



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:  
**06.02.2019 Bulletin 2019/06**

(51) Int Cl.:  
**D01H 13/32 (2006.01)**

(21) Application number: **18184218.8**

(22) Date of filing: **18.07.2018**

(84) Designated Contracting States:  
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR**  
Designated Extension States:  
**BA ME**  
Designated Validation States:  
**KH MA MD TN**

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(30) Priority: **02.08.2017 JP 2017149558**

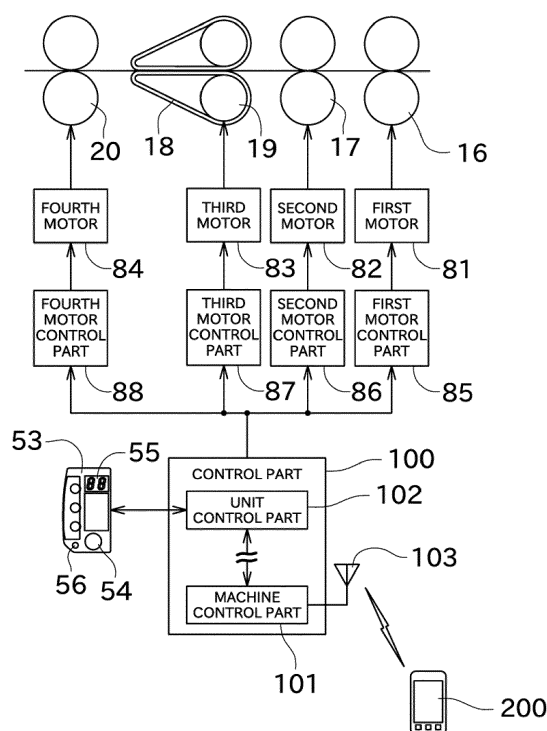
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(54) **AIR SPINNING MACHINE AND DISPLAY CONTROL METHOD**

(57) A fine spinning machine includes a back roller 16, an air spinning device, a first motor 81, and a control part 100. The back roller 16 feeds a sliver. The air spinning device produces a spun yarn by twisting a fiber bundle made from the sliver with airflow. The first motor 81 drives the back roller 16, and its rotation amount is controlled in accordance with a command signal. The control part 100 calculates a consumed length of the sliver based on the command signal.

Fig.4



## Description

### BACKGROUND OF THE INVENTION

#### 1. Field of the Invention

**[0001]** The present invention primarily relates to an air spinning machine. More specifically, the present invention relates to a configuration for calculating a consumed sliver length.

#### 2. Description of the Related Art

**[0002]** In a textile machine such as a spinning machine, a configuration is conventionally known in which a process of calculating a consumed sliver length, etc. is executed for the purpose of efficient replenishment of a sliver which is a raw material. This type of textile machine is disclosed in Japanese Examined Patent Application Publication No. H2-29770 (1990), Japanese Examined Utility Model Application Publication No. H7-40536 (1995), and Japanese Unexamined Patent Application Publication No. H11-279862 (1999).

**[0003]** Japanese Examined Patent Application Publication No. H2-29770 (1990) discloses a production management device for an open-end fine spinning machine or the like. The production management device calculates a consumed sliver length, and if the consumed sliver length reaches a pre-set value, notifies a worker of it. The production management device calculates the consumed sliver length by detecting rotation of a drive shaft that drives a winding drum or a draw-off roller.

**[0004]** Japanese Examined Utility Model Application Publication No. H7-40536 (1995) discloses an automatic sliver splicing apparatus that splices a beginning of a sliver to an end of a sliver. The automatic sliver splicing apparatus detects a terminal of a sliver by using a phototube type sensor.

**[0005]** Japanese Unexamined Patent Application Publication No. H11-279862 (1999) relates to a sliver can replacement system that supplies a sliver can accommodating a sliver to a spinning machine. The sliver can replacement system includes a sliver can replacement management device. The sliver can replacement management device calculates a next timing for sliver can replacement based on data of, for example, the amount of a sliver accommodated in the sliver can, a spinning speed in each spinning unit, and a spun yarn count.

