinning machine 1, the unit controller 10 does not split the fiber bundle F in the adjustment mode at the time of full wound. In other words, in the spinning machine 1, the operation of adjusting the dimension of the fiber bundle portion Y1 is not carried out when the package P is fully wound. Therefore, as the unnecessary operation is not carried out in the spinning machine 1, lowering in the operation efficiency can be reduced.

[0117] Moreover, the unit controller 10 uses the timing (time) T calculated to stop the injection of air in the pneumatic spinning device 7 at the same time as or after at least one part of the fiber bundle F drafted by the second drafting operation flows into the pneumatic spinning device 7 in the adjustment mode of normal time, and continues the injection of air in the pneumatic spinning device 7 until at least the time T of the same length as the timing (time) T has elapsed from when the drafting operation is stopped at the time of full wound. Thus, the fiber bundle portion Y1 can be reliably formed at the normal time, and the fiber bundle portion Y1 is not formed at the time of full wound.

[0118] An aspect of "having implementation/non-implementation of the adjustment mode of adjusting the dimension of the fiber bundle portion switchable between the time of full wound and the other times (normal time, e.g., time of yarn defect detection, time of tension abnormality detection)" described above as an alternative embodiment is a second aspect of the present invention.

[0119] A spinning machine according to a second aspect of the present invention includes: a draft device that includes a plurality of rotatable roller pairs and adapted to draft a fiber bundle with the roller pairs; a pneumatic spinning device adapted to apply twists on the fiber bundle drafted by the draft device by injecting air to produce a yarn; a winding device adapted to wind the yarn produced by the pneumatic spinning device around a bobbin to form a package; and a control section adapted to control operations of the draft device and the pneumatic spinning device, where the control section has an adjustment mode of, when splitting the fiber bundle, controlling the operations of the draft device and the pneumatic spinning device to adjust a dimension of a fiber bundle portion formed at a yarn end of a yarn by the split of the fiber bundle, the implementation/non-implementation of the adjustment mode can be switched between a time of full wound in which a defined amount of yarn is wound into the package by the winding device and a normal time other than the time of full wound, and the fiber bundle is split in the adjustment mode in the normal time and the fiber bundle is not split in the adjustment mode at the time of full wound.

[0120] In the spinning machine according to the second aspect of the present invention, the control section has the adjustment mode of adjusting the dimension of the fiber bundle portion formed at the yarn end of the yarn by the split of the fiber bundle. Therefore, in the present spinning machine, the dimension of the fiber bundle portion can be appropriately adjusted. Furthermore, in the present spinning machine, the control section does not split the fiber bundle in the adjustment mode at the time of full wound. In other words, in the spinning machine, the operation of adjusting the dimension of the fiber bundle portion is not carried out when the package is fully wound. When the package is fully wound (state in which the defined amount of yarn is wound), the yarn end does not need to be caught from the package, and thus the adjustment of the dimension of the fiber bundle portion does not need to be carried out. Thus, if the operation of adjusting the dimension of the fiber bundle portion is carried out even when the package is fully wound, the operation efficiency may lower. Therefore, in the present spinning machine, the unnecessary operation is not carried out, and hence the lowering in the operation efficiency can be reduced.

[0121] According to the second aspect of the present invention, the dimension of the fiber bundle portion formed at the yarn end of the yarn can be adjusted, and the lowering in the operation efficiency can be reduced.

[0122] The spinning machine according to the second aspect of the present invention may be further configured as each embodiment described below. Each embodiment described below can be appropriately combined with each embodiment described above.

[0123] In one embodiment, a yarn detecting device adapted to detect the yarn defect of the yarn may be arranged, and the control section may split the fiber bundle in the adjustment mode as the normal time when the yarn defect is detected by the yarn detecting device. In this configuration, the fiber bundle portion can be formed at the yarn end of

the yarn when splitting the fiber bundle due to the yarn defect.

[0124] In one embodiment, a tension sensor adapted to detect the tension of the yarn may be arranged, and the control section may split the fiber bundle in the adjustment mode as the normal time when the abnormality of the tension is detected by the tension sensor. In this configuration, the fiber bundle portion can be formed at the yarn end of the yarn when splitting the fiber bundle due to the tension abnormality

[0125] In one embodiment, the pneumatic spinning device is arranged to be movable to the spinning position of when producing the yarn and the receded position farther from the draft device than the spinning position, and, in the adjustment mode, the control section changes the drafting ratio to a ratio different from the drafting ratio for the first drafting operation of drafting the fiber bundle and causes the second drafting operation of drafting the fiber bundle to be performed in the draft device, and then may perform at least one splitting operation of stopping the rotation of at least one roller pair, stopping the injection of air in the pneumatic spinning device, and moving the pneumatic spinning device from the spinning position to the receded position.

[0126] In this configuration, the splitting operation is performed after the second drafting operation is performed in the draft device in the adjustment mode. The drafting ratio for the first drafting operation is different from the drafting ratio for the second drafting operation. Therefore, the state of the fiber bundle drafted by the second drafting operation is different from that of the fiber bundle drafted by the first drafting operation. When the ratio is increased to become higher than the drafting ratio for the first drafting operation and then the second drafting operation is performed, the fiber bundle drafted by the second drafting operation is stretched more than the fiber bundle drafted by the first drafting operation. Consequently, the fiber volume (the volume of fibers in a cross-sectional area orthogonal to the drafting direction) of the fiber bundle after the second drafting operation becomes smaller than that of the fiber bundle after the first drafting operation. When the ratio is reduced to become lower than the drafting ratio for the first drafting operation and then the second drafting operation is performed, the fiber bundle drafted by the second drafting operation becomes shorter than the fiber bundle drafted by the first drafting operation. Consequently, the fiber volume of the fiber bundle after the second drafting operation becomes larger than that of the fiber bundle after the first drafting operation. Thus, in the present spinning machine, the fiber volume of the fiber bundle can be adjusted by changing the drafting ratio for the first drafting operation and the drafting ratio of the second drafting operation. Therefore, in the present spinning machine, the dimension of the fiber bundle portion can be appropriately adjusted.

