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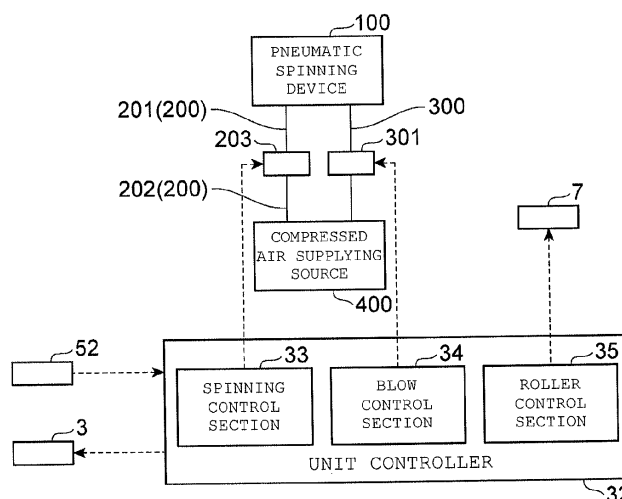
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(54) **Pneumatic spinning device, spinning unit, spinning machine, and pneumatic spinning method**

(57) A pneumatic spinning device includes a nozzle block (134) including a whirling airflow generating nozzle (127) adapted to inject spinning compressed air into a spinning chamber (126) to generate the whirling airflow in the spinning chamber (126), a flow pipe (200) adapted to enable flow of the spinning compressed air to be supplied to the whirling airflow generating nozzle (127), and

a spinning switching valve (203) provided to the flow pipe (200) and adapted to permit or shut the flow of the spinning compressed air that flows through the flow pipe (200). A volume inside a first flow pipe (201) is set such that a length of a fiber bundle (10e) at a yarn end of the spun yarn (10) cut by the shut of the flow of the spinning compressed air is a first length.

FIG. 3



Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a pneumatic spinning device, a spinning unit, a spinning machine, and a pneumatic spinning method.

2. Description of the Related Art

[0002] Conventionally, as a technique in such a field, a spinning unit described in Japanese Unexamined Patent Publication No. 2006-144136 is known. A spinning device arranged in the spinning unit injects compressed air into a spinning chamber to generate a whirling airflow, and uses the whirling airflow to apply twists to a fiber bundle introduced into the spinning chamber to produce a spun yarn. The spun yarn spun by the spinning device is wound into a package by a winding device located downstream. A yarn clearer adapted to detect a yarn defect of the spun yarn is arranged between the spinning device and the winding device.

[0003] When the yarn defect is detected by the yarn clearer, the spinning device stops the injection of the compressed air into the spinning chamber and stops the twisting of the fiber bundle. When the winding device winds the spun yarn while the twisting of the fiber bundle is stopped, a continuation of the fiber bundle and the spun yarn is disconnected in a spinning chamber portion. A fiber bundle portion not applied with the twists is attached to a yarn end of the spun yarn of a side disconnected in the spinning device and wound by the winding device.

BRIEF SUMMARY OF THE INVENTION

[0004] The inventors recognized that, according to the prior art, a length of the fiber bundle portion to be attached to the spun yarn is not controlled. Thus, depending on the length of the fiber bundle portion at the yarn end of the spun yarn, the yarn end may not be easily pulled out from the package wound by the winding device.

[0005] An object of the present invention is to provide a pneumatic spinning device capable of controlling a length of a fiber bundle portion at a yarn end of a disconnected spun yarn, a spinning unit, a spinning machine, and a pneumatic spinning method.

[0006] A pneumatic spinning device according to an aspect of the present invention produces a spun yarn by spinning a fiber bundle using a whirling airflow. The pneumatic spinning device includes a nozzle block including a whirling airflow generating nozzle adapted to inject spinning compressed air into a spinning chamber to generate the whirling airflow in the spinning chamber, a spinning-air flow pipe adapted to enable flow of the spinning compressed air to be supplied to the whirling airflow gen-

erating nozzle, and a spinning switching valve provided to the spinning-air flow pipe and adapted to permit or shut the flow of the spinning compressed air that flows through the spinning-air flow pipe. A volume inside the spinning-air flow pipe between the spinning switching valve and the whirling airflow generating nozzle is set such that a length of a fiber bundle portion at a yarn end of the spun yarn cut by the shut of the flow is a first length.

[0007] In such a pneumatic spinning device, the length of the fiber bundle portion at the yarn end of the disconnected spun yarn can be controlled by the volume inside the flow pipe between the spinning switching valve and the whirling airflow generating nozzle, and the spun yarn in which the fiber bundle portion has the first length can be obtained.

[0008] The volume inside the spinning-air flow pipe between the spinning switching valve and the whirling airflow generating nozzle is preferably at most 1500 mm³. In the conventional pneumatic spinning device, even if the spinning switching valve is shut, the compressed air remaining in the flow pipe between the spinning switching valve and the whirling airflow generating nozzle continuously flows out from the whirling airflow generating nozzle into the spinning chamber to generate the whirling airflow in the spinning chamber. This whirling airflow has a weak whirling force and the whirling force gradually weakens. With such a whirling airflow, the fiber bundle is introduced into the spinning chamber even after the spinning switching valve is shut. In addition, since the whirling force of the whirling airflow is weak, the spinning is not appropriately carried out, and the non-twisted fiber bundle portion is attached to the yarn end of the spun yarn. Therefore, the volume inside the spinning-air flow pipe between the spinning switching valve and the whirling airflow generating nozzle is at most 1500 mm³. Accordingly, at the same time as or almost at the same time as the shut of the flow of the spinning compressed air by the spinning switching valve, the injection of the compressed air from the whirling airflow generating nozzle can be stopped and the generation of the whirling airflow can be stopped. Therefore, since the introduction of the fiber bundle into the spinning chamber is stopped at the same time as or almost at the same time as the shut of the flow of the spinning compressed air by the spinning switching valve, the length of the fiber bundle portion at the yarn end of the disconnected spun yarn can be made short or the fiber bundle portion can be eliminated.

[0009] The spinning-air flow pipe between the spinning switching valve and the whirling airflow generating nozzle preferably has an inner diameter of at least 2 mm and at most 4 mm, and a pipe length of at most 500 mm. An optimum spinning-air flow pipe can be achieved which takes into consideration a pressure loss or the like of when the air flows through the spinning-air flow pipe.

[0010] The pneumatic spinning device further preferably includes an introducing passage adapted to introduce the fiber bundle into the spinning chamber, a discharge passage adapted to guide the spun yarn spun by

the whirling airflow to outside of the spinning chamber, and a blow-nozzle block including a blow nozzle adapted to inject blowing compressed air between the introducing passage and the discharge passage. By injecting the blowing compressed air between the discharge passage and the introducing passage from the blow nozzle, the fiber bundle attached to the yarn end of the spun yarn can be disconnected from the spun yarn. In this manner, the length of the fiber bundle portion at the yarn end of the spun yarn can also be controlled by the blowing compressed air injected from the blow nozzle.

[0011] The pneumatic spinning device further preferably includes a control section adapted to control injection of the blowing compressed air from the blow nozzle such that the length of the fiber bundle portion is a second length that is shorter than the first length. By injecting the blowing compressed air from the blow nozzle, the length of the fiber bundle portion of the yarn end of the disconnected spun yarn can be made to the second length that is shorter than the first length.

[0012] A spinning unit according to an aspect of the present invention includes the pneumatic spinning device described above, and a winding device adapted to form a package by winding the spun yarn spun by the pneumatic spinning device. The length of the fiber bundle portion at the yarn end of the spun yarn of the package formed by the winding device can be controlled to a suitable length, and for example, a pull-out operation of the yarn end of the spun yarn from the package, and the like can be facilitated.

[0013] A spinning unit according to an aspect of the present invention further includes the pneumatic spinning device described above, and a winding device adapted to form a package by winding the spun yarn spun by the pneumatic spinning device. The control section is adapted to control the injection of the blowing compressed air from the blow nozzle such that the second length is adjusted according to a diameter of the package formed by the winding device. The length of the fiber bundle portion at the yarn end of the spun yarn of the package formed by the winding device can be controlled to a suitable length, and for example, the pull-out operation of the yarn end of the spun yarn from the package, and the like can be facilitated. If the diameter of the package is small, and the fiber bundle portion of the yarn end of the wound spun yarn is unnecessarily long, for example, the fiber bundle portion may be wound once around the package such that the fiber bundle portion gets entangled with itself, and the pull-out operation of the yarn end from the package may be difficult to be performed. By making the second length smaller as the diameter of the package is smaller, the fiber bundle portion can be prevented from being wound once around the package and getting entangled with itself.

[0014] When the package is fully wound, the control section is preferably adapted to control the injection of the blowing compressed air from the blow nozzle such that the second length is a predetermined length. Accord-

ingly, the fiber bundle portion of the yarn end of the fully-wound package is prevented from becoming unnecessarily long.

