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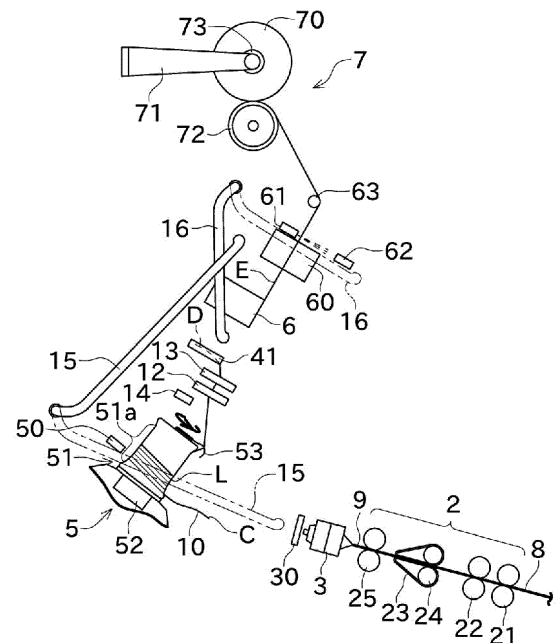
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(54) **AIR SPINNING MACHINE AND AIR SPINNING METHOD**

(57) An air spinning machine includes an air spinning device (3), a yarn storage roller (51), a winding device (7), a yarn monitoring device (4), and a control section (90). The air spinning device (3) produces a spun yarn (10) by twisting a fiber bundle (9) with a swirling airflow. The yarn storage roller (51) stores the spun yarn (10) thereon. The winding device (7) winds the spun yarn (10) having been stored on the yarn storage roller (51) so as to form a package (70). The yarn monitoring device (4) is disposed between the air spinning device (3) and the yarn storage roller (51) so as to be able to detect a long defect (L) and a short defect (S) in the spun yarn (10). The control section (90) is configured so that when the yarn monitoring device (4) detects the long defect (L) in the spun yarn (10), the control section (90) stops rotation of the package (70) so as to interrupt the winding of the spun yarn (10) by the winding device (7) while leaving at least a portion of the long defect (L) on the yarn storage roller (51).

Fig.11



Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to an air spinning machine and an air spinning method. More specifically, the present invention relates to an air spinning machine and air spinning method, in which yarn joining is operable in correspondence to yarn defects having different lengths.

2. Description of the Related Art

[0002] A well-known conventional yarn winding machine includes a yarn monitoring device for monitoring presence or absence of traveling yarn or a quality of yarn, and a yarn joining device. The yarn winding machine is configured so that when the yarn monitoring device detects a yarn defect, the yarn is cut, the yarn defect is removed, and then the yarn joining device joins a yarn from a spinning section and a yarn from a winding section.

[0003] A typical yarn winding machine as disclosed by JP2016-16957A includes an air spinning device, a yarn storage device, a yarn monitoring device disposed downstream of the yarn storage device, a yarn joining device, and a winding section for winding a yarn to form a package. This yarn winding machine is configured so that when the yarn monitoring device detects a yarn defect, the spinning operation of the air spinning device is stopped, and then, rotation of the package is stopped in a state where the yarn continues from the yarn storage device to the winding section. As a result, the yarn defect is wound into the package.

SUMMARY OF THE INVENTION

[0004] Further, the yarn winding machine is configured so that after the air spinning device stops its spinning operation, the yarn is cut at a portion thereof downstream of the yarn storage device, and a residual yarn wound in the yarn storage device is removed by a residual yarn suction device. In this way, residual yarn having a certain amount must be removed from the yarn storage device, and additionally, an amount of yarn required to remove the yarn defect must be unwound from the package. Consequently, a large amount of yarn must be removed, and a long time is required to perform a yarn joining cycle.

[0005] Further, in this yarn winding machine, the yarn monitoring device is disposed close to the winding section. The yarn is traversed to be wound into the package at the winding section, so that the yarn monitoring device is affected by the traversing of yarn so as to reduce its measurement accuracy.

[0006] An object of the present invention is to provide an air spinning machine and an air spinning method, in which high measurement accuracy of a yarn monitoring

device is maintained, an amount of waste yarn is reduced, and a time for performing a yarn joining cycle is shortened.

[0007] In a first aspect of the present invention, an air spinning machine includes an air spinning device, a yarn storage roller, a winding device, a yarn monitoring device, and a control section. The air spinning device produces a spun yarn by twisting a fiber bundle with a swirling air-flow. The yarn storage roller stores the spun yarn thereon. The winding device winds the spun yarn having been stored on the yarn storage roller so as to form a package. The yarn monitoring device is disposed between the air spinning device and the yarn storage roller so as to be able to detect a long defect and a short defect in the spun yarn. The control section is configured so that when the yarn monitoring device detects the long defect in the spun yarn, the control section stops rotation of the package so as to interrupt the winding of the spun yarn performed by the winding device in a state where at least a portion of the long defect is stored on the yarn storage roller.

[0008] Therefore, the long defect is prevented from being wound into the package, and a portion of the spun yarn to be unwound from the package is shortened, thereby reducing an amount of waste yarn, and shortening a time for a yarn joining cycle. Moreover, the yarn monitoring device is disposed at an appropriate position where the spun yarn relatively stably travels, thereby maintaining its high measurement accuracy.

[0009] Preferably, in the air spinning machine, the control section is configured so that when the yarn monitoring device detects the short defect in the spun yarn, the control section stops the rotation of the package such that the short defect is located downstream of the yarn storage roller in a traveling direction of the spun yarn.

[0010] Therefore, a normal spun yarn having been stored on the yarn storage roller before detection of the short defect (hereinafter it may be referred to as "normal yarn") is wound into the package. Consequently, even in the case where the short defect is to be removed, the amount of waste yarn is reduced, and the time for the yarn joining cycle is reduced.

[0011] Preferably, in the air spinning machine, the control section is configured so that when the yarn monitoring device detects the long defect or the short defect in the spun yarn, the control section interrupts the production of the spun yarn performed by the air spinning device, and forms a yarn end of the spun yarn wound in the package.

[0012] Therefore, when a yarn defect is detected, the production of spun yarn is interrupted so as to avoid waste production of spun yarn. Moreover, the spun yarn is cut by stopping the spinning, so that it is unnecessary to provide an additional device for cutting the spun yarn, thereby simplifying a structure of the air spinning machine.

[0013] Preferably, the air spinning machine includes a first removing device disposed close to the yarn storage roller so as to remove the long defect in the spun yarn.

[0014] Therefore, the long defect stored on the yarn storage roller is easily removed.

[0015] Preferably, in the air spinning machine, the first removing device includes a hollow pipe and an opening and closing member. The hollow pipe is connected to a negative pressure source. A suction airflow flows through the hollow pipe. The opening and closing member is opened so as to let the suction airflow flowing pass there-through, and is closed so as to shut off the suction airflow.

[0016] Therefore, the long defect is removed with the suction airflow. Moreover, by a simple structure with the opening and closing member, the first removing device is switchable between an operation state and an operation-stopped state.

[0017] Preferably, in the air spinning machine, the control section is configured so that after the rotation of the yarn storage roller is stopped, the control section reversely rotates the yarn storage roller at the same time as the opening and closing member is opened, or after the opening and closing member is opened.

[0018] Therefore, the long defect is easily caught and quickly removed by the first removing device.

[0019] Preferably, the air spinning machine includes a second removing device rotatably disposed downstream of the yarn storage roller so as to remove the short defect in the spun yarn.

[0020] Therefore, the short defect is easily removed by the second removing device when the rotation of the package is stopped at a timing when the short defect is located downstream of the yarn storage roller.

[0021] Preferably, in the air spinning machine, the second removing device is configured so as to remove the short defect in the spun yarn during a process where the second removing device catches the spun yarn from the package and guides the caught spun yarn to a yarn joining device.

[0022] Therefore, no additional process for removing the short defect is needed, thereby shortening the time for performing the yarn joining cycle. Moreover, the second removing device serves as a device for guiding the spun yarn to the yarn joining device, thereby simplifying the structure of the air spinning machine.

[0023] Preferably, in the air spinning machine, the control section is configured so as to stop the rotation of the yarn storage roller after the rotation of the package is stopped.

[0024] Therefore, a yarn end of the spun yarn having been cut at a portion thereof upstream of the yarn storage roller is wound around the rotating yarn storage roller, and then is swung slightly while being kept at a slight distance from an outer circumferential surface of the yarn storage roller by a centrifugal force. The yarn end can be kept in this state for a long time, thereby being prevented from being entangled in yarn layers stored on the yarn storage roller.

[0025] Preferably, the air spinning machine includes a stored yarn detection device for detecting presence or absence of the spun yarn stored on the yarn storage roller.

The control section is configured so that when the yarn monitoring device detects the short defect, the control section stops the rotation of the package with a delay after the stored yarn detection device detects absence of the spun yarn on the yarn storage roller.

[0026] Therefore, the short defect can be located downstream of the yarn storage roller at the time when the rotation of the package is stopped.

[0027] Preferably, the air spinning machine includes a yarn detection device and an air injection device. The yarn detection device is disposed between the yarn storage roller and the winding device so as to detect presence or absence of the spun yarn on a yarn route where the spun yarn travels. The air injection device is disposed between the yarn storage roller and the winding device so as to inject air to the yarn route. The control section is configured so that after the production of spun yarn by the air spinning device is interrupted, the control section commands the air injection device to inject air while rotating the package in the winding direction. The control section is also configured so that during the air injection by the air injection device to the yarn route, when the yarn detection device detects absence of the spun yarn on the yarn route, the control section stops the rotation of the package.

[0028] Therefore, separation of a yarn end of the spun yarn, which has been cut at the portion thereof upstream of the yarn storage roller, from the yarn storage roller is quickly and surely detected.

[0029] Preferably, in the air spinning machine, the yarn storage roller includes a storage portion having a diameter of not less than 70 millimeters and not more than 110 millimeters.

[0030] Therefore, the winding of the spun yarn into the package is stopped while the long defect is surely left on the yarn storage roller, thereby shortening a processing time required to remove the long defect.

[0031] Preferably, in the air spinning machine, the yarn storage roller is able to store the spun yarn whose length is not less than 10 meters.

[0032] Therefore, even if the long defect has a length of not less than 10 meters, the winding of the spun yarn can be stopped in the state where the long defect is left on the yarn storage roller.

[0033] In a second aspect of the present invention, an air spinning method includes an air spinning step, a yarn storage step, a winding step, a yarn monitoring step, and a control step. In the air spinning step, a fiber bundle is twisted with a swirling airflow by an air spinning device so as to produce a spun yarn. In the yarn storage step, the spun yarn is stored on a yarn storage roller. In the winding step, the spun yarn having been stored on the yarn storage roller is wound so as to form a package. In the yarn monitoring step, a yarn monitoring device disposed between the air spinning device and the yarn storage roller is operated so as to detect a long defect and a short defect in the spun yarn. In the control step, when the long defect in the spun yarn is detected by the yarn

monitoring device, rotation of the package is stopped so as to interrupt the winding step of winding the spun yarn in a state where at least a portion of the long defect is stored on the yarn storage roller.

[0034] Therefore, the long defect is prevented from being wound into the package, and a portion of the spun yarn to be unwound from the package is shortened, thereby reducing an amount of waste yarn and shortening a time for performing a yarn joining cycle.

BRIEF DESCRIPTION OF THE DRAWINGS

[0035]

FIG. 1 is a side view of a spinning unit included in a fine spinning machine according to an embodiment of the present invention, showing its structural features;

FIG. 2 is a perspective view of a yarn storage roller and a yarn suction device, showing their locational relation;

FIG. 3 is a perspective view of an air injection device, showing its schematic structure;

FIG. 4 is a control block diagram of the spinning unit; FIG. 5 is a side view of the spinning unit immediately after the air spinning device has stopped its spinning operation;

FIG. 6 is a side view of the spinning unit in which a winding device has stopped its winding operation, and a first catching guide device is located at a first yarn catching position;

FIG. 7 is a side view of the spinning unit in which the winding device is forwardly rotating a package at a low speed, and a yarn end is sucked and caught by a yarn trap;

FIG. 8 is a side view of the spinning unit in which the winding device has stopped the forward rotation of the package, and a spun yarn is regulated by a yarn regulation guide;

FIG. 9 is a side view of the spinning unit in which the winding device is reversely rotating the package, and the first catching guide device and a second catching guide device guide a first yarn and a second yarn to a yarn joining device, respectively;

FIG. 10 is a side view of the spinning unit immediately after the air spinning device stopped its spinning operation based on detection of a long defect;

FIG. 11 is a side view of the spinning unit immediately after a downstream side cutter cuts the spun yarn based on detection of the long defect;

FIG. 12 is a timing chart of operations of respective devices and members during yarn joining; and

FIG. 13 is a timing chart of operations of the air injection device and a winding drum after failure of the yarn joining.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0036] An embodiment of the present invention will now be described with reference to the drawings. The terms "upstream" and "downstream" used herein mean upstream and downstream in a traveling direction of a sliver 8, a fiber bundle 9 and a spun yarn 10 during winding of the spun yarn 10.

[0037] A fine spinning machine (i.e., an air spinning machine) includes a plurality of spinning units 100 arranged side-by-side, and an unillustrated machine base controller for centrally controlling the plurality of spinning units 100. Each of the spinning units 100 produces the spun yarn 10 from the sliver 8, and winds the produced spun yarn 10 so as to form a package 70.

[0038] The fine spinning machine includes a control section 90 (see FIG. 4) connected with the machine base controller. The control section 90 is configured as a computer including hardware such as Central Processing Unit (CPU), Read Only Memory (ROM) or Random Access Memory (RAM), and software such as controlling programs, thereby controlling component devices and members of the spinning unit 100. The plurality of spinning units 100 may be provided with respective control units 90, or a common control section 90 may be provided for each predetermined number of spinning units 100.

[0039] Referring to FIG. 1, each spinning unit 100 includes a draft device 2, an air spinning device 3, a yarn monitoring device 4, a yarn storage device 5, a yarn joining device 6, and a winding device 7, which are arranged in this order from upstream towards downstream.