[0127] In one embodiment, the control section may stop the rotation of at least one roller pair to split the fiber bundle while the first drafting operation is being performed at the time of full wound, and continue the injection of air in the pneumatic spinning device until at least one part of the split fiber bundle flows into the pneumatic spinning device. In this configuration, the twists are applied to the split fiber bundle, and thus the fiber bundle portion is not formed.

[0128] In one embodiment, a calculating section adapted to calculate the timing to stop the injection of air in the adjustment mode based on the spinning condition is arranged, and the control section may stop the injection of air in the pneumatic spinning device at the same time as or after at least one part of the fiber bundle drafted by the second drafting operation flows into the pneumatic spinning device based on the timing calculated by the calculating section in the adjustment mode at the normal time, and continue the injection of air in the pneumatic spinning device until at least the time of the same length as the timing calculated by the calculating section has elapsed at the time of full wound. In this configuration, the fiber bundle portion can be reliably formed at the normal time and the fiber bundle portion is not formed at the time of full wound.

[0129] In one embodiment, the draft device includes at least three roller pairs arranged along the draft path of the fiber bundle, the control section may cause the second drafting operation to be performed by changing a rotation speed of one or plurality of roller pairs other than a roller pair arranged on a most downstream side in the draft path, of the at least three roller pairs, and stop the injection of air in the pneumatic spinning device at the same time as or after at least one part of the fiber bundle flows into the pneumatic spinning device, the fiber bundle being located between a preceding roller pair which is a roller pair arranged on a most downstream side in the draft path, of the roller pairs in which the rotation speed is changed, and a following roller pair which is a roller pair arranged next to the preceding roller pair on a downstream side in the draft path, when the second drafting operation is performed (when the second drafting operation starts), the fiber bundle not being sandwiched by the following roller pair when the second drafting operation is performed (when the second drafting operation starts).

[0130] In this configuration, the injection of air can be stopped at an appropriate timing. Thus, in the spinning machine, the twists can be avoided from being applied to all the fiber bundles drafted by the second drafting operation, and the fiber bundle portion is formed in the fiber bundle drafted by the second drafting operation. Therefore, in the present spinning machine, the dimension of the fiber bundle portion can be appropriately adjusted.

[0131] In one embodiment, the control section may stop the injection of air in the pneumatic spinning device when at least one part of the fiber bundle drafted by the second drafting operation is discharged from the outlet of the spinning section of the pneumatic spinning device, based on the timing calculated by the calculating section. In this configuration, the injection of air can be stopped at an appropriate timing.

[0132] In one embodiment, the spinning machine includes a yarn detecting device disposed on the downstream side

of the travelling path of the yarn with respect to the pneumatic spinning device and adapted to detect the yarn defect of the yarn, where the control section may stop the injection of air in the pneumatic spinning device when at least one part of the fiber bundle drafted by the second drafting operation passes the yarn detecting device, based on the timing calculated by the calculating section. In this configuration, the injection of air can be stopped at an appropriate timing.

[0133] In one embodiment, the spinning machine includes a pull-out device disposed on the downstream side of the travelling path of the yarn with respect to the spinning device and adapted to pull out the yarn produced in the pneumatic spinning device, where the control section may stop the injection of air in the pneumatic spinning device when at least one part of the fiber bundle drafted by the second drafting operation reached the pull out device based on the timing calculated by the calculating section. In this configuration, the injection of air can be stopped at an appropriate timing.

[0134] In one embodiment, a spinning machine includes a pull-out device adapted to pull out the yarn produced in the pneumatic spinning device, and a yarn detecting device arranged between the pneumatic spinning device and the pull-out device in a travelling path of the yarn and adapted to detect a yarn defect of the yarn, where the draft device includes at least a first roller pair, a second roller pair, a third roller pair, and a fourth roller pair in order from the downstream side toward the upstream side in a draft path of the fiber bundle, the control section changes a ratio of the drafting ratio of the third roller pair and the fourth roller pair in the second drafting operation from the first drafting operation, the calculating section calculates a time as timing based on a distance in the draft path between the first roller pair and the second roller pair, a distance in the draft path between the second roller pair and the third roller pair, a value obtained by dividing the pull-out speed at which the pull-out device pulls out the yarn, by the rotation speed of the second roller pair, a value obtained by dividing the rotation speed of the second roller pair by the rotation speed of the third roller pair, a value obtained by dividing the pull-out speed by the rotation speed of the first roller pair, a distance in the travelling path of the fiber bundle and the yarn between the pneumatic spinning device and the first roller pair, a distance in the travelling path of the fiber bundle and the yarn between the yarn detecting device and the first roller pair, or a distance in the travelling path of the fiber bundle and the yarn between the pull-out device and the first roller pair, and the pull-out speed, and the control section may stop the injection of air in the pneumatic spinning device when the time has elapsed from detection of a yarn defect of the yarn by the yarn detecting device. In this configuration, the time until the fiber bundle drafted by the second drafting operation is discharged from the pneumatic spinning device can be appropriately calculated. Thus, in the spinning machine, the fiber bundle portion is formed in the fiber bundle drafted by the second drafting operation without the fiber bundle portion being formed in the fiber bundle drafted by the first drafting operation and without the twist being applied to all the fiber bundles drafted by the second drafting operation. Therefore, in the present spinning machine, the dimension of the fiber bundle portion can be appropriately adjusted.

[0135] In one embodiment, the control section may increase the drafting ratio to a ratio higher than the drafting ratio for the first drafting operation and cause the second drafting operation to be performed in the draft device.

In this configuration, the fiber bundle drafted by the second drafting operation is stretched more than the fiber bundle drafted by the first drafting operation. Consequently, the fiber volume of the fiber bundle after the second drafting operation becomes smaller than that of the fiber bundle after the first drafting operation. For example, when producing the yarn of low count (thick yarn), the fiber volume of the fiber bundle supplied to the pneumatic spinning device in a unit time is large. In this case, when the fiber bundle is split in the splitting operation, the fiber bundle may not be appropriately split and a fiber bundle portion formed at the yarn end of yarn may become thicker and longer. In the spinning machine, as the fiber volume of the fiber bundle is reduced by the second drafting operation when the fiber bundle is to be split, the fiber bundle portion can be suppressed from becoming thicker and longer when the fiber bundle is split in the splitting operation. Therefore, in the spinning machine, dimension of the fiber bundle portion formed at the yarn end of yarn can be appropriately adjusted.