[0015] The spinning unit may further include a yarn catching device adapted to catch a yarn end of the spun yarn wound by the winding device, and a yarn joining device adapted to join the spun yarn caught by the yarn catching device and the spun yarn discharged from the pneumatic spinning device. Since the yarn catching device catches the yarn end of the spun yarn in which the length of the fiber bundle portion is controlled, a success rate of catching of the spun yarn by the yarn catching device is improved. As a result, the yarn joining operation by the yarn joining device can also be efficiently carried out, and operation efficiency of the spinning unit can be improved.

[0016] A spinning machine according to an aspect of the present invention includes a plurality of spinning units described above. The length of the fiber bundle portion of the yarn end of the spun yarn of the package formed by the winding device can be controlled, and the productivity of the spun yarn can be improved in the spinning machine as a whole.

[0017] A pneumatic spinning method according to an aspect of the present invention relates to a pneumatic spinning method for spinning a fiber bundle by injecting air to the fiber bundle and producing a spun yarn. The method includes a control step of controlling a timing of stopping injection of the air applied to the fiber bundle and controlling a length of a fiber bundle portion attached to the spun yarn.

[0018] According to such a pneumatic spinning method, the length of the fiber bundle portion of the yarn end of the disconnected spun yarn can be controlled by controlling the timing of stopping the injection of the air applied to the fiber bundle.

[0019] The pneumatic spinning method may further include a setting step of setting a length of the fiber bundle portion formed at a yarn end of the spun yarn. Accordingly, the spun yarn having the fiber bundle portion of a length set by the setting step at the yarn end may be obtained.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020]

FIG. 1 is a front view of a spinning machine according to one embodiment of the present invention;

FIG. 2 is a longitudinal cross-sectional view of the spinning machine of FIG. 1;

FIG. 3 is a schematic block diagram illustrating a periphery of a flow pipe of a spinning unit of FIG. 1;

FIG. 4 is a cross-sectional view of a pneumatic spinning device according to one embodiment of the present invention;

FIG. 5 is a cross-sectional view of a pneumatic spinning device according to one embodiment of the

present invention;

FIG. 6 is a cross-sectional view of a pneumatic spinning device according to one embodiment of the present invention; and

FIG. 7 is a cross-sectional view of a pneumatic spinning device according to one embodiment of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0021] An embodiment of the present invention will be described in detail with reference to the drawings. "Upstream" and "downstream" respectively refer to upstream and downstream in a travelling direction of a yarn during spinning. In FIG. 3, each of arrows indicated with a broken line represents a signal line.

[0022] A spinning machine 1 illustrated in FIG. 1 includes a plurality of spinning units 2 arranged in line. The spinning machine 1 includes a yarn joining cart 3, a blower box 80, and a motor box 5. In the following description, a side where a yarn path of a spun yarn 10 is located with respect to the yarn joining cart 3 may be referred to as a front side of the spinning machine 1, and an opposite side thereof may be referred to as a back side. A work passage extending in a direction in which the spinning units 2 are arranged is provided on the front side of the spinning machine 1.

[0023] As illustrated in FIG. 1, each spinning unit 2 includes a draft device 7, a pneumatic spinning device 100, a yarn accumulating device 12, a waxing device 9, and a winding device 13 arranged in this order from upstream to downstream. The draft device 7 is arranged in proximity to an upper end of a housing 6 of the spinning machine 1. A fiber bundle 8 fed from the draft device 7 is spun by the pneumatic spinning device 100. A spun yarn 10 fed from the pneumatic spinning device 100 is passed through a yarn clearer 52, fed further downstream by the yarn accumulating device 12, and applied with wax in the waxing device 9. Thereafter, the spun yarn 10 is wound by the winding device 13, and a package 45 is formed.

[0024] The draft device 7 drafts a sliver 15 into the fiber bundle 8. As illustrated in FIG. 2, the draft device 7 includes four roller pairs, i.e., a back roller pair 16, a third roller pair 17, a middle roller pair 19 provided with apron belts 18, and a front roller pair 20. A bottom roller of each of the roller pairs 16, 17, 19, and 20 is driven by power from the motor box 5, or by power from a driving source (not illustrated) arranged individually. Each of the roller pairs 16, 17, 19, and 20 is driven with a different rotation speed. As a result, the draft device 7 can draft the sliver 15 supplied from the upstream into the fiber bundle 8, and feed the fiber bundle 8 to the pneumatic spinning device 100 located downstream. The pneumatic spinning device 100 uses a whirling airflow to apply twists to the fiber bundle 8 to produce the spun yarn 10.

[0025] The yarn accumulating device 12 is arranged downstream of the pneumatic spinning device 100. The

yarn accumulating device 12 has a function of applying a predetermined tension to the spun yarn 10 to pull out the spun yarn 10 from the pneumatic spinning device 100, a function of accumulating the spun yarn 10 fed from the pneumatic spinning device 100 to prevent slackening of the spun yarn 10 that may occur during a yarn joining operation by the yarn joining cart 3, and a function of adjusting the tension so that a fluctuation of the tension at the winding device 13 side is not transmitted towards the pneumatic spinning device 100. As illustrated in FIG. 2, the yarn accumulating device 12 includes a yarn accumulating roller 21, a yarn hooking member 22, an upstream guide 23, an electric motor 25, a downstream guide 26, and a yarn accumulated amount detecting sensor 27.

[0026] The yarn hooking member 22 can engage (hook) the spun yarn 10, and can wind the spun yarn 10 around an outer peripheral surface of the yarn accumulating roller 21 by integrally rotating with the yarn accumulating roller 21 while being engaged with the spun yarn 10.

[0027] The yarn accumulating roller 21 can have a prescribed amount of the spun yarn 10 wound around the outer peripheral surface thereof to accumulate the spun yarn 10. The yarn accumulating roller 21 is rotatably driven by the electric motor 25. When the yarn accumulating roller 21 is rotated, the spun yarn 10 wound around the outer peripheral surface of the yarn accumulating roller 21 is wound to tighten the yarn accumulating roller 21, and the spun yarn 10 located upstream of the yarn accumulating device 12 is pulled. That is, when the yarn accumulating roller 21 is rotated at a predetermined rotation speed with the spun yarn 10 wound around the outer peripheral surface of the yarn accumulating roller 21, a predetermined tension can be applied to the spun yarn 10 and the spun yarn 10 can be pulled out from the pneumatic spinning device 100 at a predetermined speed and transported towards the downstream at a predetermined speed.

[0028] The yarn accumulated amount detecting sensor 27 detects, in a non-contacting manner, an accumulated amount of the spun yarn 10 accumulated on the yarn accumulating roller 21, and transmits the accumulated amount to a unit controller 32.

[0029] The upstream guide 23 is arranged slightly upstream of the yarn accumulating roller 21. The upstream guide 23 appropriately guides the spun yarn 10 with respect to the outer peripheral surface of the yarn accumulating roller 21. The upstream guide 23 prevents the twist of the spun yarn 10 propagating from the pneumatic spinning device 100 from being transmitted downstream of the upstream guide 23.

[0030] The yarn clearer 52 is arranged on a front side of the housing 6 of the spinning machine 1, and at a position between the pneumatic spinning device 100 and the yarn accumulating device 12. The spun yarn 10 spun by the pneumatic spinning device 100 is passed through the yarn clearer 52 before being wound by the yarn ac-

cumulating device 12. The yarn clearer 52 monitors the thickness of the travelling spun yarn 10, and when a yarn defect of the spun yarn 10 is detected, the yarn clearer 52 transmits a yarn defect detection signal to the unit controller 32. The yarn clearer 52 transmits a signal for detecting the length of the spun yarn 10 passing through the yarn clearer 52 to the unit controller 32. For example, such a signal may be a signal relating to the time when the spun yarn 10 passed through the yarn clearer 52.

[0031] Upon receiving the yarn defect detection signal, the unit controller 32 immediately stops ejection of compressed air from a whirling airflow generating nozzle 127 of the pneumatic spinning device 100 (see FIG. 4). The whirling airflow is then stopped, the twisting of the fiber bundle 8 is stopped, and introduction of the fiber bundle 8 to the pneumatic spinning device 100 is also stopped. Then, a continuation of the fibers is disconnected in the pneumatic spinning device 100, and the spun yarn 10 is cut. Thereafter, the unit controller 32 further stops the draft device 7 and the like. The unit controller 32 also transmits a control signal to the yarn joining cart 3, and the yarn joining cart 3 travels to the front of the spinning unit 2. Thereafter, the pneumatic spinning device 100 and the like are driven again, the yarn joining cart 3 performs the yarn joining operation, and winding is resumed.

[0032] The yarn joining cart 3 includes a splicer (yarn joining device) 43, a suction pipe 44, and a suction mouth (yarn catching device) 46. When a yarn breakage or a yarn cut occurs in a spinning unit 2, the yarn joining cart 3 travels on a rail 41 to the relevant spinning unit 2 and stops. The suction pipe 44 sucks and catches a yarn end fed from the pneumatic spinning device 100 while being swung vertically with a shaft as a center, and guides the yarn end to the splicer 43. The suction mouth 46 sucks and catches a yarn end from the package 45 supported by the winding device 13 while being swung vertically with a shaft as the center, and guides the yarn end to the splicer 43. The splicer 43 joins the guided yarn ends.