[0040] The draft device 2 includes a plurality of (in this embodiment, four) draft rollers and a plurality of (in this embodiment, four) opposing rollers disposed so as to oppose the respective draft rollers. The draft device 2 conveys the sliver 8 fed from an unillustrated sliver casing via a sliver guide while sandwiching the sliver 8 between the draft rollers and the opposing rollers, thereby stretching (i.e., drafting) the sliver 8 to a certain fiber amount (or thickness) so as to form the fiber bundle 9.

[0041] The four draft rollers are a back roller 21, a third roller 22, a middle roller 24 over which a rubber apron belt 23 is looped, and a front roller 25. These draft rollers are aligned in this order from the upstream side. The draft rollers are rotated at respective preset speeds. The control section 90 is configured so as to control rotary speeds of the respective draft rollers by controlling rotation of a later-discussed draft motor 91. The control section 90 appropriately controls the rotary speeds of the respective draft rollers in correspondence to a production speed of the air spinning device 3 for producing the spun yarn 10. FIG. 4 illustrates one draft motor 91. Alternatively, the draft rollers may be provided with respective draft motors. Further alternatively, only both the back roller 21 and the third roller 22 may be driven by a common draft motor.

[0042] The air spinning device 3 is disposed immediately downstream of the front roller 25. The air spinning

device 3 includes an unillustrated spinning nozzle. The air spinning device 3 generates a swirling airflow by injecting a compressed air from the spinning nozzle into an inside thereof, and twists the fiber bundle 9 fed from the draft device 2 by the swirling airflow so as to produce the spun yarn 10.

[0043] The air spinning device 3 can selectively perform either yarn-discharge spinning or normal spinning based on a control order from the control section 90. The yarn-discharge spinning differs in a manner of producing the spun yarn 10 and spinning speed from the normal spinning. The yarn-discharge spinning is a spinning operation performed by the air spinning device 3 when starting or restarting the production of the spun yarn 10. The normal spinning is a spinning operation for continuously producing the spun yarn 10 to be wound by the winding device 7 after the yarn-discharge spinning.

[0044] A spun yarn detection device 30 is disposed immediately downstream of the air spinning device 3. The spun yarn detection device 30 detects presence or absence of the spun yarn 10 immediately after being produced and sent out by the air spinning device 3. For example, the yarn detection device 30 may use a non-contact optical sensor or a capacitive sensor.

[0045] The yarn monitoring device 4 is disposed downstream of the spun yarn detection device 30. The yarn monitoring device 4 uses a light transmission sensor to monitor a quality (e.g., thickness) of the traveling spun yarn 10 so as to detect a yarn defect in the spun yarn 10. The yarn monitoring device 4 is not limited to the light transmission sensor. For example, the yarn monitoring device 4 may use a capacitive sensor to monitor the quality of the spun yarn 10.

[0046] The yarn defect means an abnormal portion of the spun yarn 10. The yarn defects include a short defect with a length of some centimeters and a long defect with a length of one or more meters. The short defect includes any kind of short defect, such as a slub, a nep or a trash. The slub is a portion of yarn that is thicker than other portions due to defective spinning or contamination of foreign substances. The nep is a mass of entangled fine fibers. The trash is foliage of cotton. The long defect includes any kind of long defect, such as a thin and/or thick unevenness, a tapered portion or a yarn unevenness. The thin and/or thick unevenness is a relatively long unevenness of the spun yarn 10 caused by unevenness of the sliver 8 in thickness. The tapered portion is a portion of the spun yarn 10 that gradually becomes thin due to the fiber bundle 9 being wrapped up on the opposing rollers of the draft device 2. The yarn unevenness is a state in which HD (hairiness difference) is abnormal due to some reasons. In the present embodiment, the long defect is defined as a yarn defect whose length is not less than 50 centimeters, and the short defect is defined as a yarn defect whose length is less than 50 centimeters.

[0047] When the yarn monitoring device 4 detects the yarn defect, the air spinning device 3 stops its spinning operation. Therefore, a portion of the spun yarn 10 in the

air spinning device 3 is reduced in strength and the spun yarn 10 is cut. In this way, the air spinning device 3 functions as a cutting section for cutting the spun yarn 10 when the yarn monitoring device 4 detects the yarn defect. Alternatively, a cutter may be used to cut the spun yarn 10.

[0048] In comparison with an arrangement in which the yarn monitoring device 4 is disposed downstream of yarn storage device 5, according to the above-mentioned arrangement in which the yarn monitoring device 4 is disposed between the air spinning device 3 and the yarn storage device 5, the yarn defect can be located (positioned) close to a yarn end A (i.e., a yarn end C in FIG. 10) of the spun yarn 10 having been cut, thereby reducing an amount of waste yarn generated during yarn joining.

[0049] A first guide 11 is disposed downstream of the yarn monitoring device 4. The first guide 11 is configured movably for leading the spun yarn 10 toward the yarn storage device 5 during the yarn joining or so on. The first guide 11 is arranged so as to be rotatable between a guide position as drawn in solid lines in FIG. 1 and a standby position as drawn in chain lines in FIG. 1 by driving a later-discussed guide motor 93.

[0050] A tension sensor 40 is disposed downstream of the first guide 11. The tension sensor 40 is configured as a load cell sensor, for example. The tension sensor 40 measures a tension of the traveling spun yarn 10 and outputs an electric signal corresponding to the tension to the control section 90.

[0051] The yarn storage device 5 is disposed downstream of the tension sensor 40. The yarn storage device 5 includes a yarn storage roller 51, a storage motor 52 for rotatably driving the yarn storage roller 51, and a yarn hooking member 53.

[0052] The yarn storage roller 51 includes a storage portion 51a having a diameter of not less than 70 millimeters and not more than 110 millimeters. The spun yarn 10 is wound on an outer circumferential surface of the storage portion 51a so as to be temporarily stored. The yarn storage roller 51 is formed so as to be able to store the spun yarn 10 whose length is not less than 10 meters (in this embodiment, not less than 50 meters). Therefore, the yarn storage roller 51 is formed so as to be able to store a large amount of the spun yarn 10 thereon, thereby expanding a space where a stored yarn detection device 50 for detecting an amount of the spun yarn 10 stored on the yarn storage roller 51 can be mounted. FIG. 2 illustrates the storage portion 51a as formed in a circularly cylindrical shape having a constant outer diameter. Alternatively, the storage portion 51a may be tapered so as to have a diameter that becomes smaller as it goes from its upstream side to its downstream side. Further alternatively, the storage portion 51a may include a plurality of tapered portions.

[0053] An unillustrated intermediate shaft is interposed between the yarn storage roller 51 and the storage motor 52, thereby reducing abrasion of a rotary shaft and a bearing of the storage motor 52. The intermediate shaft

includes adjoining portions having mutually different diameters, thereby being formed with a step. A shaft hole of the yarn storage roller 51 is formed so as to allow only a relatively thin utmost end portion of the intermediate shaft to be inserted thereinto, thereby facilitating positional fixing of the yarn storage roller 51. Alternatively, the intermediate shaft may be formed with no step.

[0054] The yarn hooking member 53 is mounted on a downstream end portion of the yarn storage roller 51. The yarn hooking member 53 is supported rotatably relative to the yarn storage roller 51. Either the yarn hooking member 53 or the yarn storage roller 51 has a permanent magnet attached thereon, and the other of them has a magnetic hysteresis member attached thereon. These magnetic means generate a torque against rotation of the yarn hooking member 53 relative to the yarn storage roller 51. Accordingly, only when a force overcoming this torque (i.e., a tension having a magnitude of not less than a certain value) is applied onto the yarn hooking member 53, the yarn hooking member 53 rotates relative to the yarn storage roller 51 so as to enable unwinding of the spun yarn 10 from the yarn storage roller 51. Unless the force overcoming the torque is applied onto the yarn hooking member 53, the yarn hooking member 53 rotates integrally with the yarn storage roller 51 so as to store the spun yarn 10 on the yarn storage roller 51. The permanent magnet may be replaced with an electromagnet. The magnetic means may be replaced with a drive motor for rotating the yarn hooking member 53.

[0055] In this way, the yarn storage device 5 is operated so as to unwind the spun yarn 10 in response to increase of the yarn tension at the downstream side thereof, and so as to keep the spun yarn 10 from being unwound in response to reduction of the yarn tension (i.e., when the spun yarn 10 is likely to be loosened). Therefore, the yarn storage device 5 eliminates slack of the spun yarn 10 so as to apply an appropriate tension to the spun yarn 10. The yarn hooking member 53 moves so as to absorb change of the yarn tension applied to the spun yarn 10 between the yarn storage device 5 and the winding device 7 as mentioned above, thereby preventing the change of yarn tension from influencing the spun yarn 10 between the air spinning device 3 and the yarn storage device 5. Accordingly, the spun yarn 10 travels relatively stably at a position between the air spinning device 3 and the yarn storage device 5. Therefore, the yarn monitoring device 4 is disposed at this position so as to maintain its high detection accuracy.

[0056] The storage motor 52 is configured as a reversible rotary electric motor which is able to rotate the yarn storage roller 51 reversely so as to unwind the spun yarn 10 from the yarn storage roller 51 in some cases (e.g., when removing the long defect).

[0057] The stored yarn detection device 50 for detecting presence or absence of the spun yarn 10 stored on the yarn storage roller 51, and a yarn suction device (i.e., a first removing device) 54 are disposed close to the yarn storage device 5 at a position corresponding to an up-

stream side portion of the storage portion 51a of the yarn storage roller 51 (i.e., a portion on which the winding of the spun yarn 10 is started).

[0058] The stored yarn detection device 50, including an optical sensor, for example, is disposed at a position where it is possible to detect whether the spun yarn 10 having a length of not less than 10 meters and not more than 50 meters is stored on the yarn storage roller 51. The stored yarn detection device 50 also functions to detect a storage amount of the spun yarn 10 stored on the yarn storage roller 51. A desired storage amount of the spun yarn 10 can be easily obtained by locating the stored yarn detection device 50 at a position corresponding to the desired storage amount, and by adjusting a spinning speed or/and a winding speed based on a result of detection by the stored yarn detection device 50. Alternatively, the stored yarn detection device 50 may be omitted. In this case, the storage amount of the spun yarn 10 stored on the yarn storage roller 51 is calculated based on a speed difference between a speed of guiding the spun yarn 10 to the yarn storage roller 51 (i.e., the spinning speed) and a speed of unwinding the spun yarn 10 from the yarn storage roller 51 (i.e., the winding speed).

[0059] Referring to FIG. 2, the yarn suction device 54 is disposed opposite to the stored yarn detection device 50 with respect to the yarn storage roller 51. The yarn suction device 54 includes a hollow pipe and a yarn suction valve (i.e., an opening and closing member) 54a shown in FIG. 4. The hollow pipe is connected to an unillustrated blower serving as a negative pressure source so that the fine spinning machine is able to generate a suction airflow at a tip portion of the hollow pipe. The yarn suction valve 54a is disposed on an air route between the hollow pipe and the unillustrated blower, and is controlled by the later-discussed control section 90. Instead of the yarn suction valve 54a, a shutter may serve as the opening and closing member, for example.

[0060] For example, the control section 90 controls to open or close the yarn suction valve 54a to selectively pass or shut the suction airflow flowing through the pipe of the yarn suction device 54, so that the suction airflow is selectively generated at the tip portion of the pipe or shut off from the tip portion of the pipe. By generating the suction airflow at the tip portion of the pipe, the yarn suction device 54 sucks and catches a yarn end A (see FIG. 5) or a yarn end C (see FIG. 10) of the spun yarn 10 having been cut at a portion thereof upstream of the yarn storage device 5.

[0061] A yarn unhooking guide 14 is disposed downstream of the yarn storage roller 51 and close to a yarn route where the spun yarn 10 travels. The yarn unhooking guide 14 is rotatable (swingable) across the yarn route downstream of the yarn storage roller 51 from one side of the yarn route (i.e., a standby position drawn in solid lines in FIG. 1) to another side of the yarn route (i.e., an operating position drawn in chain lines in FIG. 1). The spun yarn 10 is unhooked (removed) from the yarn hooking member 53 by moving the yarn unhooking guide 14

to the operating position.

[0062] A second guide 12 is disposed downstream of the yarn storage roller 51 and the yarn unhooking guide 14. A third guide 13 is disposed immediately downstream of the second guide 12 so as to control movement of the spun yarn 10 unwound from the yarn storage roller 51.

[0063] A yarn trap 41 connected to an unillustrated blower is disposed immediately downstream of the third guide 13. The yarn trap 41 includes a hollow pipe having a tip portion disposed close to the yarn route. The yarn trap 41 generates a suction airflow at the tip portion thereof so as to suck and catch dust, e.g., fly waste, stuck to the traveling spun yarn 10.

[0064] The yarn joining device 6 is disposed downstream of the yarn trap 41. When the spun yarn 10 is disconnected at a portion thereof between the air spinning device 3 and the package 70 for some reason, the yarn joining device 6 joins the spun yarn 10 from the air spinning device 3 (i.e., a first yarn) and the spun yarn 10 from the package 70 (i.e., a second yarn). In the present embodiment, the yarn joining device 6 is a splicer device for twisting the yarn ends together with a swirling airflow. The yarn joining device 6 is not limited to the splicer device. For example, a mechanically twisting knotter may serve as the yarn joining device 6.

[0065] The spinning unit 100 includes catching guide devices for guiding the spun yarn 10 to the yarn joining device 6. The catching guide devices include a first catching guide device 15 for guiding the first yarn and a second catching guide device (i.e., a second removing device) 16 for guiding the second yarn.

[0066] The first catching guide device 15 is supported at a base portion thereof so as to be vertically rotatable with the base portion thereof as a rotation center. The first catching guide device 15 is hollow and is connected to an unillustrated blower so as to be able to generate a suction airflow at a tip portion thereof. By rotating downward, the first catching guide device 15 moves to a first yarn catching position (see FIG. 8) where the first catching guide 15 can catch a yarn end B of the first yarn. By rotating upward after catching the first yarn, the first catching guide device 15 guides the first yarn to the yarn joining device 6.

[0067] The second catching guide device 16 is supported at a base portion thereof so as to be vertically rotatable with the base portion thereof as a rotation center. The second catching guide device 16 also is hollow and is connected to an unillustrated blower so as to be able to generate a suction airflow at a tip portion thereof. By rotating upward, the second catching guide device 16 moves to a second yarn catching position (see FIG. 8) where the second catching guide device 16 can catch a yarn end (i.e., the yarn end A in FIG. 8, or a yarn end E in FIG. 11) of the second yarn. By rotating downward after catching the second yarn, the second catching guide device 16 guides the second yarn to the yarn joining device 6.