[0136] In one embodiment, the control section may cause the draft device to perform the second drafting operation when a count of the yarn produced by the pneumatic spinning device is lower than or equal to Ne 15. When producing a yarn with a count of lower than or equal to Ne 15, the fiber volume of the fiber bundle is relatively large, where if splitting of the fiber bundle is performed with such a large volume, the fiber bundle portion tends to become thicker and longer. Thus, in the spinning machine, when yarn with a count of Ne 15 or lower is generated, the second drafting operation is performed, whereby the fiber bundle portion can be prevented from becoming thicker and longer, and dimension of the fiber bundle portion can be adjusted appropriately.

[0137] In one embodiment, the control section may reduce the drafting ratio to a ratio lower than the drafting ratio for the first drafting operation and cause the second drafting operation to be performed in the draft device. In this configuration, the fiber volume of the fiber bundle after the second drafting operation becomes larger than that of the fiber bundle after the first drafting operation. Therefore, a situation in which the thickness of the fiber bundle portion becomes too small when the fiber bundle is split in the splitting operation, making it difficult for a yarn catching device to catch the corresponding yarn end in the following yarn joining operation can be avoided.

[0138] In one embodiment, the control section may cause the fiber bundle to be drafted in the second drafting operation at a drafting ratio such that a count of the yarn produced by the pneumatic spinning device falls within a range higher than or equal to Ne 15 and lower than or equal to Ne 45. In this manner, the fiber volume of the fiber bundle of when

being split can be adjusted to an appropriate volume by drafting the fiber bundle into a fiber bundle such that the count of the yarn falls within the range higher than or equal to Ne 15 and lower than or equal to Ne 45. Thus, in the spinning machine, the fiber bundle portion can be prevented from becoming too thick, too thin, too long, or too short. Furthermore, a situation in which fibers are more likely to fly in the surroundings because the fiber bundle portion is excessively thick and long can be avoided, and a situation in which it is difficult for the yarn catching device to catch the corresponding yarn end because the fiber bundle portion is too thin can be avoided.

[0139] In one embodiment, the spinning machine may include a plurality of spinning units, where each spinning unit including at least three roller pairs and a pneumatic spinning device, at least one roller pair of the at least three roller pairs being arranged to be independently rotationally drive for each spinning unit, and the control section may cause the second drafting operation to be performed by changing the rotation speed of the roller pair that is independently rotationally driven. According to such a configuration, the drafting ratio can be changed in the second drafting operation using the roller pair independently rotationally driven for each spinning unit. Thus, the second drafting operation can be performed at desired timing for each spinning unit.

[0140] A spinning method according to a second aspect of the present invention performed in a spinning machine including a draft device that includes a roller pair and that is adapted to draft a fiber bundle with the roller pair, a pneumatic spinning device adapted to apply twists to the fiber bundle drafted by the draft device by injecting air to produce a yarn, a winding device adapted to wind the yarn produced by the pneumatic spinning device around a bobbin to form a package, and a control section adapted to control operations of the draft device and the pneumatic spinning device, where the control section has an adjustment mode of controlling, when splitting the fiber bundle, the operations of the draft device and the pneumatic spinning device to adjust dimension of a fiber bundle portion formed at a yarn end of the yarn by the split of the fiber bundle, switches implementation/non-implementation of the adjustment mode between time of full wound in which a defined amount of yarn is wound into the package by the winding device and a normal time other than the time of full wound, and splits the fiber bundle in the adjustment mode at the normal time and not split the fiber bundle in the adjustment mode at the time of full wound.

[0141] In the spinning method according to the second aspect of the present invention, the adjustment mode of adjusting the dimension of the fiber bundle portion formed at the yarn end of the yarn when the yarn is split is provided. Therefore, in the spinning method, the dimension of the fiber bundle portion can be appropriately adjusted. Furthermore, in the spinning method, the fiber bundle is not split in the adjustment mode at the time of full wound. In other words, in the spinning method, the operation of adjusting the dimension of the fiber bundle portion is not carried out when the package is fully wound. Therefore, in the present spinning method, unnecessary operation is not carried out, and hence the lowering in the operation efficiency can be reduced.

Claims

1. A spinning machine (1) comprising:

a draft device (6) including a plurality of rotatable roller pairs (14, 15, 16, 17) and adapted to draft a fiber bundle (F) with the roller pairs (14, 15, 16, 17);
a pneumatic spinning device (7) adapted to apply twists on the fiber bundle (F) drafted by the draft device (6) by injecting air to produce a yarn (Y);
a control section (10) adapted to, when splitting the fiber bundle (F), change a drafting ratio to a ratio different from a drafting ratio for a first drafting operation of drafting the fiber bundle (F) and cause a second drafting operation of drafting the fiber bundle (F) to be performed in the draft device (6), and to stop the injection of air in the pneumatic spinning device (7) after the second drafting operation is performed; and
a calculating section (10) adapted to calculate timing to stop the injection of air in the pneumatic spinning device (7) based on a spinning condition,
wherein, when splitting the fiber bundle (F), the control section (10) stops injection of air in the pneumatic spinning device (7) at the same time as or after at least one part of the fiber bundle (F) drafted by the second drafting operation flows into the pneumatic spinning device (7) based on the timing (T) calculated by the calculating section (10).

2. The spinning machine (1) according to claim 1, wherein
the draft device (6) includes at least three roller pairs (14, 15, 16, 17) arranged along a draft path of the fiber bundle (F), and
the control section (10)

causes the second drafting operation to be performed by changing a rotation speed of one or a plurality of roller

pairs (14, 15, 16) other than a roller pair (17) arranged on a most downstream side in the draft path, of the at least three roller pairs (14, 15, 16, 17), and
stops the injection of air in the pneumatic spinning device (7) at the same time as or after at least one part of the fiber bundle (F) flows into the pneumatic spinning device (7), the fiber bundle being located between a preceding roller pair (14, 15, 16) which is a roller pair arranged on a most downstream side in the draft path, of the roller pair (14, 15, 16) in which the rotation speed is changed, and a following roller pair (15, 16, 17) which is a roller pair arranged next to the preceding roller pair (14, 15, 16) on a downstream side in the draft path, when the second drafting operation is performed, the fiber bundle (F) not being sandwiched by the following roller pair (15, 16, 17) when the second drafting operation is performed.