### SUMMARY OF THE INVENTION

**[0006]** The configuration of Japanese Examined Patent Application Publication No. H2-29770 (1990), however, detects rotation of the drive shaft that drives the winding drum or the draw-off roller which is arranged downstream of a spinning apparatus in a fiber travelling direction. This cannot detect a precise consumed sliver length. For example, when a fiber loss occurs in the spin-

ning apparatus, a consumed sliver length that is based on the fiber loss cannot be reflected in an overall consumed sliver length. In addition, when a yarn is partially removed for the purpose of preventing a yarn defect or the like from being wound around a package, it is difficult that a consumed sliver length based on the yarn having this removal is reflected in an overall consumed sliver length. Japanese Examined Utility Model Application Publication No. H7-40536 (1995) is a configuration that detects a sliver terminal, and is not a configuration that calculates a specific consumed sliver length. In Japanese Unexamined Patent Application Publication No. H11-279862 (1999), a timing for sliver can replacement is calculated based on a set spinning speed, and therefore the timing for sliver can replacement may not be precisely calculated.

**[0007]** A primary object of the present invention is to provide a configuration that precisely calculates a consumed sliver length in an air spinning machine for air spinning.

**[0008]** A first aspect of the present invention provides an air spinning machine having the following configuration. The air spinning machine includes a conveyor roller, an air spinning device, an electric motor, and a control part. The conveyor roller feeds a sliver. The air spinning device produces a spun yarn by twisting a fiber bundle made from the sliver with airflow. The electric motor drives the conveyor roller, and has its rotation amount controlled in accordance with a command signal. The control part calculates a consumed length of the sliver based on the command signal.

**[0009]** With this configuration, the consumed length of the sliver can be calculated without using a sensor that directly detects the rotation amount of the conveyor roller or the like. This can avoid a cost increase and complication of the configuration of the air spinning machine which may otherwise be caused by addition of a sensor. Moreover, the calculation is performed based on the rotation amount of the conveyor roller that feeds the sliver, and therefore the consumed length of the sliver can be more precisely calculated as compared to when the consumed length of the sliver is calculated based on, for example, a spinning speed.

**[0010]** Preferably, the air spinning machine includes a plurality of spinning units each having at least the conveyor roller and the air spinning device.

**[0011]** In the air spinning machine including the plurality of spinning units, it is difficult for an operator to grasp a consumed length of the sliver in each spinning unit. Accordingly, the effects of the present invention can be exerted more effectively.

**[0012]** In the air spinning machine, it is preferable that the control part calculates at least either a remaining time before the sliver runs out in any of the plurality of spinning units or a total quantity of sliver required to be replenished in a predetermined time, based on information of an initial length of the sliver and a fiber travelling speed.

**[0013]** Since information that assists in replenishment

of the sliver is calculated, for example, replenishment of the sliver can be implemented efficiently.

**[0014]** Preferably, the air spinning machine is configured as follows. The air spinning machine includes a first display part that displays information about the plurality of spinning units. The first display part displays at least either the remaining time or the quantity calculated by the control part.

**[0015]** With this configuration, an operator replenishing the sliver observes a display of the first display part, which makes it easy for the operator to efficiently replenish the sliver or to complete replenishment before the sliver runs out.

**[0016]** Preferably, the air spinning machine is configured as follows. The air spinning machine includes an alarm part individually disposed in each of the spinning units, the alarm part being configured to be switchable between an alarm state and a non-alarm state. The alarm part switches to the alarm state in a case where the spinning unit where the alarm part is disposed satisfies at least either a condition that a remaining length of the sliver in the spinning unit be equal to or less than a predetermined length or a condition that a remaining time for which the spinning unit is able to perform spinning by using the currently remaining sliver be equal to or less than a predetermined time.