[0033] The waxing device 9 is arranged downstream of the yarn accumulating device 12. The waxing device 9 applies wax to the spun yarn 10 travelling from the yarn accumulating device 12 towards the winding device 13.

[0034] The winding device 13 includes a cradle arm 71 supported to be swingable about a supporting shaft 70. The cradle arm 71 can rotatably support a bobbin 48 for winding the spun yarn 10.

[0035] The winding device 13 includes a winding drum 72 and a traverse device 75. The winding drum 72 is adapted to be driven while making contact with an outer peripheral surface of the bobbin 48 or an outer peripheral surface of the package 45. The traverse device 75 includes a traverse guide 76 capable of being engaged with the spun yarn 10. The winding device 13 drives the winding drum 72 with an electric motor (not illustrated) while reciprocating the traverse guide 76 by a driving means (not illustrated). The package 45 making contact with the winding drum 72 can be rotated and the spun yarn 10 can be wound into the package 45 while being

traversed. A traverse guide 76 of the traverse device 75 is commonly driven in each spinning unit 2 by a common shaft for the plurality of spinning units 2.

[0036] The blower box 80 stores an air supplying source (e.g., a compressed air supplying source 400) adapted to generate air to be supplied to each section of the spinning unit 2, the yarn joining cart 3, and the like.

[0037] The pneumatic spinning device 100 described above will be more specifically described with reference to FIG. 3 to FIG. 5. As illustrated in FIG. 4, the pneumatic spinning device 100 includes a pneumatic spinning nozzle 119 adapted to apply a whirling airflow to the fiber bundle 8 while passing the fiber bundle 8 fed from the front roller pair 20, and a hollow guide shaft body 120 of which a tip-end portion is coaxially inserted to the pneumatic spinning nozzle 119.

[0038] The pneumatic spinning nozzle 119 includes a needle holder 123, a nozzle block 134, a nozzle casing (blow nozzle block) 153 that supports the nozzle block 134, an upper cover 111 that covers an upstream surface of the nozzle casing 153, and a shaft body holding member 159 that covers a downstream surface of the nozzle casing 153. The needle holder 123 includes a guiding hole (introducing passage) 121 adapted to introduce the fiber bundle 8 drafted by the upstream draft device 7 into a spinning chamber 126, and holds a needle 122 on a flow path of the fiber bundle 8 discharged from the guiding hole 121. An upstream end of the needle holder 123 is exposed from the upper cover 111.

[0039] A tapered hole 154 is formed in the nozzle block 134 at a position located downstream of the needle holder 123. A tip-end portion 124 of the hollow guide shaft body 120 having a tapered angle substantially equal to the tapered hole 154 is inserted to the tapered hole 154 coaxially and with a predetermined interval therebetween. A spinning chamber 126 as a twist applying region is formed between a tip-end portion 124 of the hollow guide shaft body 120 and the needle holder 123. A tip end of the needle 122 is projected into the spinning chamber 126, and the tip end of the needle 122 faces the tip-end portion 124 of the hollow guide shaft body 120.

[0040] A whirling airflow generating chamber 125 is formed between the tapered hole 154 and the tip-end portion 124. An air discharging space 155 is formed in the nozzle casing 153. A negative pressure source (not illustrated) is connected to a side of the air discharging space 155 via a pipe 160. A blow nozzle 310 is connected to another side of the air discharging space 155. The blow nozzle 310 connects the air discharging space 155 and outside of the nozzle casing 153. In order to be connected to the blow nozzle 310, a blowing pipe 300 through which the compressed air supplied from the compressed air supplying source 400 (see FIG. 4) flows is connected to the nozzle casing 153. FIG. 4 illustrates a state in which the pipe 160 and the blowing pipe 300 face one another with the hollow guide shaft body 120 therebetween, but a positional relationship of the pipe 160 and the blow nozzle 310 is not limited to the example of FIG. 4.

[0041] The compressed air (blowing compressed air) supplied from the compressed air supplying source 400 is injected from the blow nozzle 310 towards the air discharging space 155. A second switching valve 301 is provided with respect to the blowing pipe 300 (see FIG. 3), and adapted to switch supply and stop of the compressed air from the compressed air supplying source 400 to the blow nozzle 310. The second switching valve 301 is controlled by a control signal generated by the unit controller 32.

[0042] The nozzle block 134 includes a plurality of the whirling airflow generating nozzles 127 having the respective outlet end opened to the spinning chamber 126. The whirling airflow generating nozzles 127 are holes formed through the nozzle block 134 and are provided to be inclined in a tangent direction of the spinning chamber 126 and towards the downstream in a yarn feeding direction. Between the nozzle block 134 and the upper cover 111, a compressed air introducing chamber 128 is formed at a periphery of an inlet end of the whirling airflow generating nozzle 127 (an end of the whirling airflow generating nozzle 127 located opposite to an end at the spinning chamber 126). A flow pipe (spinning-air flow pipe) 200 is connected to a side of the compressed air introducing chamber 128. The compressed air for spinning (spinning compressed air) supplied from the compressed air supplying source 400 (see FIG. 3) flows through the flow pipe 200. FIG. 4 to FIG. 7 illustrate a state in which the flow pipe 200 and the blowing pipe 300 face one another with a passage of the fiber bundle 8 and the spun yarn 10 (the guiding hole 121, the spinning chamber 126, and a yarn passage 129) in the pneumatic spinning device 100 therebetween, but the positional relationship of the flow pipe 200 and the blowing pipe 300 is not limited to the illustrated example.

[0043] The compressed air supplied from the compressed air supplying source 400 is guided through the flow pipe 200, the compressed air introducing chamber 128 and the whirling airflow generating nozzle 127, and into the spinning chamber 126. A first switching valve (spinning switching valve) 203 (see FIG. 3) is provided with respect to the flow pipe 200, and adapted to switch supply and stop of the compressed air from the compressed air supplying source 400 to the spinning chamber 126. The first switching valve 203 is controlled by a control signal generated by the unit controller 32.

[0044] Since a pipe for supplying the compressed air or the like, and a frame or the like for supporting the spinning unit 2 are arranged on the back side of the spinning unit 2 (a side located away from the work passage), an installing position of the first switching valve 203 is restricted. In the present embodiment, the first switching valve 203 is preferably arranged at a position located on the front side of the spinning unit 2 (a side located close to the work passage) and located in proximity to the pneumatic spinning device 100. However, the installing position of the first switching valve 203 is not limited to the position described above, and the first switching valve

203 can be arranged at an appropriate position according to a presence or an absence of the installing space.

[0045] As illustrated in FIG. 3, the flow pipe 200 is configured by a first flow pipe 201 for connecting the compressed air introducing chamber 128 and the first switching valve 203, and a second flow pipe 202 for connecting the first switching valve 203 and the compressed air supplying source 400. A volume inside the first flow pipe 201 is set such that a length of the fiber bundle (a fiber bundle portion) 8 attached to a yarn end when the spun yarn 10 is cut becomes a first length. The volume inside the first flow pipe 201 is preferably at most 1500 mm³. The first flow pipe 201 preferably has an inner diameter of at least 2 mm and at most 4mm, and a pipe length of at most 500 mm. The volume inside the first flow pipe 201 is preferably set by considering the volume of the compressed air introducing chamber 128 located between the first flow pipe 201 and the whirling airflow generating nozzle 127. Specifically, for example, the first flow pipe 201 in which a sum of the volume inside the first flow pipe 201 and the volume of the spinning chamber 126 satisfies at most 1500 mm³ is preferably used.

[0046] The compressed air introduced from the first flow pipe 201 is injected from the whirling airflow generating nozzle 127 into the spinning chamber 126, and the whirling airflow in a counterclockwise direction in plan view (see FIG. 5), for example, is generated in the spinning chamber 126. The whirling airflow flows spirally downstream along the whirling airflow generating chamber 125 around the tip-end portion 124 of the hollow guide shaft body 120, and is discharged from the air discharging space 155 formed in the nozzle casing 153.

[0047] The hollow guide shaft body 120 is formed by a tubular body 156 having the tip-end portion 124. The yarn passage (a discharge passage) 129 is formed in the hollow guide shaft body 120 along a shaft center thereof. After the spun yarn 10 is passed through the yarn passage 129, the spun yarn 10 is discharged through a downstream outlet hole. A large diameter portion 158 having a large diameter is formed downstream of the tip-end portion 124 in the tubular body 156. The large diameter portion 158 is exposed to the air discharging space 155. The large diameter portion 158 is inserted and fixed to the shaft body holding member 159.

[0048] Next, an operation of the pneumatic spinning device 100 will be described. As illustrated in FIG. 5, during spinning, the fiber bundle 8 or the spun yarn 10 is in continuation from the front roller pair 20 through the guiding hole 121, the spinning chamber 126, and the yarn passage 129, and to the yarn accumulating device 12 located downstream. The yarn accumulating device 12 illustrated in FIG. 2 applies a feeding force towards the downstream, such that the tension is applied to the spun yarn 10.