[0068] In this state, by driving the yarn joining device

6, the first yarn and the second yarn are joined together so as to make the spun yarn 10 to be continuous between the air spinning device 3 and the package 70, thereby enabling restart of the winding of the spun yarn 10 into the package 70.

[0069] A yarn detection device 60 is disposed downstream of the yarn joining device 6. The yarn detection device 60 detects presence or absence of the spun yarn 10 traveling on the yarn route. The yarn detection device 60 may be configured so as to further detect success or failure of yarn joining performed by the yarn joining device 6, presence or absence of waste yarn that may be mixed into the package 70, or so on. For example, the yarn detection device 60 may use a noncontact optical sensor or a capacitive sensor.

[0070] An air injection device 61 and a yarn regulation guide 62 are disposed immediately downstream of the yarn detection device 60. The air injection device 61 is connected to an unillustrated compressed air source so as to be able to inject compressed air to the yarn route. The spun yarn 10 blown off by the air injection device 61 is hooked on the yarn regulation guide 62 so as to be controlled in movement and location (position).

[0071] Referring to FIG. 3, a main guide 64 and a subsidiary guide 65 are disposed downstream of the yarn detection device 60 and are aligned in this order from the upstream side. The air injection device 61 is mounted upstream of the subsidiary guide 65 and on (more specifically, on a downstream side surface of) the main guide 64. The air injection device 61 includes a main nozzle 61a and an auxiliary nozzle 61b such as to inject compressed air to a place between the main guide 64 and the subsidiary guide 65.

[0072] The air injection device 61 injects compressed air in a direction toward the yarn route from the main nozzle 61a on a front surface thereof. The auxiliary nozzle 61b is mounted leftward from the yarn route (i.e., leftward of a tip of the yarn regulation guide 62) in FIG. 3. The air injection device 61 also injects compressed air toward the yarn route from the auxiliary nozzle 61b so as to join the air injected from the auxiliary nozzle 61b to the air injected from the main nozzle 61a. More specifically, the compressed air from the auxiliary nozzle 61b is injected slantwise to the yarn route. Therefore, the spun yarn 10 trembling because of traverse by the winding device 7 is appropriately controlled by the yarn regulation guide 62. In other words, the auxiliary nozzle 61b keeps the blown spun yarn 10 from deviating from the yarn regulation guide 62.

[0073] By disposing the air injection device 61 and the yarn regulation guide 62, the yarn end A (or E) is regulated so that the yarn end A (or E) can be easily caught by the second catching guide device 16.

[0074] The winding device 7 is disposed downstream of the air injection device 61 and the yarn regulation guide 62. The winding device 7 is located higher than an upstream end of the draft device 2. The winding device 7 includes a cradle arm 71 and a winding drum 72. The

yarn route where the spun yarn 10 travels from the yarn storage device 5 to the winding device 7 is bent and guided by a downstream guide 63 disposed between the yarn detection device 60 and the winding device 7.

[0075] The cradle arm 71 is able to rotatably support a winding tube 73 for winding the spun yarn 10 therearound. The cradle arm 71 is rotatable with a base portion thereof as a center. Therefore, even if the spun yarn 10 is wound around the winding tube 73 and a diameter of the package 70 increases, the package 70 and the winding drum 72 are kept contacting each other appropriately, thereby continuously winding the spun yarn 10.

[0076] By receiving a driving force from a later-discussed drum motor 72a, the winding drum 72 rotates while making contact with an outer circumferential surface of the winding tube 73 or the package 70. An unillustrated traverse groove is formed on an outer circumferential surface of the winding drum 72. Due to the traverse groove, the spun yarn 10 is traversed by a certain width. In this way, the winding device 7 traverses the spun yarn 10 by the rotating winding drum 72 and winds the traversed spun yarn 10 onto the rotating winding tube 73 so as to form the package 70.

[0077] An electrical configuration of the spinning unit 100 will now be described with reference to FIG. 4. To drive and control the above-mentioned devices, the spinning unit 100 includes a draft motor 91, a spinning valve 92, a first guide motor 93, a yarn unhooking guide motor 94, a second guide motor 95, a yarn joining cam motor 96, a catching guide motor 97, an air injection valve 98, a winding drum motor 72a, and a winding brake valve 99.

[0078] For example, a plurality of electric motors serve as the draft motor 91 to drive the back roller 21, the third roller 22, the middle roller 24, and the front roller 25 of the draft device 2 at respective required speeds.

[0079] The spinning valve 92 is configured as an electromagnetic valve disposed on a compressed air supply route from its compressed air source to the air spinning device 3. The spinning valve 92 is switchable so as to generate or stop the swirling airflow in the air spinning device 3 for twisting the fiber bundle 9.

[0080] The first guide motor 93 is an electric motor rotatable forwardly and reversely for rotating the first guide 11 between the guide position and the standby position with the base portion thereof as a rotation center.

[0081] The yarn unhooking guide motor 94 is an electric motor rotatable forwardly and reversely for rotating the yarn unhooking guide 14 between the standby position and the operating position.

[0082] The second guide motor 95 is an electric motor rotatable forwardly and reversely for rotating the second guide 12 between the operating position and the standby position with the base portion as a rotation center. During the winding of the spun yarn 10 into the package 70, the second guide 12 is located at the operating position as drawn in solid lines in FIG. 1 so as to guide the traveling of the spun yarn 10 in cooperation with the third guide 13. By moving the second guide 12 from the standby

position as drawn in chain lines in FIG. 1 to the operating position after the later-discussed yarn joining, the spun yarn 10 is set again on the yarn route.

[0083] The yarn joining cam motor 96 is an electric motor rotatable forwardly and reversely for rotationally driving an unillustrated cam of the yarn joining device 6. This cam is configured to move respective yarn-joining operable parts (e.g., a yarn handling lever, a yarn pressing lever, a clamp portion, and a cutter) of the yarn joining device 6.

[0084] The catching guide motor 97 is an electric motor rotatable forwardly and reversely for vertically rotating the first catching guide device 15 and the second catching guide device 16. In this regard, the catching guide motor 97 may include an electric motor for driving the first catching guide device 15 and another electric motor for driving the second catching guide device 16.

[0085] The air injection valve 98 is configured as an electromagnetic valve disposed on a compressed air route from its compressed air source to the air injection device 61. The air injection valve 98 is switchable so as to supply or stop supplying of the compressed air to the air injection device 61.

[0086] The winding brake valve 99 is an electromagnetic valve disposed on a compressed air supply route to an appropriate actuator (e.g., a pneumatic cylinder) for operating a brake mechanism (not shown) of the winding device 7. The winding brake valve 99 is switchable so as to apply or release the brake of the package 70 in the winding device 7.

[0087] The control section 90 is electrically connected to the above-mentioned motors, respectively, for controlling rotation or stop of the respective motors, controlling rotary speeds of the respective motors, and so on. The control section 90 is electrically connected to the above-mentioned valves, respectively, for controlling opening or closing of each valve. The spun yarn detection device 30, the yarn monitoring device 4, the stored yarn detection device 50 and the yarn detection device 60 are electrically connected to the control section 90 so that they can output their detection results to the control section 90.

[0088] The yarn joining performed when the yarn monitoring device 4 detects a yarn defect will now be described. First of all, a flow of yarn joining performed when a short defect S is detected will be described with reference to FIGS. 5 to 9.

[0089] When the yarn monitoring device 4 detects the short defect S, the control section 90 immediately closes the spinning valve 92 and stops rotation of the draft motor 91. Due to the stop of spinning, the spun yarn 10 is cut at a portion thereof upstream of the stored yarn detection device 50 as shown in FIG. 5. Therefore, the spun yarn 10 stored in the yarn storage device 5 comes to have the yarn end A as an upstream end thereof.

[0090] After the spinning valve 92 is closed, the control section 90 continues rotation of the package 70 until a predetermined winding time elapses from detection of absence of the spun yarn 10 by the stored yarn detection

device 50. In other words, the control section 90 keeps rotating the package 70 for the predetermined winding time and then stops the rotation of the package 70 such that the short defect S in the spun yarn 10 is located downstream of the yarn storage roller 51. Therefore, the normal yarn having been stored in the yarn storage device 5 is wound into the package 70, thereby reducing the amount of waste yarn to be removed with the short defect S. The normal yarn having been stored in the yarn storage device 5 is wound at a normal winding speed, thereby shortening a later-discussed first low speed winding time so as to shorten a time for performing a yarn joining cycle.

[0091] The above-mentioned predetermined winding time can be set appropriately based on traveling speed of the spun yarn 10, thickness of the spun yarn 10, or so on. It is preferable that the rotation of the package 70 is completely stopped in a state where a small amount of the spun yarn 10 is wound around the storage portion 51a of the yarn storage roller 51. Therefore, the yarn end A is prevented from being entangled in any device between the yarn storage device 5 and the winding drum 72.

[0092] After the stop of spinning, and after the predetermined winding time elapsed from the detection of absence of the spun yarn 10 by the stored yarn detection device 50, the control section 90 stops rotation of the winding drum motor 72a and opens the winding brake valve 99 so as to activate the unillustrated brake mechanism, thereby stopping the rotation of the package 70.

[0093] After the rotation of the package 70 is stopped, the control section 90 stops rotation of the storage motor 52 (i.e., of the yarn storage roller 51). During the rotation of the yarn storage roller 51, the yarn end A is swung by a centrifugal force while being kept at a slight distance from the outer circumferential surface of yarn storage roller 51. Due to the delayed stop of rotation of the yarn storage roller 51, the yarn end A is prevented from being entangled in the yarn layers stored on the yarn storage roller 51.

[0094] At an appropriate time after the stop of spinning and before the stop of rotation of the yarn storage roller 51, the control section 90 commands to perform a cleaning operation using the spinning nozzle. Alternatively, the cleaning operation may be omitted.

[0095] After the cleaning operation is finished, the control section 90 rotates the first guide motor 93 so as to move the first guide 11 to the standby position (drawn in solid lines) as shown in FIG. 6.

[0096] Simultaneously, or before or after the rotation of the first guide motor 93, the control section 90 rotates the catching guide motor 97 so as to move the first catching guide device 15 to the first yarn catching position (see the corresponding solid lines in FIG. 6).

[0097] After the rotation of the yarn storage roller 51 is stopped, the control section 90 opens the yarn suction valve 54a so as to generate the suction airflow at the tip of the yarn suction device 54. Simultaneously or subsequently, the control section 90 reversely rotates the stor-

age motor 52 so as to reversely rotate the yarn storage roller 51 as shown in FIG. 2 for 1.5 to 2 turns. Therefore, the spun yarn 10 is slightly unwound from the yarn storage roller 51 so that the yarn end A of the spun yarn 10 can be easily caught by the yarn suction device 54. In this way, the yarn end A is sucked and caught by the yarn suction device 54, so that during the subsequent first low speed winding process, the yarn end A is prevented from being entangled in the yarn layers stored on the yarn storage roller 51.

[0098] After the reverse rotation of the yarn storage roller 51 is finished, i.e., after the yarn end A is sucked and caught by the yarn suction device 54, the control section 90 activates the winding drum motor 72a to start winding of the spun yarn 10 into the package 70 at a first low speed (e.g., 10-30 m/min) as shown in FIG. 7.

[0099] After a predetermined time elapses from the start of the first low speed winding operation, the control section 90 opens the air injection valve 98 so as to command the air injection device 61 to inject a compressed air to the yarn route. The predetermined time is appropriately set so as to enable the air injection device 61 to start injecting the compressed air at a time before the yarn end A passes the yarn detection device 60.

[0100] By the first low speed winding operation of the winding device 7, the spun yarn 10 having been stored on the yarn storage roller 51 is gradually wound into the package 70. Afterward, the yarn end A is drawn out of the yarn suction device 54. The yarn end A released from the yarn suction device 54 is sucked by the yarn trap 41 as shown in FIG. 7. The first low speed winding operation of the winding device 7 is continued so as to further draw the yarn end A out of the yarn trap 41. In this way, the yarn end A is held in stages while it moves towards the downstream side, thereby being prevented from being entangled in another device.

[0101] The yarn end A drawn out of the yarn trap 41 becomes free so that the yarn end A is blown away from the yarn route by the air injection device 61 and is hooked on the yarn regulation guide 62 as shown in FIG. 8.

[0102] Referring to FIG. 8, the yarn end A does not pass the yarn detection device 60 because it is hooked on the yarn regulation guide 62 and is located away from the yarn route. The yarn detection device 60 detects absence of the spun yarn 10 from the yarn route and sends a detection signal indicating the absence of the spun yarn 10 to the control section 90. When the control section 90 receives this detection signal, the control section 90 stops the rotation of the package 70.

[0103] By using the air injection device 61, the yarn end A is instantly detected as being away from the yarn storage device 5 and drawn out of the yarn trap 41, so that the first low speed winding operation of the winding device 7 can be stopped in a state where the second catching guide device 16 can catch the yarn end A at the second yarn catching position, thereby preventing the yarn end A from being wound into the package 70. Therefore, the yarn end A is prevented from being entangled

in yarn layers of the package 70, and the second yarn is set to be easily caught by the second catching guide device 16.

[0104] Afterward, the control section 90 commands the second catching guide device 16 to move to the second yarn catching position as drawn in solid lines in FIG. 8 so as to catch the yarn end A. After the second catching guide device 16 catches the yarn end A, the control section 90 closes the air injection valve 98 so as to stop the compressed air injection operation of the air injection device 61.

[0105] Subsequently, the control section 90, while rotating the package 70 reversely, commands the second catching guide device 16 to move to a yarn joining position as drawn in solid lines in FIG. 9. Therefore, the second yarn caught by the second catching guide device 16 is guided to the yarn joining device 6.

[0106] Alternatively, the second catching guide device 16 may be once moved to a standby position as drawn in dotted lines in FIG. 9 and after the reverse rotation of the package 70 is finished, the second catching guide device 16 may be moved to the yarn joining position. The standby position may be located appropriately so that the spun yarn 10 can be kept from contacting a nozzle of the yarn joining device 6 or the like and can pass the yarn detection device 60. Therefore, the spun yarn 10 is prevented from being hooked on the yarn joining device 6 during the reverse rotation of the package 70.