**[0017]** With this configuration, an operator replenishing the sliver observes details of alarming given by the alarm part, which enables the operator to identify the spinning unit that needs replenishment of the sliver at an early stage. Accordingly, replenishment of the sliver can be implemented efficiently.

**[0018]** Preferably, the air spinning machine is configured as follows. The air spinning machine includes a second display part individually disposed in each of the spinning units, the second display part being capable of displaying at least a numeral. The second display part displays at least either a remaining length of the sliver or a remaining time before the sliver runs out in the spinning unit where the second display part is disposed.

**[0019]** With this configuration, the status of usage of the sliver in each spinning unit is displayed in detail, which enables an operator replenishing the sliver to efficiently replenish the sliver by observing the display.

**[0020]** Preferably, the air spinning machine includes a transmitter that transmits, to outside, at least either the quantity of sliver required to be replenished or a timing when replenishment of the sliver is required, for the plurality of spinning units.

**[0021]** With this configuration, as compared to a configuration in which an operator observes a display part or the like of the air spinning machine, information about replenishment of the sliver can be observed in various places.

**[0022]** Preferably, the air spinning machine is configured as follows. The air spinning machine includes a guide device that guides the sliver, and a feed device that forms the fiber bundle from the sliver guided by the

guide device and feeds the fiber bundle to the air spinning device. The conveyor roller is provided in the guide device or in the feed device, or the conveyor roller is disposed between the guide device and the feed device with respect to a fiber travelling direction.

**[0023]** With this configuration, the effects of the present invention can be exerted in an air spinning machine including the guide device and the feed device.

**[0024]** Preferably, the air spinning machine is configured as follows. The control part executes a process of calculating a remaining length of the sliver based on the consumed length of the sliver. The control part is capable of performing a control that stops the feed device for each of the spinning units based on the calculated remaining length of the sliver, and in this control, the control part stops the feed device in such a manner that an upstream end portion of the sliver in the fiber travelling direction is located at a position upstream of the guide device.

**[0025]** With this configuration, for example, at a time of replenishing the sliver (replacing a sliver can), a work for setting the sliver on the guide device is not required, and therefore replenishment of the sliver can be implemented in a short time. Accordingly, a reduction in operation efficiency of the air spinning machine as a whole can be avoided.

**[0026]** In the air spinning machine, it is preferable that the control part stores a stop length that is a threshold for the remaining length of the sliver, and stops the feed device upon the remaining length of the sliver becoming equal to or less than the stop length.

**[0027]** This configuration can prevent a portion of the sliver near its terminal, which is likely to have a poor quality, from being used to produce the spun yarn.

**[0028]** Preferably, the air spinning machine is configured as follows. The feed device is a draft device that forms a fiber bundle by drafting a sliver guided by the guide device. The conveyor roller is formed of a plurality of draft rollers and a plurality of facing rollers included in the draft device. The air spinning machine includes a draft device cradle that presses the plurality of facing rollers included respectively in adjacent two of the spinning units to the plurality of draft rollers, or that presses the plurality of draft rollers included respectively in adjacent two of the spinning units to the plurality of facing rollers. The control part stops the draft device of one of the two spinning units while the draft device cradle is pressing the draft rollers or the facing rollers and the draft devices of the two spinning units are holding the slivers.

**[0029]** In this configuration, one of the spinning units, whose draft device is stopped with the sliver held thereon, can resume the spinning operation without cancelling the pressing applied by the draft device cradle. Since one of the spinning units can resume the spinning operation while the other of the spinning units keeps performing the spinning operation, a reduction in production efficiency can be prevented.

**[0030]** Preferably, the air spinning machine is configured as follows. The air spinning machine includes a sliv-

er storage part and a package placement part. The sliver storage part stores the sliver to be guided by the guide device. In the package placement part, a package obtained after the spun yarn spun by the air spinning device is wound is placed. In a plan view, the package placement part, the spinning unit, the guide device, and the sliver storage part are arranged in this order with respect to a direction perpendicular to a direction in which the spinning units are juxtaposed, and a passage extending in the juxtaposition direction is provided on a side opposite to the spinning unit relative to the package placement part.