[0049] The whirling airflow (illustrated by a thick black line arrow in FIG. 5) generated by the compressed air injected from the whirling airflow generating nozzle 127 causes the spinning chamber 126 to be negative-pres-

sured. As a result, a suction airflow is generated for causing the fiber bundle 8 from the upstream to be introduced into the spinning chamber 126 through the guiding hole 121 (outlined arrows in FIG. 5). Therefore, the fiber bundle 8 discharged from the front roller pair 20 of the draft device 7 is introduced into the spinning chamber 126 by the suction airflow, and is subjected to an action of the whirling airflow by the whirling airflow generating nozzle 127. The trailing end of the surrounding fibers is thus separated and opened with respect to the fibers that are to be core fibers among the fiber bundle 8, and is swung and twisted in the whirling airflow generating chamber 125 to be wound around the core fibers.

[0050] The twists tend to propagate towards the front roller pair 20, but such propagation is inhibited by the needle 122. Therefore, the fiber bundle 8 fed from the front roller pair 20 is not twisted by such twists. The fibers twisted as described above are sequentially formed into the truly-twisted spun yarn 10, and passed through the yarn passage 129 to be discharged from the pneumatic spinning device 100. Then, the spun yarn 10 passes through the yarn clearer 52 and the yarn accumulating device 12, and is wound by the winding device 13.

[0051] Next, control of the first switching valve 203 and the second switching valve 301 of the pneumatic spinning device 100 will be described. As illustrated in FIG. 3, the unit controller 32 includes a spinning control section (control section) 33 adapted to carry out the control of the first switching valve 203, and a blow control section (control section) 34 adapted to carry out the control of the second switching valve 301. The spinning control section 33 controls the first switching valve 203 to inject the compressed air from the whirling airflow generating nozzle 127 and generate the whirling airflow in the spinning chamber 126. When the yarn defect detection signal is input from the yarn clearer 52, for example, the spinning control section 33 controls the first switching valve 203 to stop the injection of the compressed air from the whirling airflow generating nozzle 127 to the spinning chamber 126.

[0052] When the first switching valve 203 is controlled by the spinning control section 33 such that the supply of the compressed air to the spinning chamber 126 is stopped and the package 45 is determined to be fully-wound, the blow control section 34 controls the second switching valve 301 such that the compressed air is injected from the blow nozzle 310. The unit controller 32 calculates the length of the spun yarn 10 wound by the winding device 13 in accordance with a signal for detecting the length of the spun yarn 10 input from the yarn clearer 52. The blow control section 34 determines whether or not the package 45 is fully-wound in accordance with the calculation result of the unit controller 32. When the first switching valve 203 is controlled by the spinning control section 33 such that the supply of the compressed air to the spinning chamber 126 is stopped, and the length of the wound spun yarn 10 is at most a predetermined winding length, the blow control section 34 controls the second switching valve 301 such that the

compressed air is injected from the blow nozzle 310. The predetermined winding length is a length in which the diameter of the package 45 formed by winding the spun yarn 10 of a predetermined length is at most a predetermined diameter.

[0053] The unit controller 32 further includes a roller control section 35. When the yarn defect detection signal is input from the yarn clearer 52, the roller control section 35 stops the motor adapted to drive each of the roller pairs 16, 17, 19, and 20. When the roller control section 35 determines that the package 45 is fully-wound in accordance with the length of the spun yarn 10 wound by the winding device 13 calculated in the unit controller 32, the unit controller 32 stops the motor adapted to drive each of the roller pairs 16, 17, 19, and 20.

[0054] Next, a description will be made on an operation of each section when the yarn defect is detected by the yarn clearer 52. First, a description will be made on the operation of each section when the yarn defect is detected under a state in which the diameter of the package 45 is greater than a predetermined diameter and not yet fully-wound. During spinning, when the yarn clearer 52 monitoring the spun yarn 10 detects the yarn defect, the yarn clearer 52 transmits the yarn defect detection signal to the unit controller 32. The roller control section 35 of the unit controller 32 that received the signal stops the motor adapted to drive the back roller pair 16 and the third roller pair 17. As a result, the supply of the fiber bundle 8 from the draft device 7 is stopped.

[0055] Even after the back roller pair 16 and the third roller pair 17 are stopped, the driving of the middle roller pair 19 and the front roller pair 20 is continued for at least a predetermined period of time. As a result, the sliver 15 or the fiber bundle 8 is disconnected between the driven middle roller pair 19 and the stopped third roller pair 17.

[0056] Immediately after or substantially at the same time as the control to stop the back roller pair 16 and the third roller pair 17 described above, the spinning control section 33 controls the first switching valve 203 such that the injection of the compressed air from the whirling airflow generating nozzle 127 to the spinning chamber 126 is stopped. Consequently, since the whirling airflow disappears, twisting is stopped, and the suction airflow that introduces the fiber bundle 8 from the guiding hole 121 into the spinning chamber 126 disappears. As a result, the fiber bundle 8 is not introduced into the hollow guide shaft body 120.

[0057] The spun yarn 10 already fed into the yarn passage 129 of the hollow guide shaft body 120 is pulled towards the downstream by the yarn accumulating device 12 with the non-twisted fiber bundle 8 being attached to the end of the spun yarn 10. As a result, the continuation of the fibers of the fiber bundle 8 and the spun yarn 10 is disconnected at a portion near the tip-end portion 124 of the hollow guide shaft body 120 as a boundary. As illustrated in FIG. 6, a non-twisted fiber bundle (fiber bundle portion) 10e is attached to the yarn end of the spun yarn 10 located downstream of the tip-end portion

124 of the hollow guide shaft body 120. After the spun yarn 10 is disconnected, the upstream fiber bundle 8d is accumulated in the guiding hole 121 or in proximity thereof by the feeding of the front roller pair 20. The accumulated fiber bundle 8d is sucked and removed by a suction means (not illustrated).

[0058] The volume inside the first flow pipe 201 arranged between the whirling airflow generating nozzle 127 and the first switching valve 203 is at most 1500 mm³ as described above. By arranging the volume inside the first flow pipe 201 to be as small as described above, after the first switching valve 203 is controlled to stop the supply of the compressed air to the whirling airflow generating nozzle 127, the supply of the compressed air to the whirling airflow generating nozzle 127 is immediately stopped. Thus, the compressed air remaining in the first flow pipe 201 is not continuously fed and the weak whirling airflow is not generated for a long period of time in the spinning chamber 126 as in the conventional device, and the whirling airflow can be promptly made to disappear. Therefore, the length of the fiber bundle 8 introduced into the hollow guide shaft body 120 can be made short, and when the continuation of the fiber is disconnected at the portion near the tip-end portion 124 of the hollow guide shaft body 120, the length of the fiber bundle 10e attached to the yarn end of the spun yarn 10 can be made short.

[0059] If the volume inside the first flow pipe 201 exceeds 1500 mm³, the supply of the compressed air to the whirling airflow generating nozzle 127 cannot be promptly stopped, and the length of the fiber bundle 10e attached to the yarn end of the spun yarn 10 becomes long.

[0060] The length of the fiber bundle 10e attached to the yarn end of the spun yarn 10 (the first length) is preferably from 5 cm to 20 cm, for example. If the length of the fiber bundle 10e is from 5 cm to 20 cm, for example, when the yarn end of the spun yarn 10 is wound into the package 45, the fiber bundle 10e attached to the yarn end of the spun yarn 10 is not wound once around the package 45 such that the fiber bundle 10e gets entangled with itself. As a result, the suction of the yarn end of the spun yarn 10 (a portion of the fiber bundle 10e) by the suction mouth 46 is facilitated.

[0061] Next, a description will be made on an operation of each section in a case where the diameter of the package 45 is at most a predetermined diameter when the yarn defect is detected by the yarn clearer 52. During the spinning, when the yarn clearer 52 monitoring the spun yarn 10 detects the yarn defect, the yarn clearer 52 transmits the yarn defect detection signal to the unit controller 32. The roller control section 35 of the unit controller 32 that received such a signal stops the motor adapted to drive the back roller pair 16 and the third roller pair 17. As a result, the supply of the fiber bundle 8 from the draft device 7 is stopped.

[0062] Even after the back roller pair 16 and the third roller pair 17 are stopped, the driving of the middle roller

pair 19 and the front roller pair 20 is continued at least for a predetermined period of time. As a result, the sliver 15 and the fiber bundle 8 are disconnected between the driven middle roller pair 19 and the stopped third roller pair 17.

[0063] Immediately after or substantially at the same time as the control to stop the back roller pair 16 and the third roller pair 17 described above, the spinning control section 33 controls the first switching valve 203 such that the injection of the compressed air from the whirling airflow generating nozzle 127 into the spinning chamber 126 is stopped. Consequently, since the whirling airflow disappears, twisting is stopped, and the suction airflow that introduces the fiber bundle 8 from the guiding hole 121 into the spinning chamber 126 disappears. As a result, the fiber bundle 8 is not introduced into the hollow guide shaft body 120.