[0107] Referring to FIG. 9, the spun yarn 10 is guided by the second catching guide device 16 so as to pass the yarn detection device 60, and presence or absence of the spun yarn 10 can be detected by the yarn detection device 60.

[0108] Based on the result of detection by the yarn detection device 60, it can be easily judged whether the second catching guide device 16 has succeeded in catching the yarn end A or not. More specifically, after the second catching guide device 16 reaches the yarn joining position, if the yarn detection device 60 detects the spun yarn 10, the control section 90 determines the second catching guide device 16 as succeeding in catching the second yarn, and if the yarn detection device 60 would not detect the spun yarn 10, the control section 90 determines the second catching guide device 16 as failing to catch the second yarn. In the case where the second catching guide device 16 fails to catch the second yarn, the control section 90 interrupts the yarn joining.

[0109] In the case where the control section 90 determines that the second yarn has been successfully caught by the second catching guide device 16, the control section 90 stops the reverse rotation of the winding drum 72 (i.e., the winding drum motor 72a) to stop the reverse rotation of the package 70 after a predetermined length of the spun yarn 10 has been unwound from the package 70. This predetermined length is set appropriately based on the thickness of the spun yarn 10, the reverse rotation speed of package 70, or so on, so as to enable the second catching guide device 16 to remove the short defect S.

However, the present invention is not limited to such an example. For example, the yarn detection device 60 may be adapted to monitor the spun yarn 10 and the control section 90 may stop the reverse rotation of the package 70 after the yarn detection device 60 detects the short defect S passing therethrough.

[0110] In this way, during the process of guiding the second yarn from the package 70 to the yarn joining device 6, the second catching guide device 16 removes the short defect S in the caught spun yarn 10. Therefore, no additional process of removing the short defect S is required, thereby shortening the time for performing the yarn joining cycle.

[0111] After the reverse rotation of the package 70 is stopped, the control section 90 opens the spinning valve 92 so as to command the air spinning device 3 to start the yarn-discharge spinning operation, and rotates the rollers of the draft device 2 at respective rotary speeds corresponding to the yarn-discharging spinning.

[0112] When a predetermined yarn-discharge spinning time elapses since the spun yarn detection device 30 detects the spun yarn 10 produced by the yarn-discharge spinning, the control section 90 commands the first catching guide device 15 to move to a yarn joining position as drawn in solid lines in FIG. 9. Therefore, the first yarn caught by the first catching guide device 15 is guided to the yarn joining device 6. The predetermined yarn-discharge spinning time can be set appropriately so as to enable the first catching guide device 15 to catch the first yarn. For example, the first catching guide device 15 may incorporate an unillustrated yarn detection sensor so that the first catching guide device 15 is moved when the yarn detection sensor detects the first yarn.

[0113] The control section 90 activates the second guide motor 95 so as to move the second guide 12 to the standby position as drawn in solid lines in FIG. 9 before the movement of the first catching guide device 15 is started.

[0114] During the movement of the first catching guide device 15 from the first yarn catching position to the yarn joining position, the control section 90 commands the first guide 11 to move to the guide position as drawn in solid lines in FIG. 9. Simultaneously or subsequently, the control section 90 commands the second guide 12 to return to the operating position as drawn in chain lines in FIG. 9 so as to hook the spun yarn 10 on the yarn hooking member 53, thereby starting the storage of the spun yarn 10 on the yarn storage roller 51. The control section 90 starts rotation of the yarn storage roller 51 at an appropriate timing such that the yarn storage roller 51 rotates at a speed corresponding to the yarn-discharge spinning at a time when the first catching guide device 15 reaches the yarn joining position.

[0115] Simultaneously or subsequently, the control section 90 commands the yarn unhooking guide 14 to rotate from the standby position (drawn in chain lines) to the operating position (drawn in solid lines) as shown in FIG. 9. Therefore, the spun yarn 10 is unhooked from

the yarn hooking member 53 of the yarn storage device 5 so as not to be stored on the yarn storage roller 51 but so as to be sucked by the first catching guide device 15.

[0116] Simultaneously, the control section 90 commands the air spinning device 3 to start the normal spinning operation, and commands the rollers of the draft device 2 to rotate at a speed corresponding to the normal spinning.

[0117] After a predetermined normal spinning time elapses from the start of the normal spinning operation of the air spinning device 3, the control section 90 commands the yarn unhooking guide 14 to return to the standby position so as to restart the storage of the spun yarn 10 by the yarn storage device 5, and simultaneously, commands the yarn joining device 6 to start the yarn joining operation.

[0118] After the yarn joining operation of the yarn joining device 6 is finished, the control section 90 commands the winding device 7 to start a second low speed winding operation, and commands the air injection device 61 to start injection of compressed air so as to judge whether the yarn joining has succeeded or failed. The second low speed winding means forward rotation of the package 70 at a second low speed (e.g., 10-20m/min) for winding the spun yarn 10 at a low speed.

[0119] If the yarn joining has failed, the disconnected spun yarn 10 is blown by the air injection device 61 away from the yarn detection device 60. Accordingly, the yarn detection device 60 detects absence of the spun yarn 10 from the yarn route and transmits a corresponding detection signal to the control section 90. The control section 90 determines that the yarn joining has failed, and stops the drafting operation of the draft device 2, the spinning operation of the air spinning device 3, and the second low speed winding operation of the winding device 7. Then, as shown in FIG. 13, the control section 90 commands the air injection device 61 to continuously inject compressed air for a predetermined time. During the continuous injection of compressed air, the control section 90 commands the winding drum 72 to rotate slightly reversely so as to unwind the spun yarn 10 from the package 70, thereby lengthening a portion of the spun yarn 10 between the winding device 7 and the yarn joining device 6. The predetermined time for the compressed air injection is set appropriately so as to eliminate a torque in the spun yarn 10, thereby stabilizing movement or location of the yarn end during the subsequent yarn joining operation or so on.

[0120] After the predetermined time elapses, the control section 90 commands the air injection device 61 to temporarily stop the injection operation and commands the second catching guide device 16 to move to the second yarn catching position so as to restart the yarn joining. During the operation of the second catching guide device 16 to catch the second yarn, the air injection device 61 intermittently performs the injection operation. Intervals among the intermittent injection operations of the air injection device 61 are set appropriately so as to

keep enabling the second catching guide device 16 to catch the second yarn. Therefore, the second yarn can be surely caught by the second catching guide device 16 and consumption of compressed air can be reduced.

[0121] If the yarn joining has succeeded, the spun yarn 10 is detected by the yarn detection device 60 without being influenced by the compressed air injected by the air injection device 61. In this case, the control section 90 determines the yarn joining has succeeded, and commands the winding drum motor 72a to increase its driving speed to the normal winding speed so as to restart the normal winding operation of the winding device 7.

[0122] The predetermined amount of the spun yarn 10 having the short defect S is cut off by a cutter of the yarn joining device 6, and is sucked and removed by the second catching guide device 16 as shown in FIG. 9.

[0123] A flow of yarn joining performed when the yarn monitoring device 4 detects a long defect L will now be described in detail with reference to FIGS. 10 to 12. Hereinafter, only operations different from those when the short defect S is detected will be described, and description of the same operations as those when the short defect S is detected will be omitted.

[0124] When the yarn monitoring device 4 detects the long defect L, the control section 90 immediately closes the spinning valve 92 and stops rotation of the draft motor 91. Due to the stop of spinning, the spun yarn 10 is cut at a portion thereof upstream of the stored yarn detection device 50 as shown in FIG. 10. Therefore, the spun yarn 10 stored by the yarn storage device 5 has an upstream end formed as the yarn end C.

[0125] At a timing earlier than that in the case where the short defect S is detected, the control section 90 stops the winding operation of winding device 7 in a state where at least a portion of the long defect L is stored by the yarn storage device 5 as shown in FIG. 10. For example, the control section 90 can stop the winding operation of the winding device 7 simultaneously with the stop of spinning. In this case, some amount of the spun yarn 10 can be wound during a time lag from start of stopping the winding operation of the winding device 7 until the complete stop of the winding operation. However, the present invention is not limited to such an example. The control section 90 may stop the winding operation of the winding device 7 after a predetermined time elapses from the closing of the spinning valve 92.

[0126] In this regard, it is preferable to stop the winding operation of the winding device 7 while the long defect L is stored entirely or a major portion thereof is stored by the yarn storage device 5. Therefore, a large amount of the long defect L is prevented from being wound into the package 70. In other words, a portion of the spun yarn 10 to be unwound from package 70 for removing the long defect L can be shortened. Therefore, a time for performing the yarn joining cycle is shortened.

[0127] Similarly to the case of removing the short defect S, after the rotation of the package 70 is stopped, the control section 90 stops the storage operation of the

yarn storage device 5. After the rotation of the yarn storage roller 51 is stopped, the control section 90 commands the yarn suction device 54 to generate the suction airflow at the tip thereof so as to suck and catch the yarn end C. Simultaneously or subsequently, the control section 90 commands the storage motor 52 to rotate reversely so that the yarn storage roller 51 reversely rotates for 1.5-2 turns as shown in FIG. 2.

[0128] Simultaneously or subsequently, the control section 90 commands the yarn joining device 6 to cut the spun yarn 10 by its cutter while the spun yarn 10 is held by the yarn joining device 6 as shown in FIG. 11. Accordingly, two yarn ends are formed. In the following description, the yarn end on the yarn storage device 5 side (i.e., the yarn end as a downstream end of the spun yarn 10 stored in the yarn storage device 5) is referred to as a yarn end D, and the yarn end on the winding device 7 side (i.e., the yarn end of the spun yarn 10 wound into the package 70) is referred to as a yarn end E.

[0129] Referring to FIG. 11, the yarn end D is sucked and caught by the yarn trap 41, and the yarn end E is held by the yarn joining device 6.

[0130] Subsequently, the control section 90 commands the yarn storage roller 51 to rotate reversely. At this time, the yarn end D having been sucked by the yarn trap 41 as shown in FIG. 11 is drawn out of the yarn trap 41 by the yarn unhooking guide 14 being moved to the operating position as drawn in solid lines in FIG. 9. The spun yarn 10 with the long defect L is unwound from the yarn storage roller 51 and is sucked and removed by the yarn suction device 54. If the stored yarn detection device 50 still detects the spun yarn 10 after lapse of a predetermined time from start of the reverse rotation of the yarn storage roller 51, the control section 90 determines that the unwinding operation has failed, and interrupts the yarn joining.

[0131] Referring to a timing chart of FIG. 12, simultaneously or subsequently, the control section 90 commands the air injection device 61 to start the injection of compressed air while the yarn end E is held by the yarn joining device 6. During the compressed air injection by the air injection device 61, the control section 90 commands the winding drum 72 to rotate slightly reversely so as to unwind a small amount of the spun yarn 10 from the package 70, thereby slacking the spun yarn 10 between yarn joining device 6 and winding device 7. Therefore, a tension of the spun yarn 10 is reduced so as to prevent the spun yarn 10 from being swung.

[0132] After start of the compressed air injection by the air injection device 61, the control section 90 commands the yarn joining device 6 to release the yarn end E. The released yarn end E is blown by the air injection device 61, and is hooked on the yarn regulation guide 62 (see FIG. 8).

[0133] After the yarn joining device 6 acts to release the yarn end E, the control section 90 commands the second catching guide device 16 to move to the second yarn catching position as shown in FIG. 8. Referring to

FIG. 12, during the movement of the second catching guide device 16 to the second yarn catching position, the control section 90 commands the air injection device 61 to temporarily stop the compressed air injection operation. After the second catching guide device 16 reaches the second yarn catching position, the control section 90 commands the air injection device 61 to restart the compressed air injection operation. At an appropriate timing after the compressed air injection, a zero point of the yarn detection device 60 is amended (adjusted). Description regarding operation of the first catching guide device 15 to catch the first yarn, operation of the second catching guide device 16 to catch the second yarn, operation of guiding the spun yarn 10 to the yarn joining device 6, the yarn joining operation, and so on is omitted because the operations are the same as those in the case where the short defect S is detected.

[0134] The winding of the spun yarn 10 may be restarted after completion of the yarn joining operation after removal of the long defect L. Alternatively, after the removal of the long defect L, an alarm may be given so as to inform an operator that there was the long defect L.

[0135] As described above, the fine spinning machine according to the present embodiment includes the air spinning device 3, the yarn storage roller 51, the winding device 7, the yarn monitoring device 4, and the control section 90. The air spinning device 3 produces the spun yarn 10 by twisting the fiber bundle 9 with the swirling airflow. The yarn storage roller 51 stores the spun yarn 10 thereon. The winding device 7 winds the spun yarn 10 having been stored on the yarn storage roller 51 so as to form the package 70. The yarn monitoring device 4 is disposed between the air spinning device 3 and the yarn storage roller 51 so as to be able to detect the long defect L and the short defect S in the spun yarn 10. The control section 90 is configured so that when the yarn monitoring device 4 detects the long defect L in the spun yarn 10, the control section 90 stops rotation of the package 70 so as to interrupt the winding of the spun yarn 10 performed by the winding device 7 in the state where at least a portion of the long defect L is stored on the yarn storage roller 51.

[0136] Therefore, the long defect L is prevented from being wound into the package 70, and the portion of the spun yarn 10 to be unwound from the package 70 is shortened, thereby reducing the amount of waste yarn, and shortening the time for the yarn joining cycle. Moreover, the yarn monitoring device 4 is disposed at the appropriate position where the spun yarn 10 relatively stably travels, thereby maintaining its high measurement accuracy.

[0137] In the fine spinning machine, the control section 90 is configured so that when the yarn monitoring device 4 detects the short defect S in the spun yarn 10, the control section 90 stops the rotation of the package 70 such that the short defect S is located downstream of the yarn storage roller 51 in the traveling direction of the spun yarn 10.

[0138] Therefore, a normal yarn having been stored

on the yarn storage roller 51 before the detection of the short defect S is wound into the package 70. Consequently, even in the case where the short defect S is to be removed, the amount of waste yarn is reduced, and the time for the yarn joining cycle is reduced.

[0139] In the fine spinning machine, the control section 90 is configured so that when the yarn monitoring device 4 detects the long defect L or the short defect S in the spun yarn 10, the control section 90 interrupts the production of the spun yarn 10 performed by the air spinning device 3, and forms the yarn end C (see FIG. 10) or A (see FIG. 5) of the spun yarn 10 wound in the package 70.