**[0031]** In such a layout, the sliver storage part is arranged on the side opposite to the passage relative to the spinning unit, which usually would make it difficult for an operator working on the passage to visually observe the remaining length of the sliver. As a result, replenishment of the sliver is often implemented after the sliver runs out, and therefore the production efficiency is reduced. In this respect, adoption of the present invention can make it easy for an operator to grasp the consumed length of the sliver even in the above-described layout. Consequently, replenishment of the sliver is more likely to be implemented before the sliver runs out. Accordingly, the production efficiency can be increased.

**[0032]** Preferably, the air spinning machine is configured as follows. The air spinning machine includes a sliver storage part that stores the sliver to be guided by the guide device. A sensor for detecting the sliver is not provided between the sliver storage part and the air spinning device.

**[0033]** In the air spinning machine, a sensor for detecting a rotation amount of the conveyor roller or a length over which the sliver is fed is not provided between an upstream end portion of the feed device and an upstream end portion of the guide device.

**[0034]** Since at least one of the sensor for detecting the sliver or the sensor for detecting a rotation amount of the conveyor roller or a length over which the sliver is fed is not required, the configuration of the air spinning machine can be simplified, and manufacturing costs can be lowered.

**[0035]** In the air spinning machine, it is preferable that the electric motor is a step motor.

**[0036]** With this configuration, a consumed sliver length can be calculated from a command signal through a simple arithmetic operation.

**[0037]** Preferably, the air spinning machine is configured as follows. The air spinning device includes a nozzle block and a hollow guide shaft member. The nozzle block jets air to generate a swirling flow in a spinning chamber, to twist the fiber bundle. The hollow guide shaft member guides the fiber bundle twisted in the spinning chamber to outside.

**[0038]** In general, the air spinning machine of the above-described type has a high spinning speed, and therefore a consumed length of a sliver in a spinning unit whose spinning operation is temporarily stopped for

some reason is significantly smaller than consumed lengths of slivers in the other spinning units. As a result, a timing for replenishing the sliver largely differs among the plurality of spinning units. Accordingly, the effects of the present invention can be exerted more effectively.

**[0039]** Preferably, the air spinning machine includes a reset operation part that enables implementation of an operation for resetting a result of calculation of the consumed length of the sliver calculated by the control part.

**[0040]** With this configuration, for example, by operating the reset operation part after replenishment of the sliver, a length of the sliver consumed after the replenishment can be precisely calculated.

**[0041]** A second aspect of the present invention provides a display control method for controlling a display of sliver replenishment information, having the following configuration. In the display control method for controlling a display of sliver replenishment information, an external apparatus capable of communicating with the air spinning machine performs a receiving step and a display step as follows. In the receiving step, at least either a consumed length of a sliver calculated based on the command signal or information calculated based on the consumed length of the sliver is received. In the display step, a content received in the receiving step is displayed on the external apparatus.

**[0042]** Since information useful for replenishment of the sliver can be displayed on the external apparatus, an operator carrying the external apparatus can efficiently replenish the sliver.

## BRIEF DESCRIPTION OF THE DRAWINGS

### **[0043]**

FIG. 1 is a front view showing an overall configuration of a fine spinning machine according to an embodiment of the present invention;

FIG. 2 is a vertical cross-sectional view of the fine spinning machine;

FIG. 3 is a cross-sectional side view showing configurations of an air spinning device and its peripheral equipment;

FIG. 4 is a control block diagram of the fine spinning machine;

FIG. 5 is a flowchart of a process that a unit control part executes during a spinning operation;

FIG. 6 is a flowchart of a process that the unit control part executes after the spinning operation is stopped;

FIG. 7 is a flowchart of a process that a machine control part executes;

FIG. 8 is a flowchart of a process that a portable terminal executes;

FIG. 9 shows an exemplary display of a unit display part;

FIG. 10 shows an exemplary display of a machine display part; and

FIG. 11 is a control block diagram of a fine spinning

machine according to a reference example.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

**[0044]** A fine spinning machine according to 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 with respect to a fiber travelling direction.