[0064] The spun yarn 10 already fed to the yarn passage 129 of the hollow guide shaft body 120 is pulled towards the downstream by the yarn accumulating device 12 with the non-twisted fiber bundle 10e being attached to the end of the spun yarn 10.

[0065] After the control of the first switching valve 203 by the spinning control section 33, the blow control section 34 controls the second switching valve 301 such that the blowing compressed air is injected from the blow nozzle 310. At interruption of the spinning, as illustrated in FIG. 7, the nozzle casing 153 and the shaft body holding member 159 adapted to hold the hollow guide shaft body 120 are spaced apart. In other words, the spun yarn 10 is exposed to outside air. The compressed air is injected from the blow nozzle 310 to between the guiding hole 121 and the yarn passage 129, that is, towards the tip-end portion 124 of the hollow guide shaft body 120 that moves when the nozzle casing 153 and the shaft body holding member 159 are separated. Accordingly, the continuation of the non-twisted fiber bundle 10e attached to the end of the spun yarn 10 is disconnected by the pressure of air. Therefore, as illustrated in FIG. 7, a non-twisted fiber bundle (a fiber bundle portion) 10f of a predetermined length is attached to the yarn end of the spun yarn 10.

[0066] The blow control section 34 controls the second switching valve 301 such that the length of the fiber bundle 10f attached to the yarn end of the spun yarn 10 becomes a second length, and the blowing compressed air is injected from the blow nozzle 310. The length of the fiber bundle 10f attached to the yarn end of the spun yarn 10 can be controlled by a period of time after the injection of the compressed air into the spinning chamber 126 is stopped by the control of the spinning control section 33 and until the injection of the blowing compressed air from the blow nozzle 310 by the control of the blow control section 34, for example. The predetermined length of the fiber bundle 10f attached to the yarn end of the spun yarn 10 is the length in which the fiber bundle 10f cannot be wound once around the package 45, for example. The length of the fiber bundle 10f attached to the yarn end of

the spun yarn 10 may be zero. However, the fiber bundle 10f of a predetermined length is preferably attached to the yarn end of the spun yarn 10 such that the yarn end of the spun yarn 10 can be easily sucked by the suction mouth 46. Furthermore, as the diameter of the package 45 is smaller, the blow control section 34 may control the second switching valve 301 such that the length of the fiber bundle 10f attached to the yarn end of the spun yarn 10 becomes shorter.

[0067] As described above, if the diameter of the package 45 is at most the predetermined diameter, by injecting the blowing compressed air from the blow nozzle 310 to make the length of the fiber bundle 10f attached to the yarn end of the spun yarn 10 to be the predetermined length, a drawback in which the fiber bundle attached to the yarn end of the spun yarn 10 is wound once around the package 45 and the fiber bundle gets entangled with itself can be prevented, for example. Furthermore, by injecting the blowing compressed air from the blow nozzle 310 by the control of the blow control section 34 and actively cutting the fiber bundle 10e attached to the yarn end of the spun yarn 10, the length of the fiber bundle 10f attached to the yarn end of the spun yarn 10 can be made shorter as compared to a case where the spun yarn 10 is cut without using the blowing compressed air.

[0068] Next, an operation of each section when the package 45 is fully-wound will be described. During the spinning, when the fully-wound state of the package 45 is detected in accordance with a signal input from the yarn clearer 52, the roller control section 35 stops the motor adapted to drive the back roller pair 16 and the third roller pair 17. As a result, the supply of the fiber bundle 8 from the draft device 7 is stopped. In this case, similarly to the roller control section 35, the spinning control section 33 and the blow control section 34 also detect the fully-wound state of the package 45 in accordance with the signal from the yarn clearer 52. In the subsequent operations, similarly to the operation of each section in "a case where the diameter of the package 45 is at most a predetermined diameter when the yarn defect is detected" described above, the first switching valve 203 is controlled to stop the supply of the compressed air into the spinning chamber 126, and the second switching valve 301 is controlled to inject the blowing compressed air from the blow nozzle 310.

[0069] Accordingly, when the package 45 is fully-wound, the length of the fiber bundle 10f attached to the yarn end of the spun yarn 10 may be zero, or the length with which the yarn end of the spun yarn 10 can be easily sucked by the suction mouth 46. In this case as well, as compared to the case where the spun yarn 10 is cut without using the blowing compressed air, the length of the fiber bundle 10f attached to the yarn end of the spun yarn 10 can be further shortened.

[0070] As described above, in the pneumatic spinning device 100 according to the present embodiment, the volume inside the first flow pipe 201 arranged between the first switching valve 203 and the whirling airflow gen-

erating nozzle 127 is set such that the fiber bundle 8 attached to the yarn end of the spun yarn 10 becomes the first length. Accordingly, the length of the fiber bundle 10e attached to the yarn end of the disconnected spun yarn 10 can be controlled by the volume inside the first flow pipe 201, and the spun yarn 10 to which the fiber bundle 10e of the first length is attached can be obtained.

[0071] The volume inside the first flow pipe 201 arranged between the first switching valve 203 and the whirling airflow generating nozzle 127 is at most 1500 mm³. Thus, at the same time as or almost at the same time as the shut of the flow of the spinning compressed air by the first switching valve 203, the injection of the compressed air from the whirling airflow generating nozzle 127 can be stopped and the generation of the whirling airflow can be stopped. Therefore, at the same time as or almost at the same time as the shut of the flow of the spinning compressed air by the first switching valve 203, the introduction of the fiber bundle 8 into the spinning chamber 126 is stopped. As a result, the length of the fiber bundle 10e attached to the yarn end of the disconnected spun yarn 10 can be shortened or the attachment of the fiber bundle 10e can be eliminated.

[0072] The first flow pipe 201 preferably has an inner diameter of at least 2 mm and at most 4 mm, and a pipe length of at most 500 mm. In this case, an optimum first flow pipe 201 can be obtained that takes into consideration the pressure loss of when the spinning compressed air flows through the first flow pipe 201.

[0073] By injecting the blowing compressed air from the blow nozzle 310, the fiber bundle 10e attached to the yarn end of the spun yarn 10 can be disconnected from the spun yarn 10. The fiber bundle 10e attached to the yarn end of the spun yarn 10 can be actively cut, and as compared to the case where the spun yarn 10 is cut without using the blowing compressed air, the length of the fiber bundle 10f attached to the yarn end of the spun yarn 10 can be further shortened.

[0074] In the spinning unit 2 including the pneumatic spinning device 100 as described above, the pneumatic spinning device 100 controls the length of the fiber bundles 10e and 10f attached to the yarn end of the spun yarn 10 to the length that can be easily sucked by the suction mouth 46. Therefore, during the yarn joining operation by the splicer 43, the yarn end of the spun yarn 10 wound by the winding device 13 can be reliably caught by the suction mouth 46.

[0075] If the package 45 wound by the winding device 13 is fully-wound, when cutting the spun yarn 10, the spinning unit 2 including the pneumatic spinning device 100 described above controls the second switching valve 301 such that the fiber bundle 10e attached to the yarn end of the spun yarn 10 becomes the second length. The fiber bundle of unnecessary length thus can be prevented from being attached to the yarn end of the spun yarn 10 in which the winding is completed, for example.

[0076] In the spinning unit 2 including the pneumatic spinning device 100 described above, if the diameter of

the package 45 wound by the winding device 13 is small, the second switching valve 301 is controlled such that the fiber bundle 8 attached to the yarn end of the spun yarn 10 wound by the winding device 13 becomes the second length. Accordingly, an occurrence of the draw-back can be prevented, for example, the fiber bundle 10f attached to the spun yarn 10 wound once around the package 45 can be prevented from being entangled with the fiber bundle 10f itself.

[0077] In the spinning machine 1 including a plurality of the spinning units 2 described above, since the yarn end of the spun yarn 10 wound by the winding device 13 can be reliably caught by the suction mouth 46, the productivity of the spun yarn 10 can be improved in the entire spinning machine 1.

[0078] In the embodiment, controlling the timing to stop the injection of the whirling airflow by the volume inside the first flow pipe 201 corresponds to a control step of the pneumatic spinning method according to an aspect of the present invention. Furthermore, setting the volume inside the first flow pipe 201 such that the fiber bundle 10e of the desired length is attached to the yarn end of the spun yarn 10 corresponds to a setting step of the pneumatic spinning method according to an aspect of the present invention.

[0079] One embodiment of the present invention has been described above, but the present invention is not limited to the above embodiment, and modifications may be made within a scope of not changing the gist described in each claim.

[0080] For example, in the spinning machine 1 and the spinning unit 2 of the embodiment, the spun yarn 10 is pulled out from the pneumatic spinning device 100 by the yarn accumulating roller 21 that winds and accumulates a prescribed amount of the spun yarn 10. The present invention may be applied to a spinning machine and a spinning unit in which a spun yarn is pulled out from a pneumatic spinning device by a delivery roller and a nip roller.