3. The spinning machine according to claim 1 or 2, wherein the control section (10) stops the injection of air in the pneumatic spinning device (7) when at least one part of the fiber bundle (F) drafted by the second drafting operation is discharged from an outlet (83) of a spinning section of the pneumatic spinning device (7), based on the timing calculated by the calculating section (10).

4. The spinning machine (1) according to claim 1 or 2, further comprising a yarn detecting device (8) disposed on a downstream side of a travelling path of the yarn (Y) with respect to the pneumatic spinning device (7) and adapted to detect a yarn defect of the yarn (Y),
wherein the control section (10) stops the injection of air in the pneumatic spinning device (7) when at least one part of the fiber bundle (F) drafted by the second drafting operation passes the yarn detecting device (8), based on the timing calculated by the calculating section (10).

5. The spinning machine (1) according to claim 1 or 2, further comprising a pull-out device (11) disposed on a downstream side of a travelling path of the yarn (Y) with respect to the pneumatic spinning device (7) and adapted to pull out the yarn (Y) produced in the pneumatic spinning device (7),
wherein the control section (10) stops the injection of air in the pneumatic spinning device (7) when at least one part of the fiber bundle (F) drafted by the second drafting operation reaches the pull-out device (11), based on the timing calculated by the calculating section (10).

6. The spinning machine (1) according to any one of claims 1 to 5, further comprising:

a pull-out device (11) adapted to pull out the yarn (Y) produced in the pneumatic spinning device (7); and
a yarn detecting device (8) arranged between the pneumatic spinning device (7) and the pull-out device (11) in a travelling path of the yarn (Y) and adapted to detect a yarn defect of the yarn (Y),
wherein
the draft device (6) includes at least a first roller pair (17), a second roller pair (16), a third roller pair (15), and a fourth roller pair (14) in order from downstream side toward upstream side in a draft path of the fiber bundle (F),
the control section (10) changes a ratio of the drafting ratios of the third roller pair (15) and the fourth roller pair (14) for the second drafting operation from the ratio for the first drafting operation,
the calculating section (10) calculates a time (T) as the timing based on,

a distance (D2) in the draft path between the first roller pair (17) and the second roller pair (16), a distance (D1) in the draft path between the second roller pair (16) and the third roller pair (15),
a value (M) obtained by dividing a pull-out speed (S) at which the pull-out device (11) pulls out the yarn (Y), by a rotation speed of the second roller pair (16),
a value (I) obtained by dividing the rotation speed of the second roller pair (16) by a rotation speed of the third roller pair (15),
a value (Fe) obtained by dividing the pull-out speed (S) by a rotation speed of the first roller pair (17),
a distance (D3) in the travelling path of the fiber bundle (F) and the yarn (Y) between the pneumatic spinning device (7) and the first roller pair (17), a distance (D3) in the travelling path of the fiber bundle (F) and the yarn (Y) between the yarn detecting device (8) and the first roller pair (17), or a distance (D3) in the travelling path of the fiber bundle (F) and the yarn (Y) between the pull-out device (11) and the first roller pair (17), and
the pull-out speed (S), and

the control section (10) stops the injection of air in the pneumatic spinning device (7) when the time (T) has elapsed from detection of a yarn defect of the yarn (Y) by the yarn detecting device (8).

7. The spinning machine (1) according to claim 5 or 6, wherein the pull-out device (11) is a yarn accumulating device

(11) adapted to accumulate the yarn while pulling out the yarn (Y).

8. The spinning machine (1) according to any one of claims 1 to 7, wherein the control section (10) increases the drafting ratio to a ratio higher than the drafting ratio for the first drafting operation and causes the second drafting operation to be performed in the draft device (6).

9. The spinning machine (1) according to claim 8, wherein the control section (10) is adapted to cause the draft device to perform the second drafting operation when a count of the yarn (Y) produced by the pneumatic spinning device (7) is lower than or equal to Ne 15.

10. The spinning machine (1) according to any one of claims 1 to 7, wherein the control section (10) is adapted to reduce the drafting ratio to a ratio lower than the drafting ratio for the first drafting operation and cause the second drafting operation to be performed in the draft device (6).

11. The spinning machine (1) according to any one of claims 1 to 10, wherein the control section (10) causes the fiber bundle (F) to be drafted in the second drafting operation at a drafting ratio such that a count of the yarn (Y) produced by the pneumatic spinning device (7) falls within a range higher than or equal to Ne 15 and lower than or equal to Ne 45.

12. The spinning machine according to any one of claims 1 to 11, further comprising a plurality of spinning units (2), wherein
each of the spinning units (2) includes at least three roller pairs (14, 15, 16, 17) and the pneumatic spinning device (7), at least one (14, 15) of the at least three roller pairs (14, 15, 16, 17) being arranged to be independently rotationally driven for each spinning unit (2), and
the control section (10) causes the second drafting operation to be performed by changing a rotation speed of the roller pair (14, 15) that is independently rotationally driven.

13. The spinning machine (1) according to any one of claims 1 to 12, further comprising a winding device (13) adapted to wind the yarn (Y) produced by the pneumatic spinning device (7) around a bobbin (B) to form a package (P), wherein
the control section (10) has an adjustment mode of adjusting a dimension of a fiber bundle portion formed at a yarn end of the yarn (Y) by split of the fiber bundle (F),
the adjustment mode is a mode of stopping the injection of air in the pneumatic spinning device (7) at the same time as or after at least one part of the fiber bundle (F) drafted by the second drafting operation flows into the pneumatic spinning device (7) based on the timing calculated by the calculating section (10),
implementation/non-implementation of the adjustment mode is switchable between time of full wound in which a defined amount of yarn (Y) is wound into the package (P) by the winding device (13) and a normal time other than the time of full wound,
the fiber bundle (F) is split in the adjustment mode at the normal time, and
the fiber bundle (F) is not split in the adjustment mode at the time of full wound.