**[0045]** As shown in FIG. 1, a fine spinning machine (air spinning machine) 1 includes a plurality of spinning units 2 juxtaposed, a yarn splicing cart 41, a doffing cart 42, and an engine box 43.

**[0046]** The engine box 43 has a machine control part 101 disposed therein. The machine control part 101 controls the plurality of spinning units 2. The engine box 43 includes a machine display part (first display part) 50. The machine display part 50, when appropriately operated by an operator, displays information about an operation status and/or yarn quality of each spinning unit 2. The machine control part 101 is configured to transmit the information to a portable terminal (external apparatus) 200 carried by the operator, via an antenna (transmitter) 103. The machine control part 101 may transmit the information to a drawing frame which is a machine that performs a process preceding to the process of the fine spinning machine 1. The machine display part 50 and the machine control part 101 may be provided in a place other than the engine box 43.

**[0047]** The portable terminal 200, which is a smartphone, a tablet terminal, a wearable terminal, or the like, includes at least a communication part that performs wireless communication with the fine spinning machine 1 and a display part that displays predetermined information. The portable terminal 200 may be a general purpose machine capable of executing various applications, or may be a special purpose machine (embedded machine) capable of executing only an application related to a textile machine as exemplified by the fine spinning machine 1.

**[0048]** As shown in FIG. 2, each spinning unit 2 includes a sliver storage part (sliver can) 5, a plurality of guide devices 6, a draft device (feed device) 7, an air spinning device 9, a yarn storage device 12, and a winding device 13, which are arranged in this order from upstream to downstream. The draft device 7 drafts a sliver 15 while feeding the sliver 15 from the sliver storage part 5, to form a fiber bundle 8. The fiber bundle 8 fed by the draft device 7 is spun by the air spinning device 9. A spun yarn 10 outputted from the air spinning device 9 passes through a later-described yarn clearer 49, and then further passes through a yarn storage device 12. Then, the spun yarn 10 is wound around a bobbin 48 by the winding device 13, to form a package 28.

**[0049]** The guide devices 6 guide the sliver 15, which is stored in the sliver storage part 5, toward the draft device 7. Each of the guide devices 6 is a columnar mem-

ber including a guide portion that guides the sliver 15 in its widthwise direction. The guide portion is disposed along a direction parallel to a fiber travelling direction. In this embodiment, a driving part for driving the guide devices 6 is not provided, but the draft device 7 arranged on the downstream side pulls the sliver 15 so that the sliver 15 is conveyed downstream. Here, it may be acceptable that a driving part for driving the guide devices 6 is provided. The shape of the guide device 6 is not limited to a columnar shape. The guide device 6 may, for example, be provided with a guide surface for contacting the sliver 15 and a regulating surface for making the sliver 15 less likely to deviate from the guide surface. The guide device 6 may be configured to move (rotate) together with the sliver 15, or may be configured not to displace (rotate) even though the sliver 15 is moved. In a case where the guide device 6 rotates together with the sliver 15, the guide device 6 may be a roller that is rotationally driven, or may be a follower roller that is rotated due to friction against the sliver 15.

**[0050]** The draft device 7 conveys the sliver 15 fed from the guide devices 6 while pinching the sliver 15 with a plurality of draft rollers (bottom rollers, conveyor rollers) and a plurality of facing rollers (top rollers, conveyor rollers), thereby stretching (drafting) the sliver 15 to reach a predetermined fiber amount (or thickness), to form the fiber bundle 8. The draft device 7 includes four draft rollers, namely, a back roller 16, a third roller 17, a middle roller 19, and a front roller 20, which are arranged in this order from upstream. An apron belt 18 made of rubber is wrapped around the middle roller 19. Each of the draft rollers is rotationally driven at a predetermined rotation speed.