[0081] In the spinning machine 1 and the spinning unit 2 of the embodiment, the yarn path is set such that the spun yarn 10 travels downward from the draft device 7 at an upper part towards the winding device 13 at a lower part. The present invention may be applied to a spinning machine and a spinning unit in which a yarn path is set such that the spun yarn travels from bottom to top in a machine height direction.

[0082] In the pneumatic spinning device 100 of the embodiment, the compressed air is supplied into the spinning chamber 126 from the first switching valve 203 through the first flow pipe 201. By directly attaching the first switching valve 203 to the upper cover 111 and the like, the compressed air may be supplied from the first switching valve 203 to the spinning chamber 126 without interposing the first flow pipe 201. In this case, the fiber bundle of a length corresponding to a volume of a space between the first switching valve 203 and the whirling airflow generating nozzle 127 formed in the upper cover

111, that is, a volume of the compressed air introducing chamber 128 (a volume inside the spinning-air flow pipe) is attached to the yarn end of the spun yarn 10.

[0083] In the spinning machine 1 and the spinning unit 2 of the embodiment, the pneumatic spinning device 100 includes the needle 122 for preventing the propagation of the twist of the fiber bundle 8. In place of the needle 122, the propagation of the twist of the fiber bundle 8 may be prevented by a downstream end of the guiding hole 121. Further, the pneumatic spinning device 100 may also include a pair of air-jet nozzles adapted to apply twists in opposite directions from one another.

[0084] In the spinning machine 1 and the spinning unit 2 of the embodiment, at least some of the plurality of bottom rollers of the draft device 7 and the traverse guide 76 of the traverse device 75 are driven commonly for the plurality of spinning units 2. The present invention may be applied to a spinning machine and a spinning unit in which each section of the spinning unit (e.g., the draft device, the pneumatic spinning device, and/or the yarn winding device) is independently driven for each spinning unit 2.

[0085] In the spinning units 2 of the embodiment, the splicer 43, the suction mouth 46, and the suction pipe 44 are shared. Alternatively, each spinning unit 2 may include the splicer 43, the suction mouth 46, and the suction pipe 44.

[0086] The yarn clearer 52 of the embodiment monitors the thickness of the spun yarn 10 to detect a yarn defect of the spun yarn 10, but the yarn clearer 52 may monitor a presence or an absence of foreign substances contained in the spun yarn 10 and detect the foreign substance as the yarn defect.

Claims

1. A pneumatic spinning device adapted to produce a spun yarn (10) by spinning a fiber bundle (8) using a whirling airflow, the pneumatic spinning device comprising:

a nozzle block (134) including a whirling airflow generating nozzle (127) adapted to inject spinning compressed air into a spinning chamber (126) to generate the whirling airflow in the spinning chamber (126),
a spinning-air flow pipe (200) adapted to enable flow of the spinning compressed air to be supplied to the whirling airflow generating nozzle (127), and
a spinning switching valve (203) provided to the spinning-air flow pipe (200) and adapted to permit or shut the flow of the spinning compressed air that flows through the spinning-air flow pipe (200),

wherein a volume inside the spinning-air flow pipe

- (200) between the spinning switching valve (203) and the whirling airflow generating nozzle (127) is set such that a length of a fiber bundle portion (10e) at a yarn end of the spun yarn (10) cut by the shut of the flow is a first length.
2. The pneumatic spinning device according to claim 1, wherein the volume inside the spinning-air flow pipe (200) between the spinning switching valve (203) and the whirling airflow generating nozzle (127) is at most 1500 mm³.
 3. The pneumatic spinning device according to claim 1 or claim 2, wherein the spinning-air flow pipe (200) between the spinning switching valve (203) and the whirling airflow generating nozzle (127) has an inner diameter of at least 2 mm and at most 4 mm, and a pipe length of at most 500 mm.
 4. The pneumatic spinning device according to any one of claim 1 through claim 3, further comprising:
 - an introducing passage (121) adapted to introduce the fiber bundle (8) into the spinning chamber (126),
 - a discharge passage (129) adapted to guide the spun yarn (10) spun by the whirling airflow to outside of the spinning chamber (126), and
 - a blow-nozzle block (153) including a blow nozzle (310) adapted to inject blowing compressed air between the introducing passage (121) and the discharge passage (129).
 5. The pneumatic spinning device according to claim 4, further comprising a control section (34) adapted to control injection of the blowing compressed air from the blow nozzle (31) such that the length of the fiber bundle portion (10e) is a second length that is shorter than the first length.
 6. A spinning unit comprising:
 - the pneumatic spinning device (100) according to any one of claim 1 through claim 5, and
 - a winding device (13) adapted to form a package (45) by winding the spun yarn (10) spun by the pneumatic spinning device (100).
 7. A spinning unit comprising:
 - the pneumatic spinning device (100) according to claim 5, and
 - a winding device (13) adapted to form a package (45) by winding the spun yarn (10) spun by the pneumatic spinning device (100),
 wherein the control section (34) is adapted to control the injection of the blowing compressed air from the blow nozzle (31) such that the second length is adjusted according to a diameter of the package (45) formed by the winding device (13).
 8. The spinning unit according to claim 7, wherein when the package (45) is fully wound, the control section (34) is adapted to control the injection of the blowing compressed air from the blow nozzle (31) such that the second length is a predetermined length.
 9. The spinning unit according to any one of claim 6 through claim 8, further comprising:
 - a yarn catching device (46) adapted to catch a yarn end of the spun yarn (10) wound by the winding device (13), and
 - a yarn joining device (43) adapted to join the spun yarn caught by the yarn catching device (46) and the spun yarn (10) discharged from the pneumatic spinning device (100).
 10. A spinning machine comprising a plurality of spinning units (2) according to any one of claim 6 through claim 9.
 11. A pneumatic spinning method for spinning a fiber bundle (8) by injecting air to the fiber bundle (8) and producing a spun yarn (10), the method comprising:
 - a control step of controlling a timing of stopping injection of the air applied to the fiber bundle (8) and controlling a length of a fiber bundle portion (10e) attached to the spun yarn (10).
 12. The pneumatic spinning method according to claim 11, further comprising a setting step of setting a length of the fiber bundle portion (10e, 10f) formed at a yarn end of the spun yarn (10).