14. The spinning machine (1) according to claim 13, wherein, at the time of full wound, the control section (10) stops rotation of the back roller pair (14) which is a roller pair arranged most upstream in a drafting direction, of the plurality of roller pairs (14, 15, 16, 17) and continues the injection of air in the pneumatic spinning device (7) until at least a time (T) of a same length as the timing calculated by the calculating section (10) has elapsed from when the rotation of the back roller pair (14) is stopped.

15. A spinning method performed in a spinning machine (1) including a draft device (6) including a plurality of rotatable roller pairs (14, 15, 16, 17) and adapted to draft a fiber bundle (F) with the roller pairs (14, 15, 16,17), a pneumatic spinning device (7) adapted to apply twists on the fiber bundle (F) drafted by the draft device (6) by injecting air to produce a yarn (Y), and a control section (10) adapted to, when splitting the fiber bundle (F), change a drafting ratio to a ratio different from a drafting ratio for a first drafting operation of drafting the fiber bundle (F) and cause a second drafting operation of drafting the fiber bundle (F) to be performed in the draft device (6), and to stop the injection of air in the pneumatic spinning device (7) after the second drafting operation is performed, the method comprising the steps of:

calculating timing to stop the injection of air in the pneumatic spinning device (7) based on a spinning condition; and
stopping the injection of air in the pneumatic spinning device (7) at the same time as or after at least one part

of the fiber bundle (F) drafted by the second drafting operation flows into the pneumatic spinning device (7) based on the timing when splitting the fiber bundle (F).