**[0051]** The facing rollers of two adjacent spinning units 2 have their shafts coupled to each other and supported by a draft device cradle 21. The draft device cradle 21 is displaceable between a position where the draft device cradle 21 presses the facing rollers against the draft rollers and a position where the draft device cradle 21 separates the facing rollers away from the draft rollers. Separating the facing rollers away from the draft rollers makes cleaning of the draft device 7 possible. The draft device cradle 21 may be configured to support the draft rollers as well as the facing rollers.

**[0052]** As shown in FIG. 4, the draft device 7 includes a first motor 81 for driving the back roller 16, a second motor 82 for driving the third roller 17, a third motor 83 for driving the middle roller 19, and a fourth motor 84 for driving the front roller 20. In this embodiment, the first motor 81 to the fourth motor 84 are provided for each spinning unit 2, and therefore whether to rotate the draft rollers and a rotation speed of the draft rollers can be changed for each spinning unit 2.

**[0053]** The draft device 7 includes a first motor control part 85, a second motor control part 86, a third motor control part 87, and a fourth motor control part 88, serving as motor drivers for driving the first motor (electric motor) 81 to the fourth motor 84, respectively. The first motor

81 to the fourth motor 84 are controlled by a unit control part 102 provided for each spinning unit 2. Here, the unit control part 102 may be provided for every plurality of spinning units 2, instead of being provided for each spinning unit 2.

**[0054]** To be specific, for example, the first motor 81 is a step motor whose rotation amount (the number of rotations and the angle of rotation) is controlled based on the number of pulses (the number of pulses indicating rotation of the first motor 81) that are inputted from the unit control part 102 to the first motor control part 85. Thus, the number of rotations of the first motor 81 per unit time can be controlled by changing the number of pulses inputted per unit time. The unit control part 102 is able to obtain the number of rotations of the first motor 81 based on the number of pulses (command signal) indicating rotation of the first motor 81. In a case of the first motor 81 being a step motor, therefore, it is easy to obtain the number of rotations of the first motor 81. In the second motor 82 to the fourth motor 84 as well, the number of rotations can be obtained in the same manner. This is why the fine spinning machine 1 is not provided with a sensor for detecting the presence or absence of the sliver 15 guided by the guide devices 6. The fine spinning machine 1 is also not provided with a sensor for detecting the number of rotations of the draft rollers (especially the back roller 16 which is a conveyor roller arranged most upstream in the fiber travelling direction). The fine spinning machine 1 is also not provided with a sensor for directly or indirectly detecting a length over which the sliver 15 travels. In the fine spinning machine 1, as described above, a sensor for detecting the amount of sliver 15 is not arranged in a range from the sliver storage part 5 to the air spinning device 9 (in another aspect, from the guide devices 6 to the draft device 7).

**[0055]** The air spinning device 9 produces the spun yarn 10 by using the fiber bundle 8 fed from the draft device 7. More specifically, as shown in FIG. 3, the air spinning device 9 includes a first holder (nozzle block) 60 and a second holder 70. The first holder 60 is arranged in an upstream end portion of the air spinning device 9. The first holder 60 includes a fiber guide 61, a spinning chamber 62, and a nozzle 63.

**[0056]** The fiber guide 61 guides the fiber bundle 8 drafted by the draft device 7 toward the inside of the air spinning device 9. The fiber guide 61 has a fiber introducing port 61a and a guide needle 61b. The fiber bundle 8 drafted by the draft device 7 is introduced through the fiber introducing port 61a, and is guided into the spinning chamber 62 while being wrapped around the guide needle 61b. The air spinning device 9 is configured such that air is jetted from the nozzle 63 into the spinning chamber 62 to apply a swirling airflow to the fiber bundle 8 in the spinning chamber 62. It may be acceptable that the guide needle 61b is omitted and a downstream end portion of the fiber guide 61 has a function as the guide needle 61b.