FIG. 1

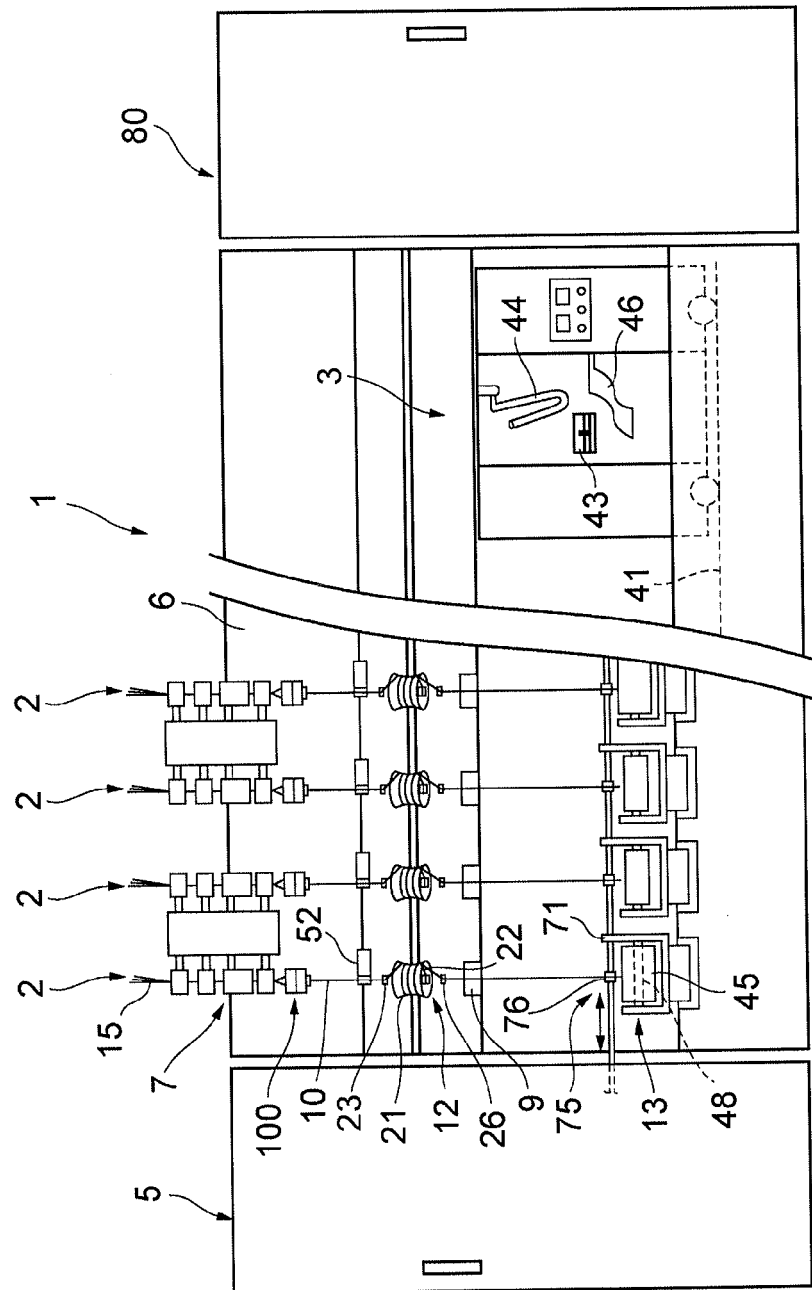


FIG. 2

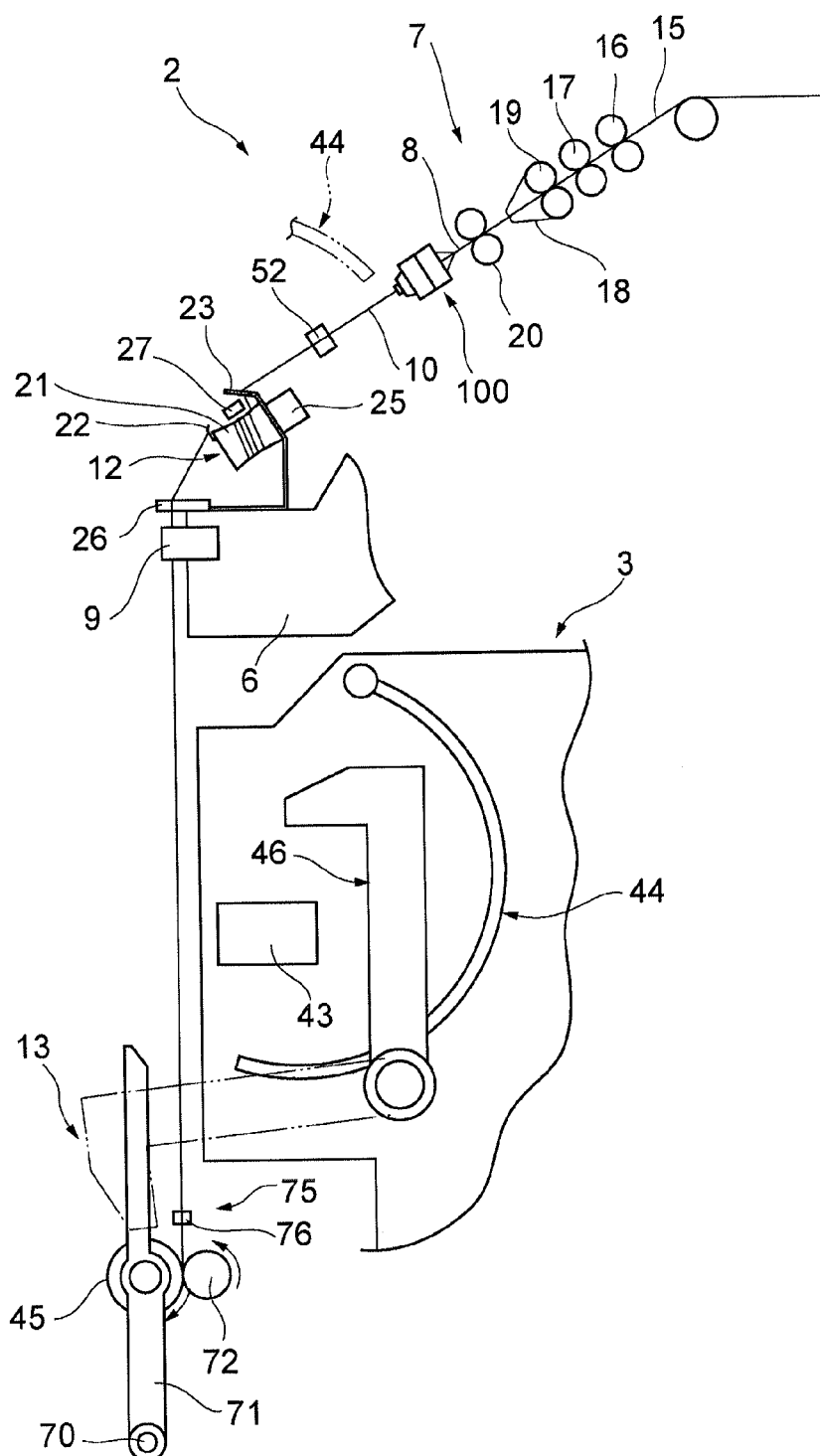


FIG. 3

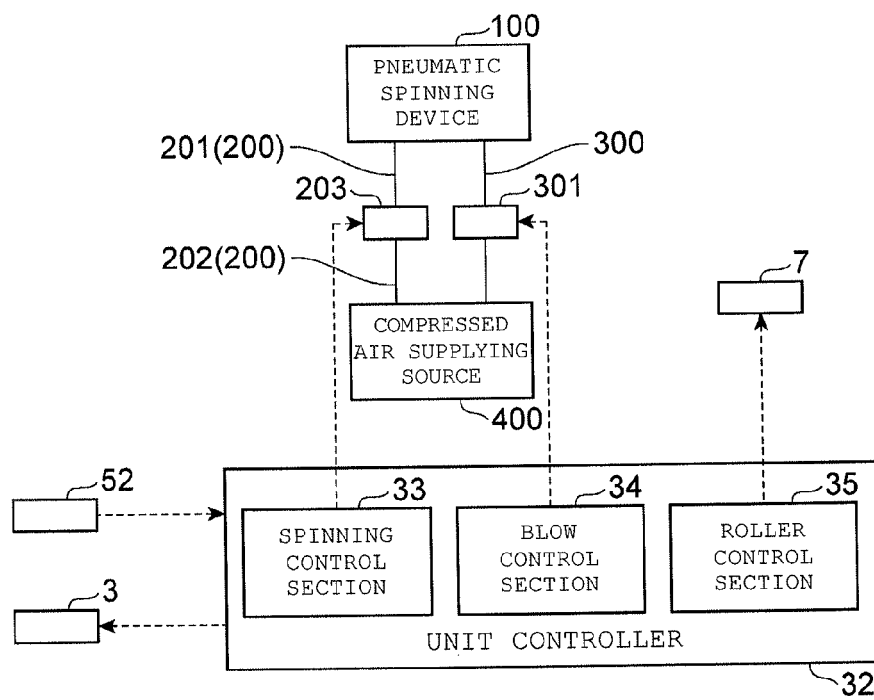
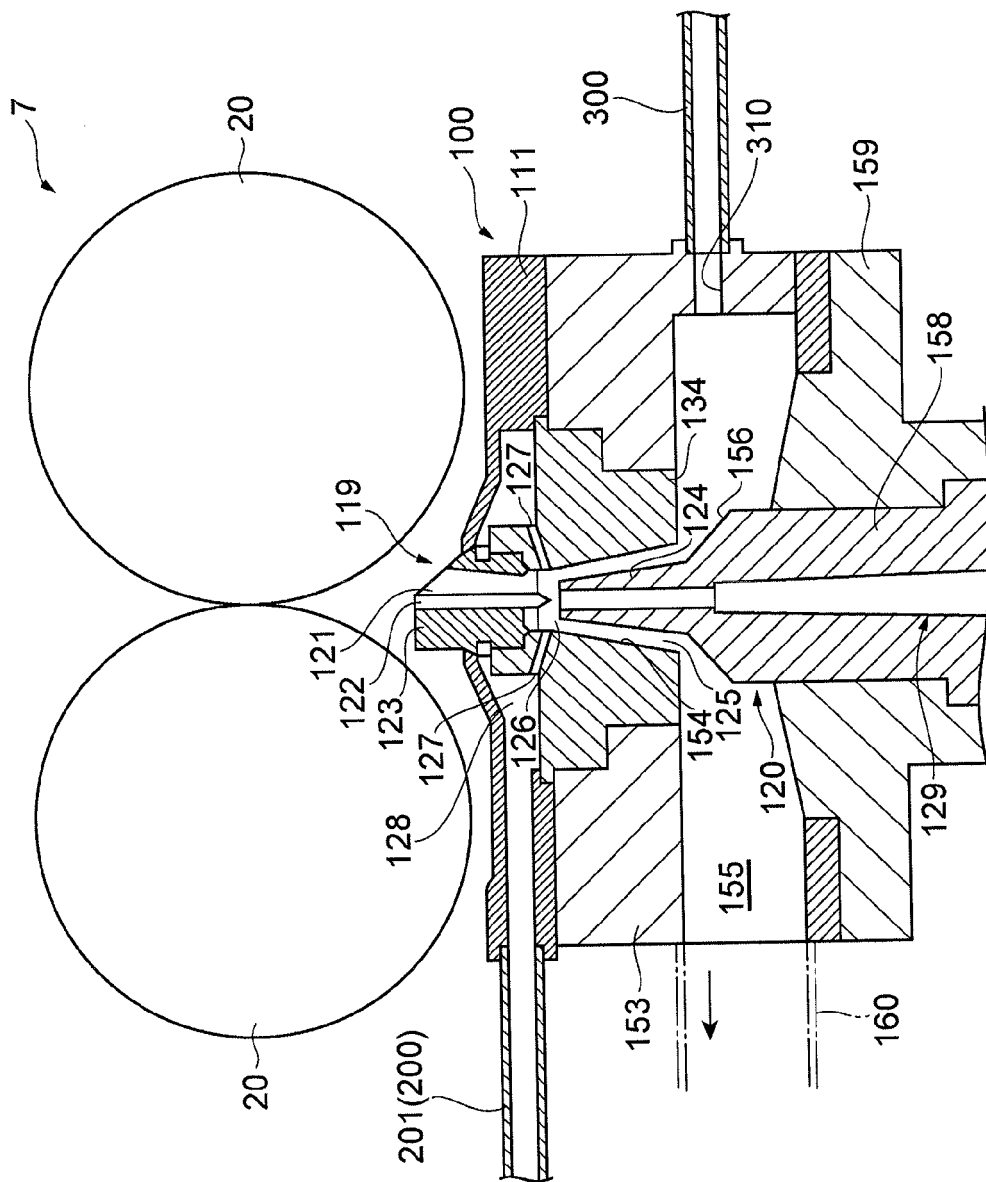