[0140] Therefore, when the yarn defect is detected, the production of the spun yarn 10 is interrupted so as to avoid waste production of the spun yarn 10. Moreover, the spun yarn 10 is cut by stopping the spinning, so that it is unnecessary to provide an additional device for cutting the spun yarn 10, thereby simplifying the structure of the fine spinning machine.

[0141] The fine spinning machine includes the yarn suction device 54 disposed close to the yarn storage roller 51 so as to remove the long defect L in the spun yarn 10.

[0142] Therefore, the long defect L stored on the yarn storage roller 51 is easily removed.

[0143] In the fine spinning machine, the yarn suction device 54 includes the hollow pipe and the yarn suction valve 54a. The hollow pipe is connected to the negative pressure source. An airflow flows through the hollow pipe. The yarn suction valve 54a is opened so as to let the suction airflow pass therethrough, and is closed so as to shut off the suction airflow.

[0144] Therefore, the long defect L is removed with the suction airflow. Moreover, by the simple structure with the yarn suction valve 54a, the yarn suction device 54 is switchable between the operation state and the operation-stopped state.

[0145] In the fine spinning machine, the control section 90 is configured so that after the rotation of the yarn storage roller 51 is stopped, the control section 90 reversely rotates the yarn storage roller 51 at the same time as the yarn suction valve 54a is opened, or after the yarn suction valve 54a is opened.

[0146] Therefore, the long defect L is easily caught and quickly removed by the yarn suction device 54.

[0147] The fine spinning machine includes the second catching guide device 16 rotatably disposed downstream of the yarn storage roller 51 so as to remove the short defect S in the spun yarn 10.

[0148] Therefore, the short defect S is easily removed by the second catching guide device 16 when the rotation of the package 70 is stopped at the timing when the short defect S is located downstream of the yarn storage roller 51.

[0149] In the fine spinning machine, the second catching guide device 16 is configured so as to remove the short defect S in the spun yarn 10 during the process where the second catching guide device 16 catches the

spun yarn 10 from the package 70 and guides the caught spun yarn 10 to the yarn joining device 6.

[0150] Therefore, no additional process for removing the short defect S is needed, thereby shortening the time for performing the yarn joining cycle. Moreover, the second catching guide device 16 serves as the device for guiding the spun yarn 10 to the yarn joining device 6, thereby simplifying the structure of the fine spinning machine.

[0151] In the fine spinning machine, the control section 90 is configured so as to stop the rotation of the yarn storage roller 51 after the rotation of the package 70 is stopped.

[0152] Therefore, the yarn end A (or C) of the spun yarn 10 having been cut at the portion thereof upstream of the yarn storage roller 51 is wound around the rotating yarn storage roller 51, and then is swung slightly while being kept at a slight distance from the outer circumferential surface of the yarn storage roller 51 by a centrifugal force. The yarn end A (or C) can be kept in this state for a long time, thereby being prevented from being entangled in yarn layers stored on the yarn storage roller 51.

[0153] The fine spinning machine includes the stored yarn detection device 50 for detecting presence or absence of the spun yarn 10 stored on the yarn storage roller 51. The control section 90 is configured so that when the yarn monitoring device 4 detects the short defect S, the control section 90 stops the rotation of the package 70 with a delay after the stored yarn detection device 50 detects absence of the spun yarn 10 on the yarn storage roller 51.

[0154] Therefore, the short defect S can be located downstream of the yarn storage roller 51 at the time when the rotation of the package 70 is stopped.

[0155] The fine spinning machine includes the yarn detection device 60 and the air injection device 61. The yarn detection device 60 is disposed between the yarn storage roller 51 and the winding device 7 so as to detect presence or absence of the spun yarn 10 on the yarn route where the spun yarn 10 travels. The air injection device 61 is disposed between the yarn storage roller 51 and the winding device 7 so as to inject air to the yarn route. The control section 90 is configured so that after the production of the spun yarn 10 by the air spinning device 3 is interrupted, the control section 90 commands the air injection device 61 to inject air while rotating the package 70 in the winding direction. The control section 90 is also configured so that during the air injection by the air injection device 61 to the yarn route, when the yarn detection device 60 detects absence of the spun yarn 10 on the yarn route, the control section 90 stops the rotation of the package 70.

[0156] Therefore, separation of the yarn end A of the spun yarn 10, which has been cut at the portion thereof upstream of the yarn storage roller 51, from the yarn storage roller 51 is quickly and surely detected.

[0157] In the fine spinning machine, the yarn storage roller 51 includes the storage portion 51a having the di-

ameter of not less than 70 millimeters and not more than 110 millimeters.

[0158] Therefore, the winding of the spun yarn 10 into the package 70 is stopped while the long defect L is surely left on the yarn storage roller 51, thereby shortening the processing time required to remove the long defect L.

[0159] In the fine spinning machine, the yarn storage roller 51 is able to store the spun yarn 10 whose length is not less than 10 meters.

[0160] Therefore, even if the long defect L has the length of not less than 10 meters, the winding of the spun yarn 10 can be stopped in the state where the long defect L is left on the yarn storage roller 51.

[0161] The above description is given of a preferred embodiment of the present invention. However, the above-mentioned configuration may be modified into the following exemplary alternative configurations.

[0162] The operations of the respective devices and members in the timing chart of FIG. 12 can also be performed in the case where the short defect S is detected.

[0163] The operations of the respective devices and members in the timing chart of FIG. 12 may be performed only in the case where the yarn joining has failed.

[0164] In the case where a determination is made that the yarn joining has failed, the continuous air injection operation of the air injection device 61 may be stopped, and for example, an unillustrated clamp or the like may be used to hold the yarn end A (or E) if it can stabilize the movement of the yarn end A (or E) during the reverse rotation of the package 70. Alternatively, neither the continuous injection operation of the air injection device 61 nor the holding of the yarn end A (or E) by the clamp or the like may be performed.

[0165] Neither the air injection device 61 nor the yarn regulation guide 62 may be disposed on the main guide 64. Alternatively, the air injection device 61 and the yarn regulation guide 62 may be disposed at another position upstream of the winding drum 72, where the second yarn can be caught by the second catching guide device 16.

[0166] The air injection device 61 may include a single nozzle.

[0167] Instead of the yarn suction device 54, the yarn trap 41 can be used to suck and remove the part of the spun yarn 10 between the yarn ends C and D with the long defect L. In this case, the control section 90 closes the yarn suction valve 54a so as to stop the operation of the yarn suction device 54, and forwardly rotates the yarn storage roller 51. Alternatively, the yarn trap 41 may be omitted.

[0168] The air injection device 3 may include a pair of air jet nozzles for twisting the fiber bundle in mutually opposite directions. The spinning unit 100 may include an open end spinning device (a rotor spinning device) instead of the draft device 2 and the air spinning device 3.

[0169] Paired delivery rollers may be disposed between the air spinning device 3 and the yarn storage device 5 so as to draw the spun yarn 10 out from the air spinning device 3. In this case, one roller of the paired

delivery rollers is rotationally driven independently of rollers in other spinning units 100 so that this roller can be rotated individually in the spinning unit 100 in which the yarn joining is to be performed. When the winding of the spun yarn 10 into the package 70 is interrupted, the rotation of the corresponding paired delivery rollers is stopped synchronously with the stop of rotation of the package 70.

[0170] Instead of the splicer device or the knotter, a piecing operation may be performed to make the spun yarn 10 in a continuous form. The piecing operation is a method for making the spun yarn 10 to be continuous by reversely feeding the spun yarn 10 from the package 70 to the air spinning device 3, and then restarting the drafting operation of the draft device 2 and the spinning operation of the air spinning device 3.

[0171] In the case where the short defect S is detected, the winding of the spun yarn 10 into the package 70 may not be stopped but the winding speed may be reduced to the first low speed so as to gradually wind the generated yarn end A. In this case, the rotation of the yarn storage roller 51 may be maintained, may be slowed, or may be stopped for the subsequent 1.5-2 reverse rotations of the yarn storage roller 51 as mentioned above.

[0172] In addition to the stored yarn detection device 50, a second stored yarn detection device may be provided at the base end side (i.e., at the upstream side in the traveling direction of the spun yarn 10) of the storage portion 51a of the yarn storage roller 51. Therefore, when the spun yarn 10 including the long defect L is to be unwound from the yarn storage roller 51 so as to be sucked and removed by the yarn suction device 54, it can be judged more accurately based on the detection result of the second stored yarn detection device whether the unwinding of the spun yarn 10 has succeeded or failed. Moreover, the detection operation of the second stored yarn detection device may be performed in place of a part or the whole of detection operation of the stored yarn detection device 50 during the yarn joining. More specifically, the control section 90 can use the detection result of the second stored yarn detection device in place of a part or the whole of detection result of the stored yarn detection device 50.

[0173] The devices in the spinning unit 100 may be arranged so that the spun yarn 10 supplied from an upper portion is wound at a lower portion.

[0174] The yarn joining device 6 may be provided on a working cart movable among the plurality of spinning units 100. When cutting the spun yarn 10 between the package 70 and the yarn storage device 5 in this structure, the spun yarn 10 is cut by a cutter of the working cart, the cutter of the yarn joining device 6, or another cutter provided in the corresponding spinning unit 100.

[0175] The winding drums 72 of the plurality of spinning units 100 may be driven by a single drive motor. When interrupting the winding of the spun yarn 10 into the package 70, the package 70 may be spaced from the winding drum 72 and the rotation of the package 70 may be

stopped by an unillustrated brake mechanism. After the spun yarn 10 is cut at the portion thereof between the package 70 and the yarn storage device 5, the package 70 may be brought into contact with the winding drum 72 so that the spun yarn 10 continuing to the package 70 is wound into the package 70. Subsequently, the package 70 may be spaced from the winding drum 72 again for the yarn joining.

[0176] A configuration for preventing the spun yarn 10 from being hooked on the yarn hooking member 53 when the spun yarn 10 is to be removed from the yarn storage roller 51 is not limited to the configuration in the above-mentioned embodiment. Alternatively, the yarn storage device 5 may be provided with a yarn unhooking lever, for example, so that the yarn unhooking lever can be operated to prevent the spun yarn 10 from being hooked on the yarn hooking member 53.

Claims

1. An air spinning machine comprising:

an air spinning device (3) for producing a spun yarn (10) by twisting a fiber bundle (9) with a swirling airflow;

a yarn storage roller (51) for storing the spun yarn (10) thereon;

a winding device (7) for winding the spun yarn (10) having been stored on the yarn storage roller (51) so as to form a package (7); **characterized by**

a yarn monitoring device (4) disposed between the air spinning device (3) and the yarn storage roller (51) so as to be able to detect a long defect (L) and a short defect (S) in the spun yarn (10); and

a control section (90) configured so that when the yarn monitoring device (4) detects the long defect (L) in the spun yarn (10), the control section (90) stops rotation of the package (70) so as to interrupt the winding of the spun yarn (10) performed by the winding device (7) in a state where at least a portion of the long defect (L) is stored on the yarn storage roller (51).

2. The air spinning machine according to claim 1, wherein the control section (90) is configured so that when the yarn monitoring device (4) detects the short defect (S) in the spun yarn (10), the control section (90) stops the rotation of the package (70) such that the short defect (S) is located downstream of the yarn storage roller (51) in a traveling direction of the spun yarn (10).

3. The air spinning machine according to claim 1 or 2, wherein the control section (90) is configured so that when the yarn monitoring device (4) detects the long

defect (L) or the short defect (S) in the spun yarn (10), the control section (90) interrupts the production of the spun yarn (10) performed by the air spinning device (3) to form a yarn end of the spun yarn (10) wound in the package (70).

4. The air spinning machine according to any one of claims 1 to 3, further comprising:

a first removing device (54) disposed close to the yarn storage roller (51) so as to remove the long defect (L) in the spun yarn (10).

5. The air spinning machine according to claim 4, wherein the first removing device (54) includes:

a hollow pipe connected to a negative pressure source and through which a suction airflow flows, and

an opening and closing member (54a), which is opened so as to let the suction airflow pass therethrough, and which is closed so as to shut off the suction airflow.

6. The air spinning machine according to claim 5, wherein the control section (90) is configured so that after the rotation of the yarn storage roller (51) is stopped, the control section (90) reversely rotates the yarn storage roller (51) at the same time as the opening and closing member (54a) is opened, or after the opening and closing member (54a) is opened.

7. The air spinning machine according to any one of claims 1 to 6, further comprising:

a second removing device (16) rotatably disposed downstream of the yarn storage roller (51) so as to remove the short defect (S) in the spun yarn (10).

8. The air spinning machine according to claim 7, wherein the second removing device (16) is configured so as to remove the short defect (S) in the spun yarn (10) during a process where the second removing device (16) catches the spun yarn (10) from the package (70) and guides the caught spun yarn (10) to a yarn joining device (6).

9. The air spinning machine according to any one of claims 1 to 8, wherein the control section (90) is configured so as to stop the rotation of the yarn storage roller (51) after the rotation of the package (70) is stopped.

10. The air spinning machine according to any one of claims 1 to 9, further comprising:

a stored yarn detection device (50) for detecting

presence or absence of the spun yarn (10) stored on the yarn storage roller (51), wherein the control section (90) is configured so that when the yarn monitoring device (4) detects the short defect (S), the control section (90) stops the rotation of the package (70) with a delay after the stored yarn detection device (50) detects absence of the spun yarn (10) on the yarn storage roller (51). 5 10

11. The air spinning machine according to any one of claims 1 to 10, further comprising:

a yarn detection device (60) disposed between the yarn storage roller (51) and the winding device (7) so as to detect presence or absence of the spun yarn (10) on a yarn route where the spun yarn (10) travels; and an air injection device (61) disposed between the yarn storage roller (51) and the winding device (7) so as to inject air to the yarn route, wherein the control section (90) is configured so that after the production of spun yarn (10) by the air spinning device (3) is interrupted, the control section (90) commands the air injection device (61) to inject air while rotating the package (70) in the winding direction, and wherein the control section (90) is also configured so that during the air injection by the air injection device (61) to the yarn route, when the yarn detection device (60) detects absence of the spun yarn (10) on the yarn route, the control section (90) stops the rotation of the package (70). 15 20 25 30 35

12. The air spinning machine according to any one of claims 1 to 11, wherein the yarn storage roller (51) includes a storage portion (51a) having a diameter of not less than 70 millimeters and not more than 110 millimeters. 40

13. The air spinning machine according to any one of claims 1 to 12, wherein the yarn storage roller (51) is able to store the spun yarn (10) whose length is not less than 10 meters. 45

14. An air spinning method comprising:

an air spinning step of twisting a fiber bundle (9) with a swirling airflow by an air spinning device (3) so as to produce a spun yarn (10); a yarn storage step of storing the spun yarn (10) on a yarn storage roller (51); a winding step of winding the spun yarn (10) having been stored on the yarn storage roller (51) so as to form a package (70); **characterized by** a yarn monitoring step of monitoring the spun 50 55

yarn (10) between the air spinning device (3) and the yarn storage roller (51) so as to detect a long defect (L) and a short defect (S) in the spun yarn (10); and

a control step in which when the long defect (L) in the spun yarn is detected, rotation of the package (70) is stopped so as to interrupt the winding step of winding the spun yarn (10) in a state where at least a portion of the long defect (L) is stored on the yarn storage roller (51).