FIG. 1

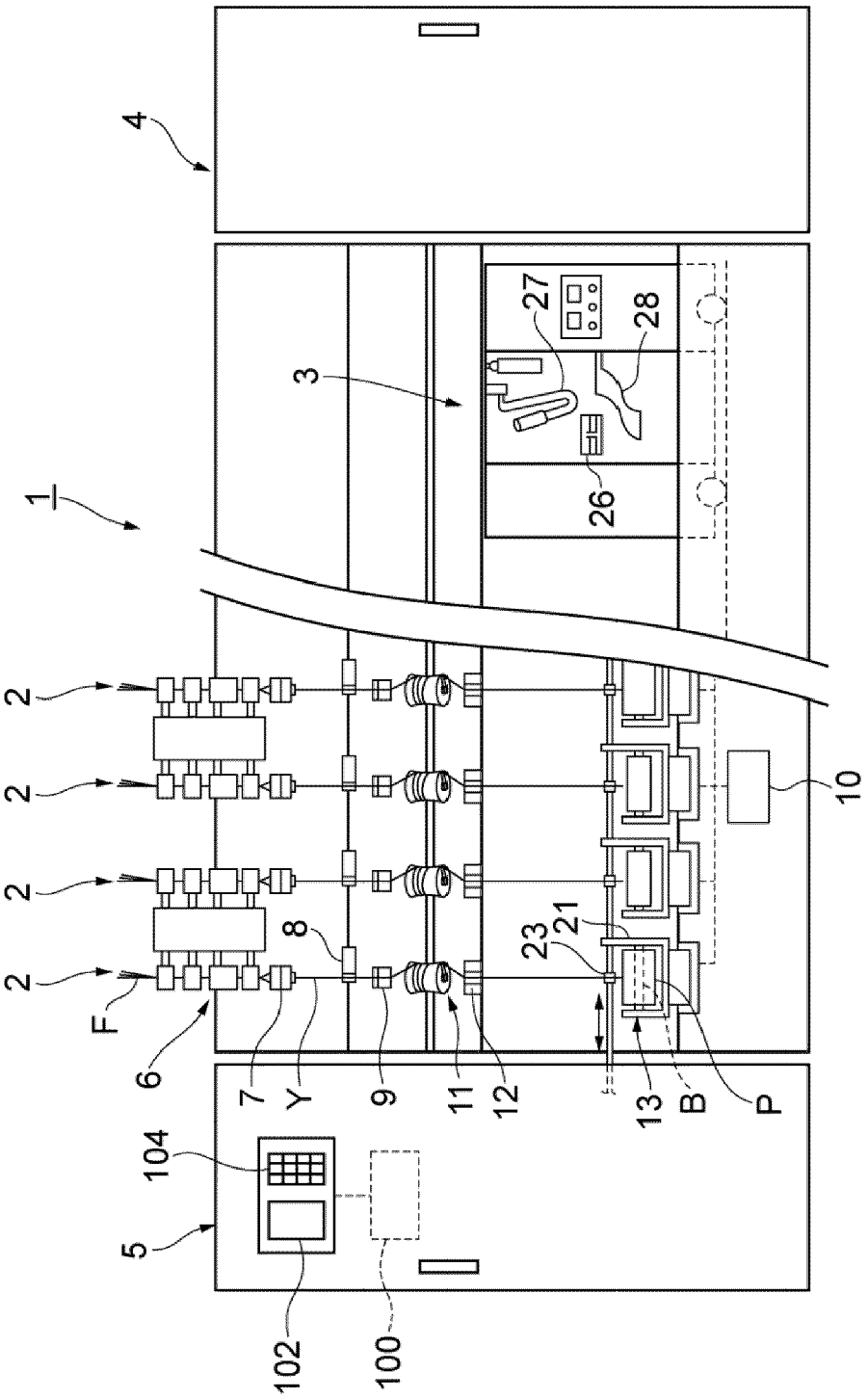


FIG. 2

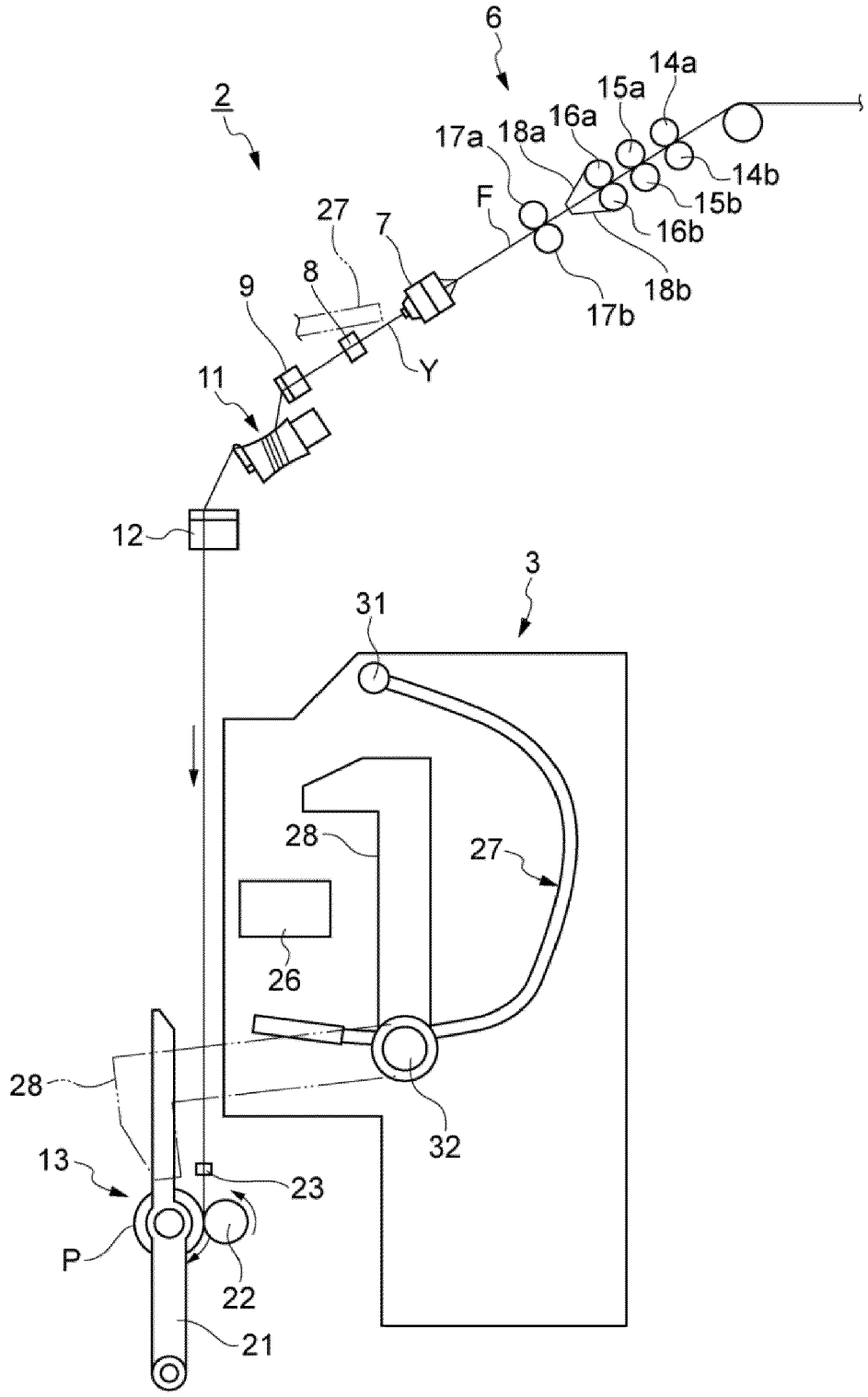

6
2
14a
15a
16a
17a
18a
14b
15b
16b
18b
17b
F
27
7
8
9
Y
11
12
3
31
28
27
26
28
32
13
23
P
22
21