FIG. 4



5. THE

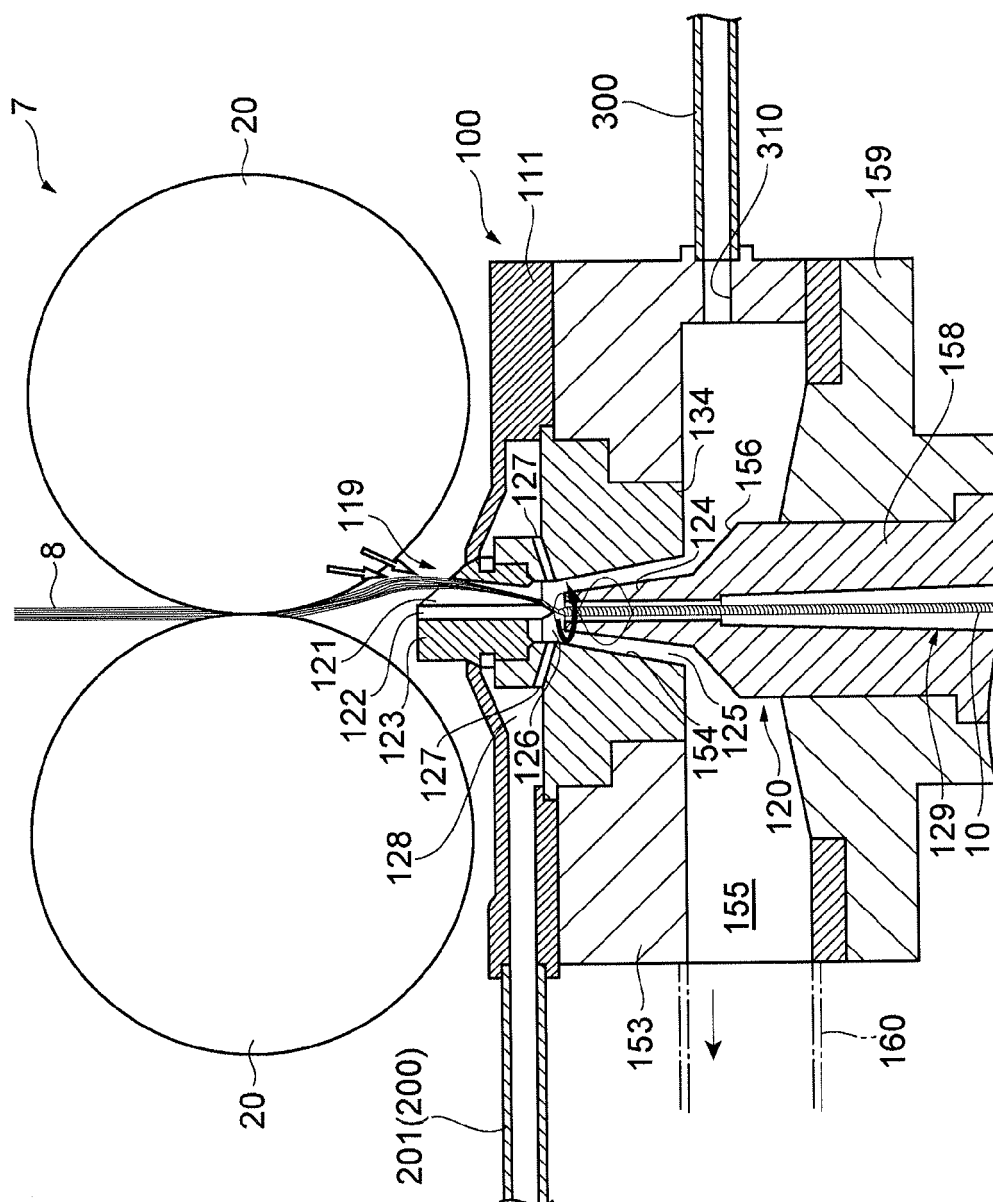
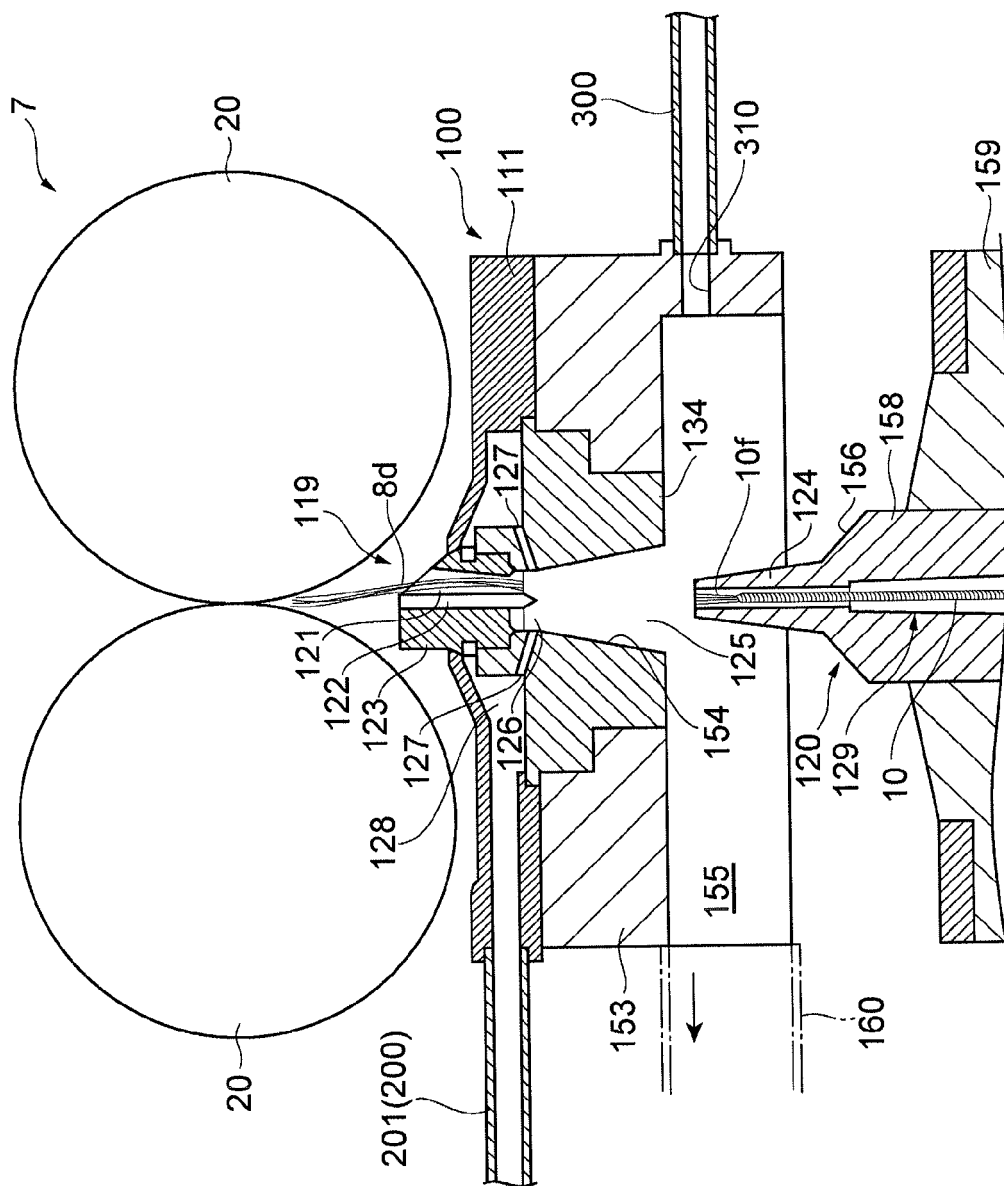


FIG. 7



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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