Fig.1

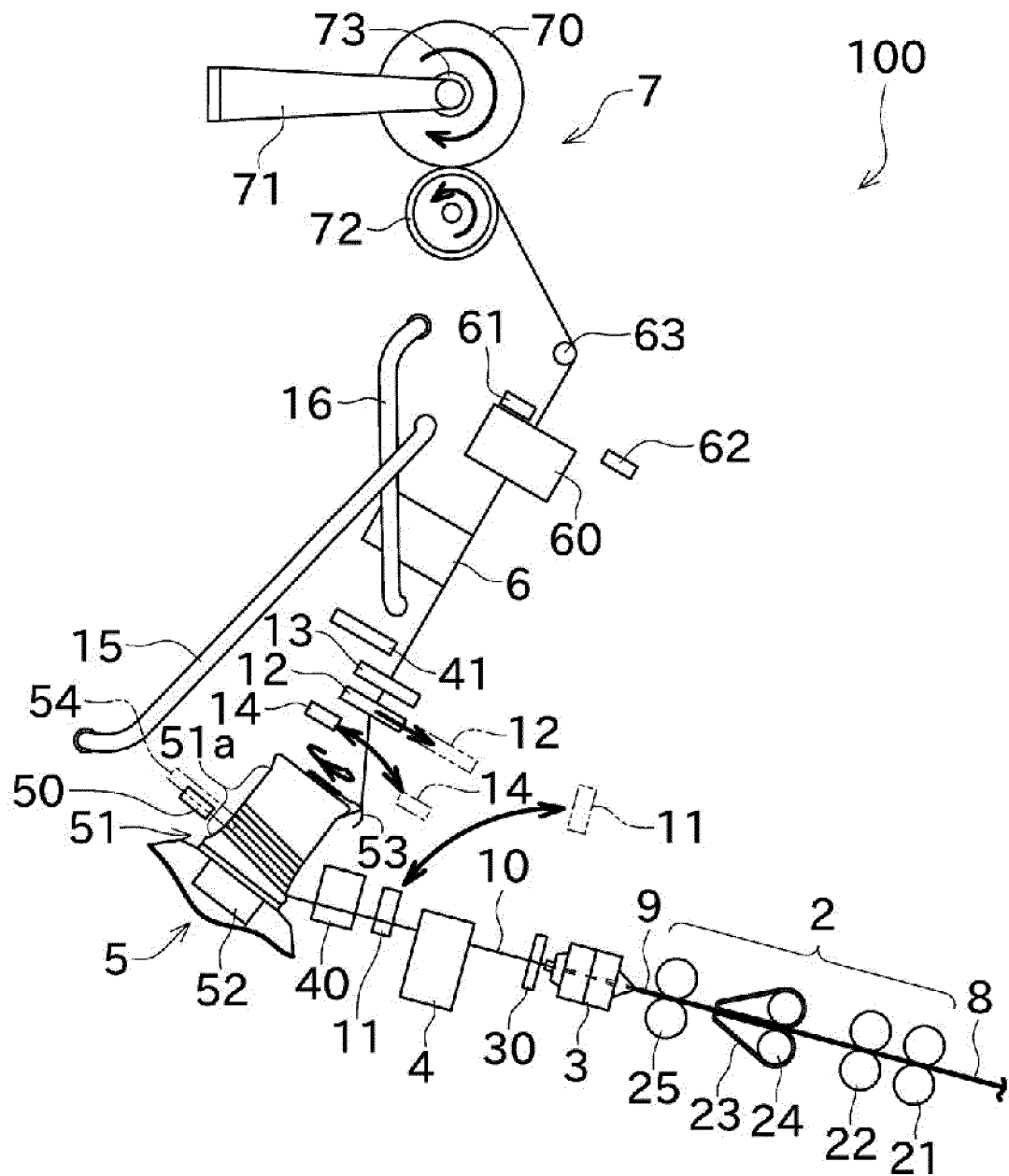


Fig.2

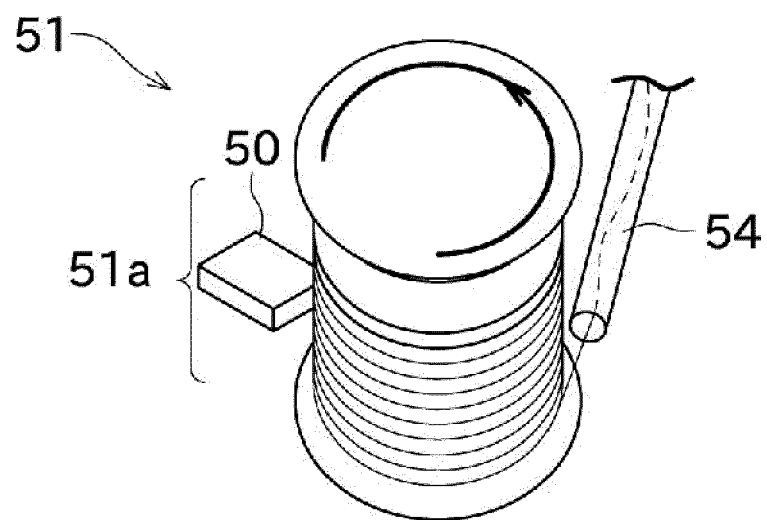


Fig.3

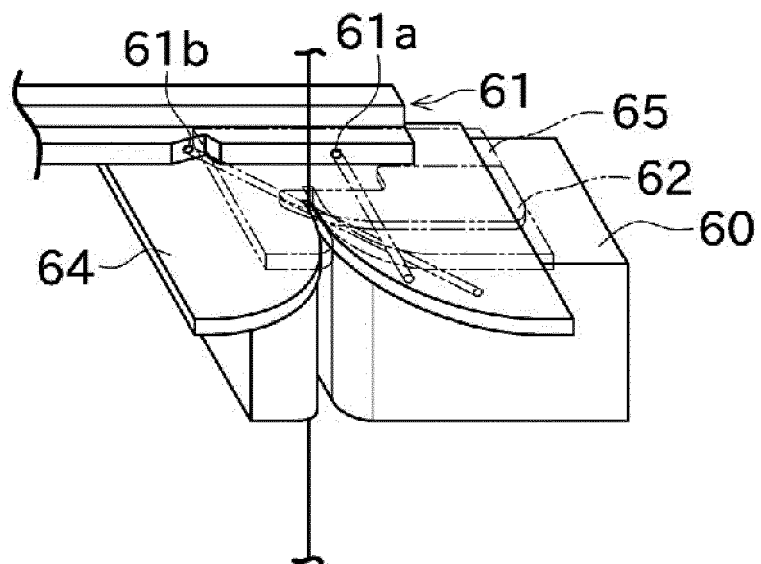


Fig.4

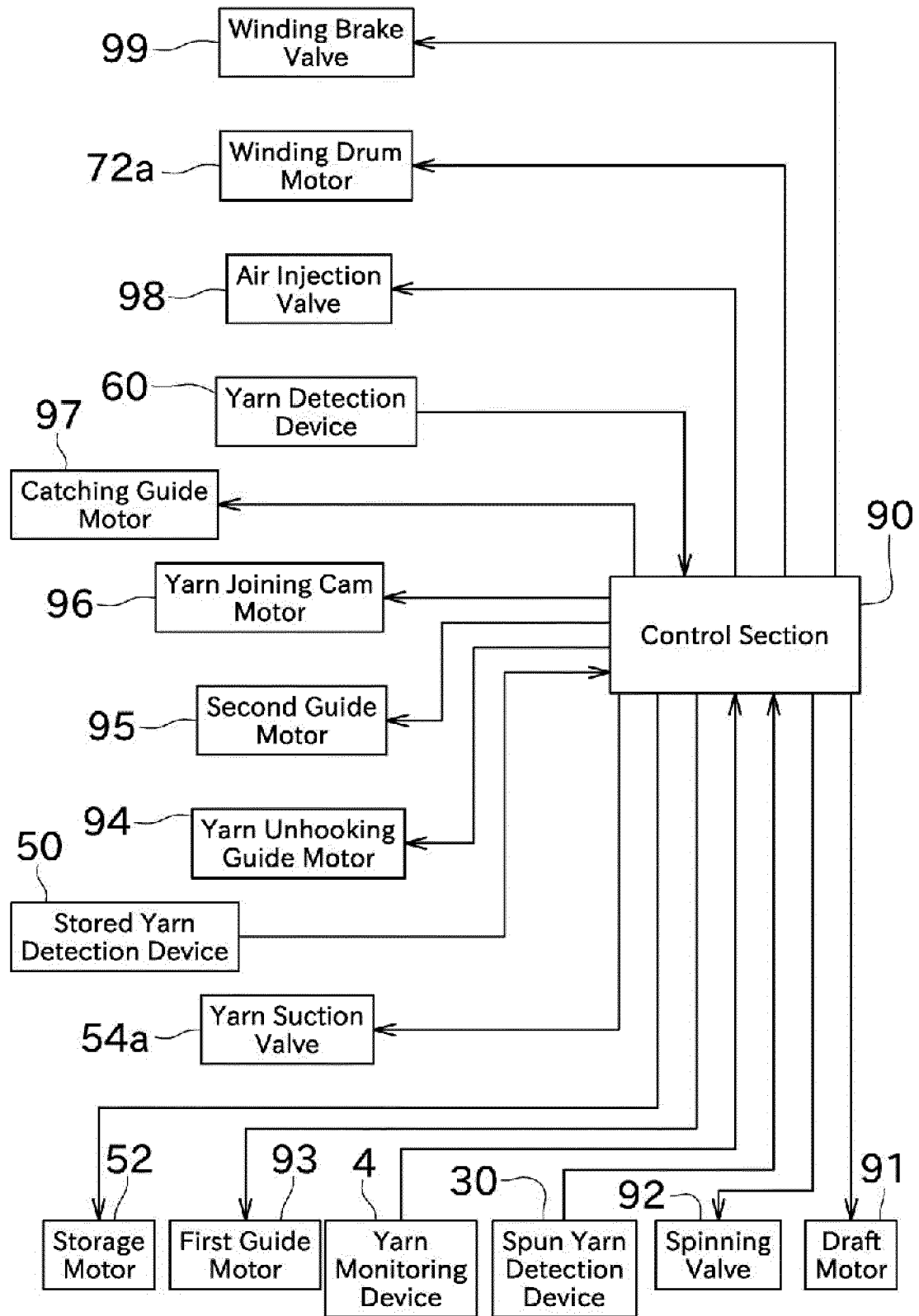


Fig.5

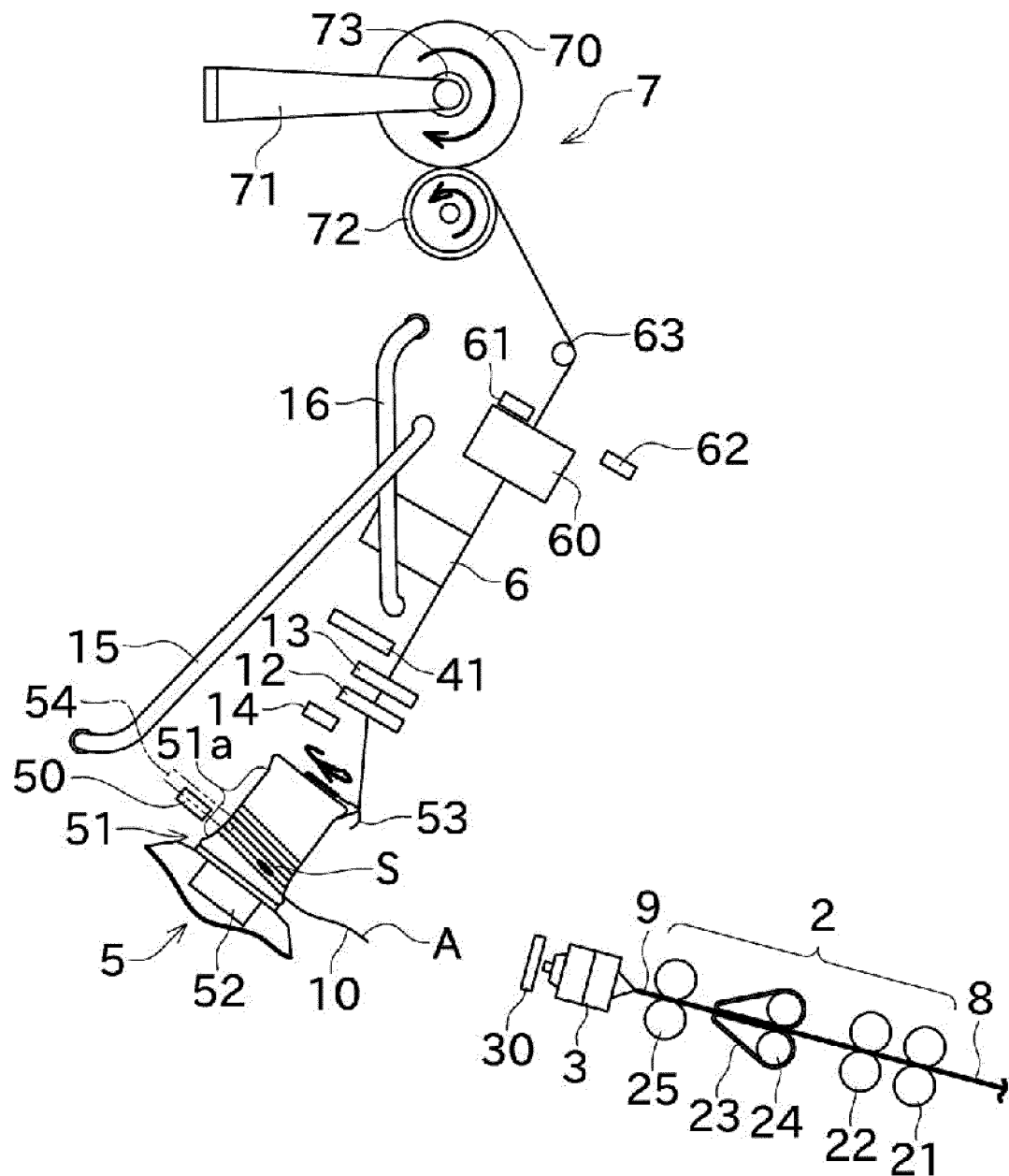