FIG. 3

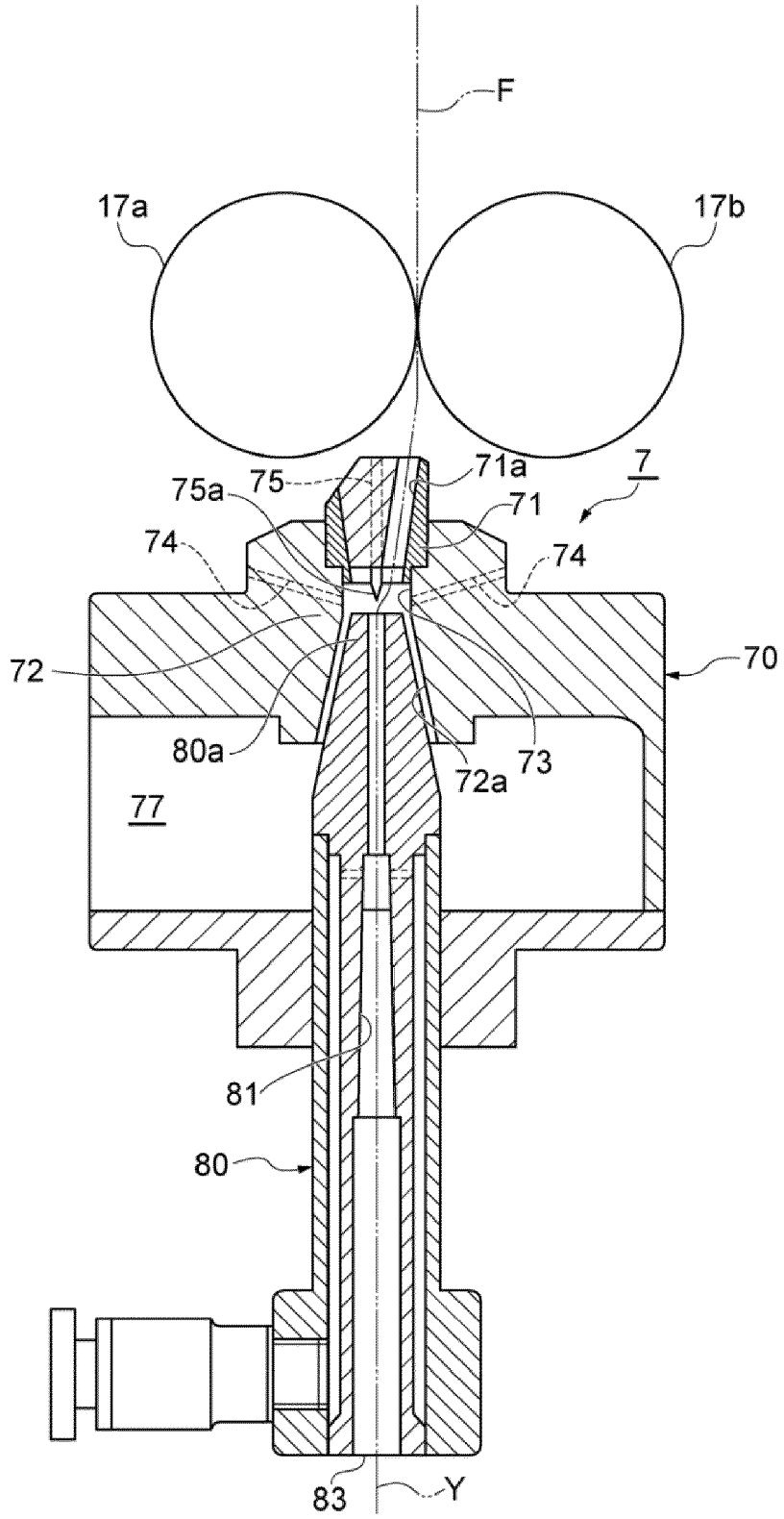


FIG. 4

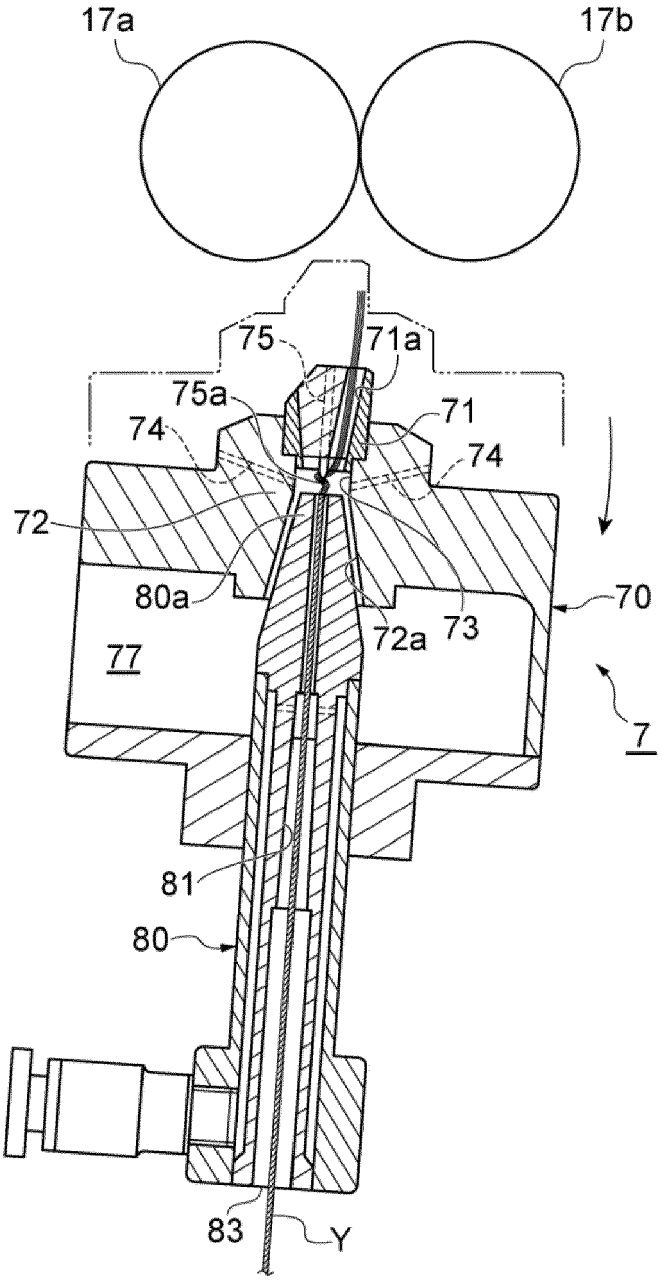


FIG. 5

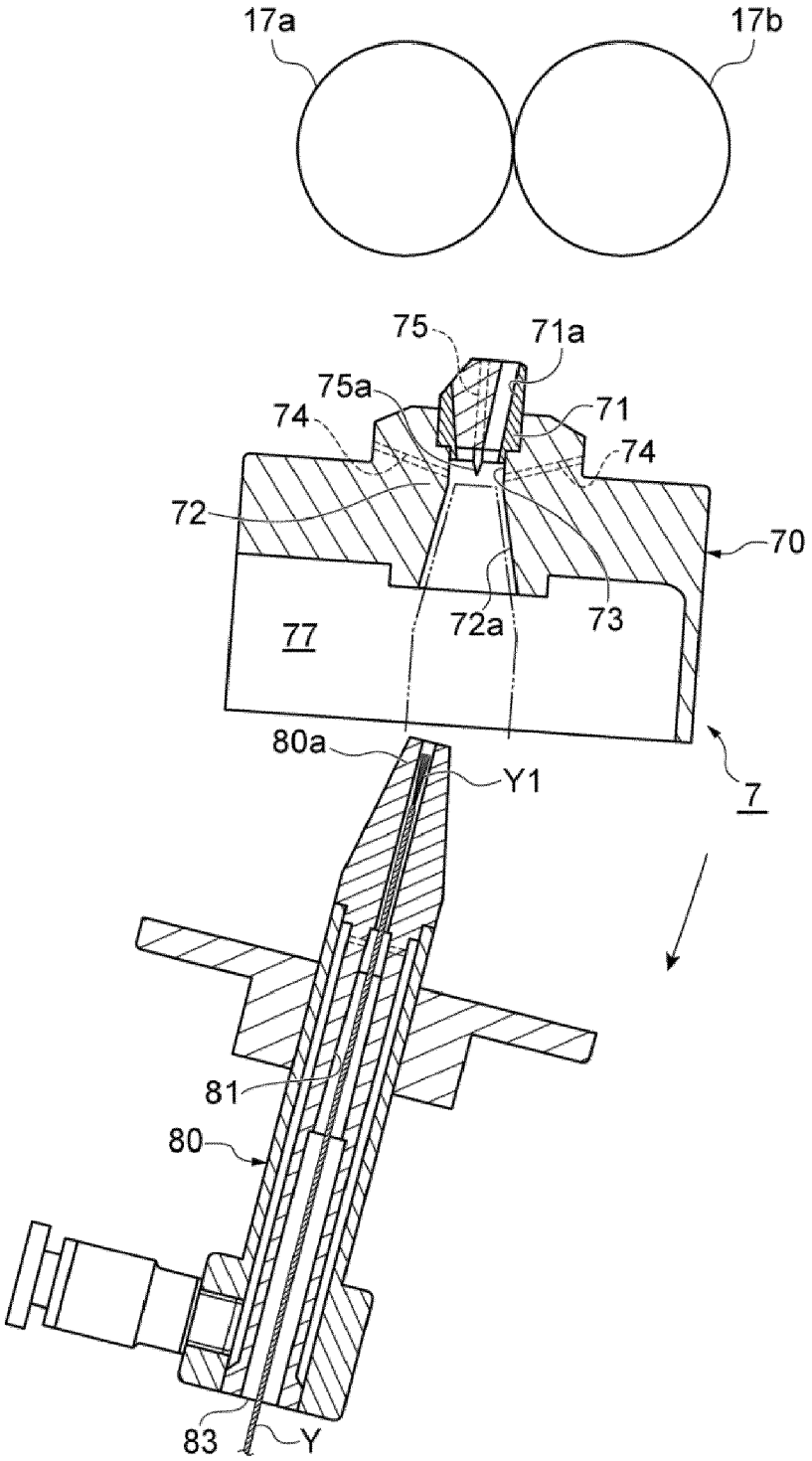


FIG. 6

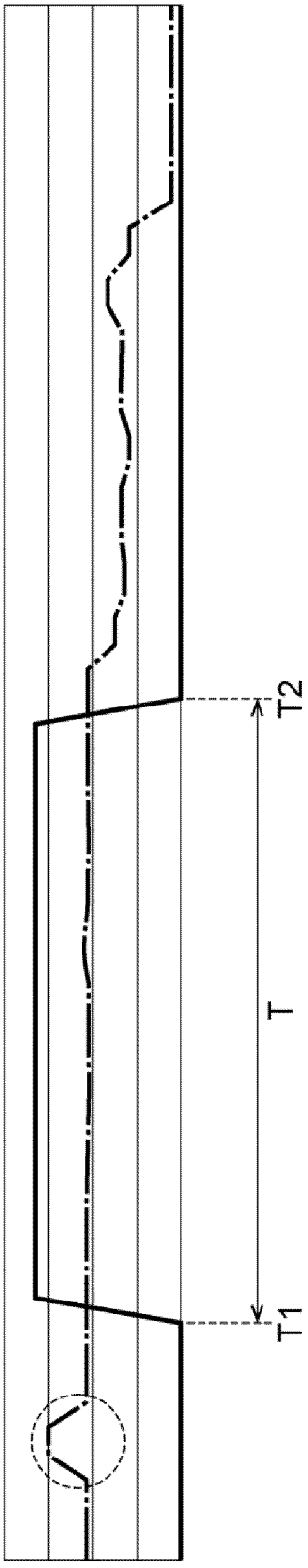
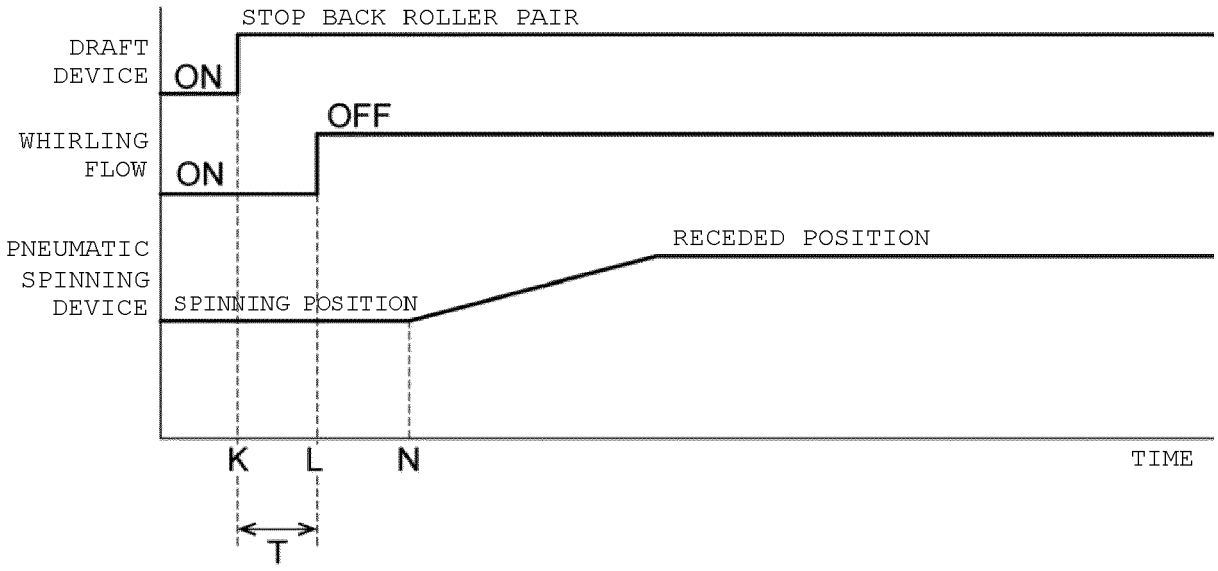


FIG. 7


STOP BACK ROLLER PAIR
DRAFT DEVICE
ON
WHIRLING FLOW
OFF
ON
PNEUMATIC SPINNING DEVICE
RECEDED POSITION
SPINNING POSITION
K
L
N
TIME
T

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EUROPEAN SEARCH REPORT

Application Number
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D01H

The present search report has been drawn up for all claims

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Munich	13 May 2019	Clivio, Eugenio

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