Fig.6

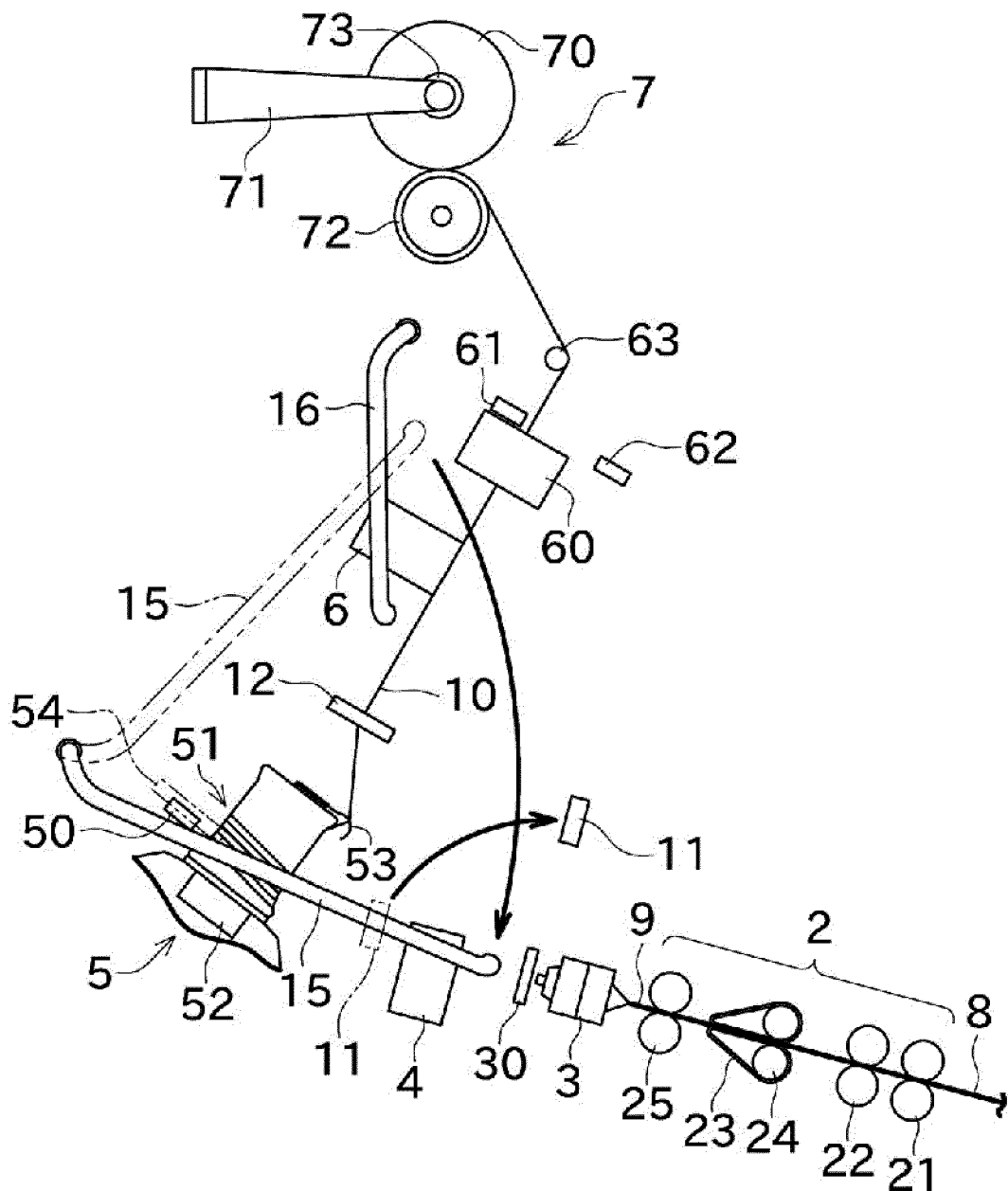


Fig.7

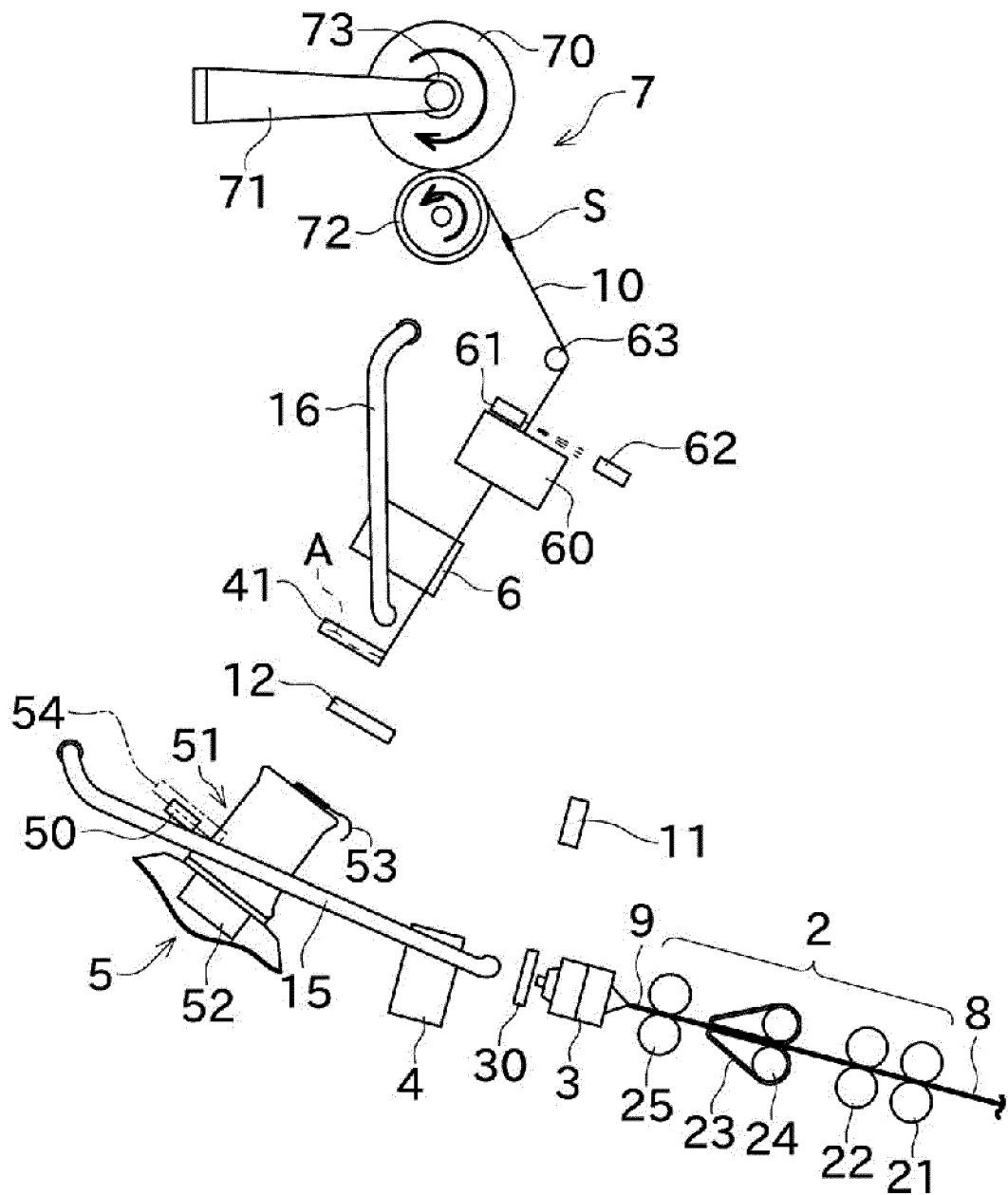


Fig.8

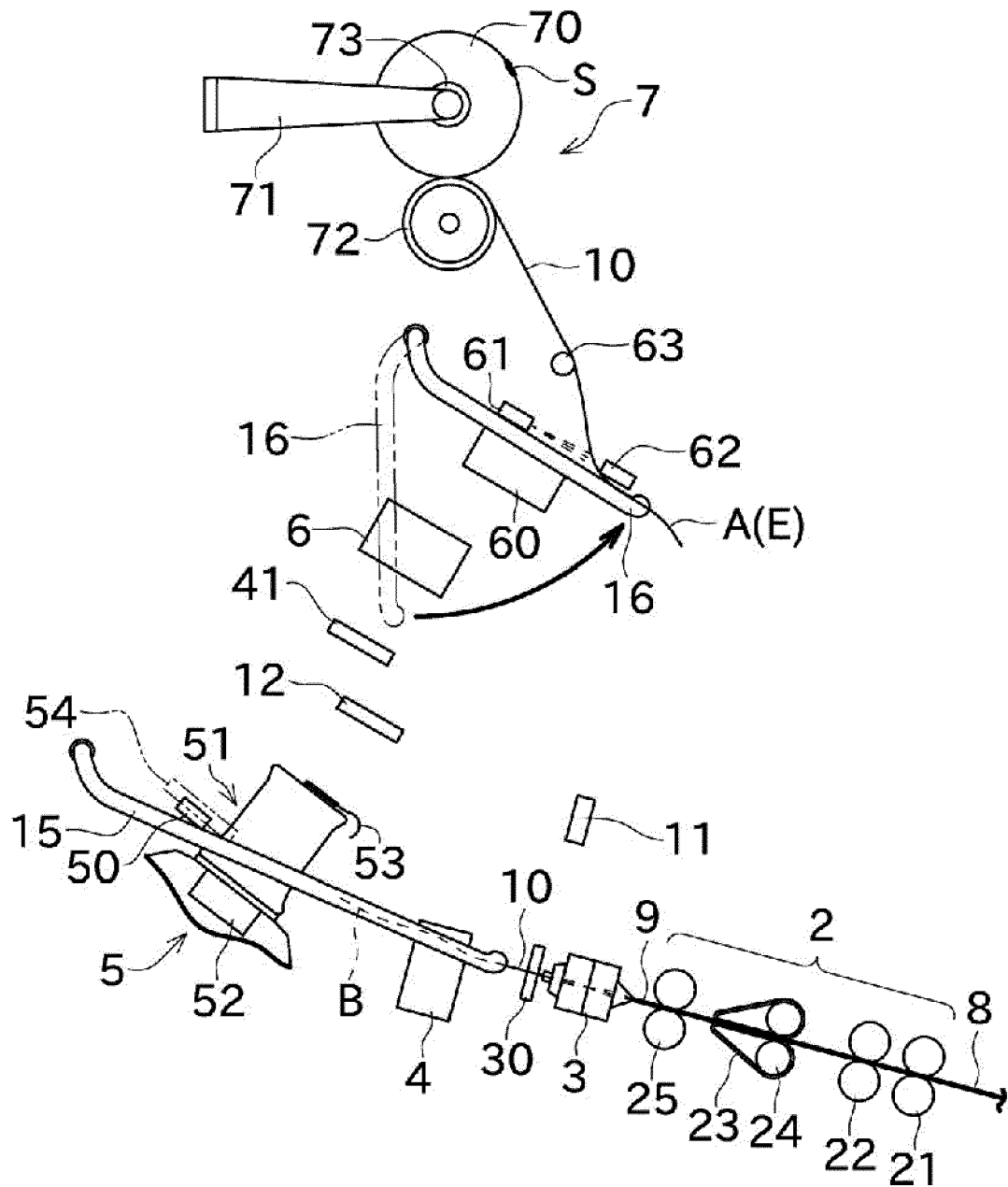


Fig.9

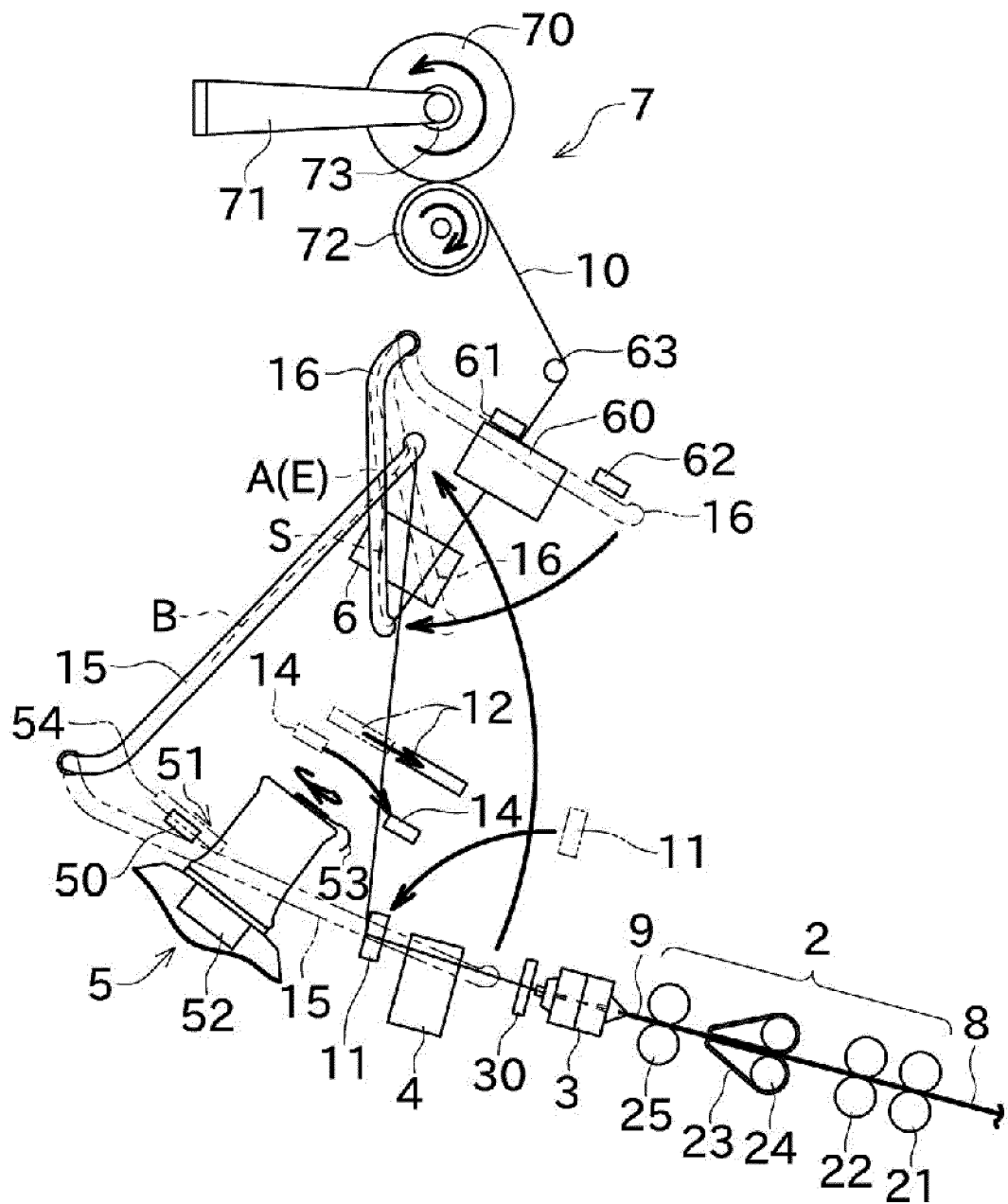


Fig.10

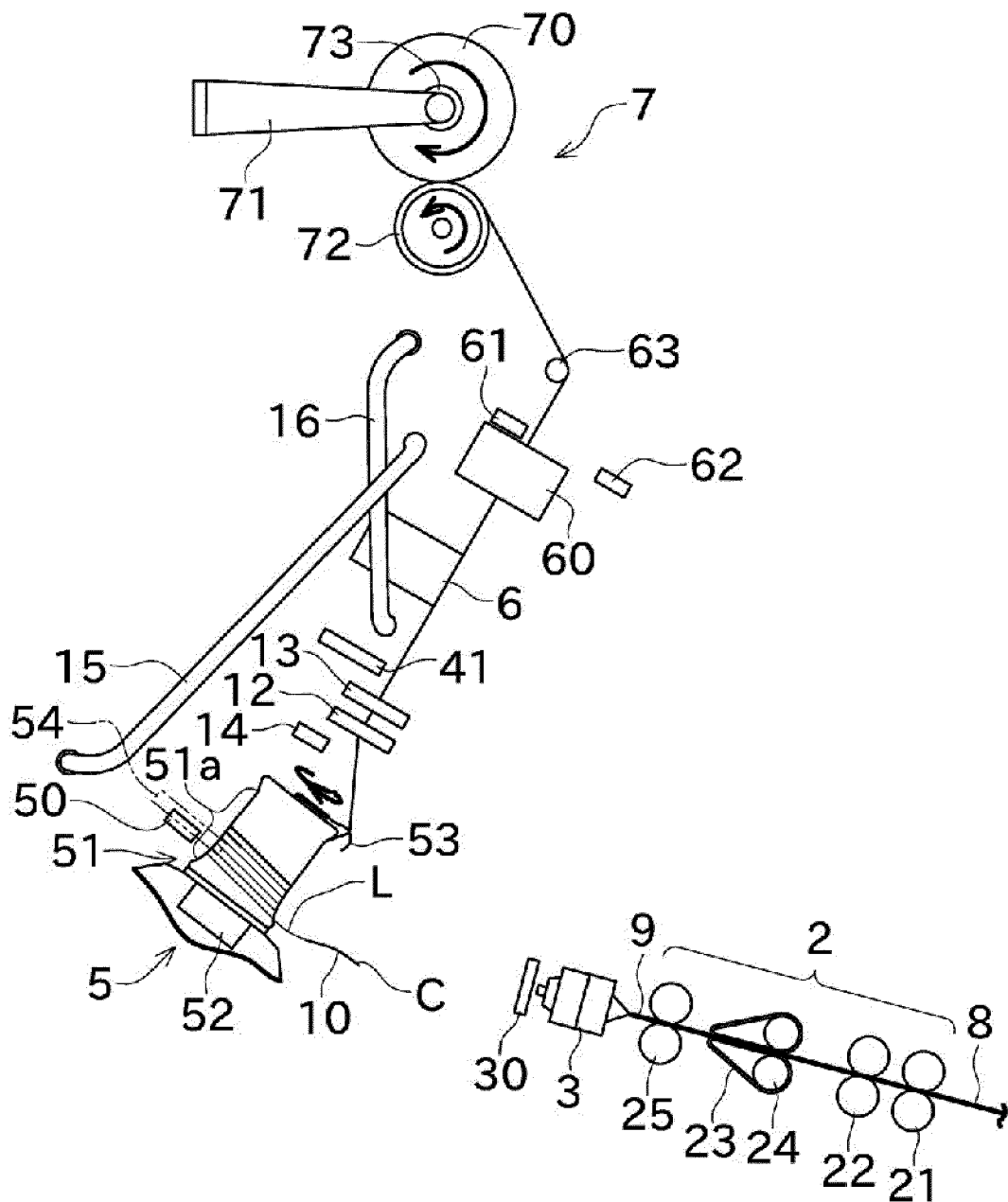


Fig.11

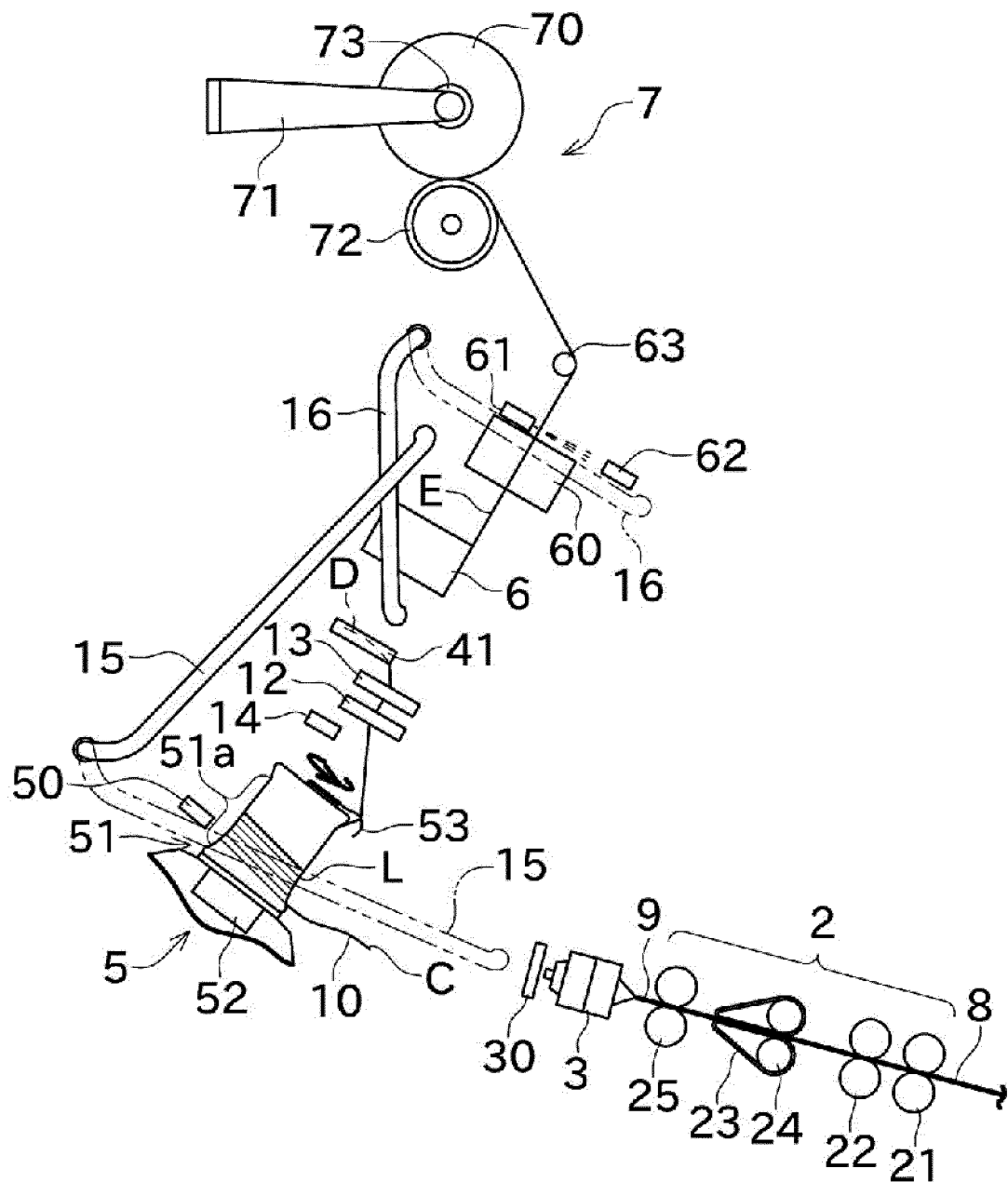


Fig.12

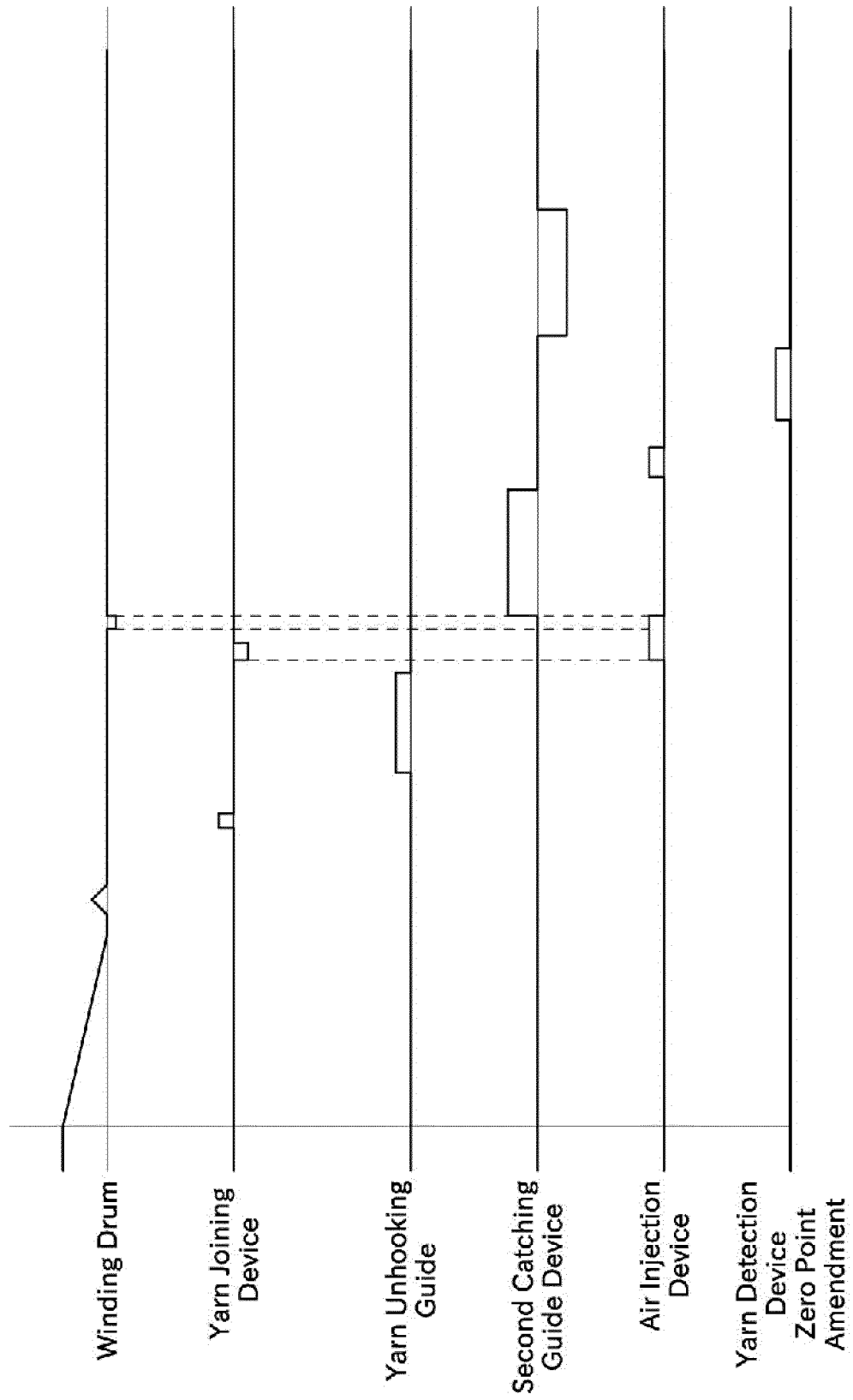
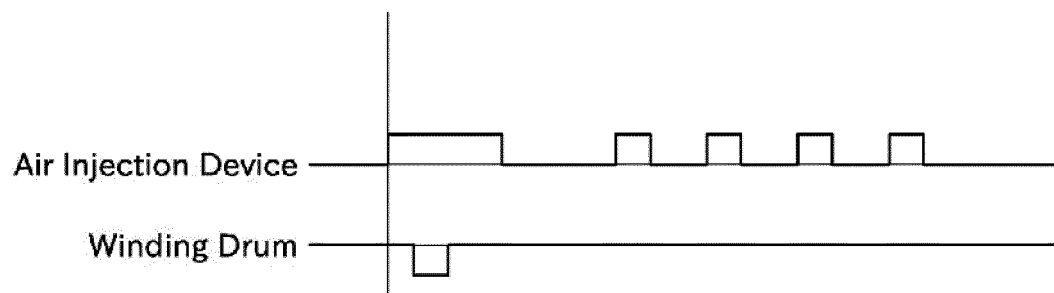


Fig.13





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