**[0057]** The second holder 70 includes a hollow guide shaft member 71. The hollow guide shaft member 71 has

a yarn passage 72 formed in its shaft center. Due to the air jetted from the nozzle 63, the rear ends of fibers of the fiber bundle 8 swing around the distal end of the hollow guide shaft member 71. The fiber bundle 8 twisted in this manner passes through the yarn passage 72, and is outputted outside the air spinning device 9 through a yarn outlet (not shown) which is provided on the downstream side.

**[0058]** The yarn storage device 12 is provided downstream of the air spinning device 9. The yarn storage device 12 includes a yarn storage roller 26 as shown in FIG. 2.

**[0059]** The yarn storage roller 26 is configured to have a certain amount of spun yarn 10 wound on its outer peripheral surface, for temporary storage. Rotating the yarn storage roller 26 at a predetermined rotation speed with the spun yarn 10 wound on the outer peripheral surface of the yarn storage roller 26 enables the spun yarn 10 to be drawn out from the air spinning device 9 and conveyed downstream at a predetermined speed. Since the spun yarn 10 can be temporarily stored on the outer peripheral surface of the yarn storage roller 26, the yarn storage device 12 is able to function as a buffer of sorts. This can deal with a trouble (for example, a slack of the spun yarn 10) caused by a phenomenon in which a spinning speed of the air spinning device 9 and a winding speed (a travelling speed of the spun yarn 10 wound around the package 28) are inconsistent for some reason. Instead of the yarn storage device 12, a delivery roller and a nip roller may be provided to draw out the spun yarn 10 from the air spinning device 9 with this roller pair. Alternatively, a delivery roller and a nip roller may be provided between the air spinning device 9 and the yarn storage device 12. In a case where a delivery roller and a nip roller are provided, a slack tube that temporarily stores the spun yarn 10 with air, instead of the yarn storage device 12, may be provided downstream of the roller pair.

**[0060]** A yarn guide 25 and the winding device 13 are arranged downstream of the yarn storage device 12. It may be acceptable that a waxing device is provided between the yarn guide 25 and the winding device 13, to apply a wax to the spun yarn 10.

**[0061]** The winding device 13 includes a cradle arm 46, a winding drum 98, and a traverse guide 99. The cradle arm 46 rotatably supports the bobbin 48 for winding the spun yarn 10. The winding drum 98 receives a drive force transmitted from a winding drum drive motor (not shown), to be rotated while being in contact with an outer peripheral surface of the package 28 or the bobbin 48. The winding drum drive motor, for example, is shared by the plurality of spinning units 2, and is arranged in the engine box 43. The traverse guide 99 is capable of engaging with the spun yarn 10. The winding device 13 drives the winding drum 98 by the winding drum drive motor while reciprocating the traverse guide 99 by drive means (not shown). Thereby, the winding device 13 rotates the package 28 which is in contact with the winding

drum 98, to wind the spun yarn 10 around the package 28 while traversing the spun yarn 10.

**[0062]** Each spinning unit 2 includes a unit display panel 53. The unit display panel 53 includes an alarm lamp (alarm part) 54, a unit display part (second display part) 55, and a reset operation part 56. For example, the alarm lamp 54 is turned off in a normal state (non-alarm state), and is turned on when an abnormality requiring intervention of an operator occurs in the spinning unit 2 (alarm state). Alternatively, the alarm lamp 54 may be turned on both in the normal state and in an abnormal state, and be configured to have its color in the normal state different from its color in the abnormal state. Alternatively, the alarm lamp 54 may be turned off or turned on in the normal state, and be configured to flash in the abnormal state. The operator is able to recognize occurrence of an abnormality by visually observing the state of the alarm lamp 54. The unit display part 55 is a segment display which, at a time of occurrence of an abnormality, displays information about the abnormality, an error code, and the like. The reset operation part 56 is, for example, a button for resetting a result (accumulated length) of calculation of a consumed length of the sliver 15 which will be described later.

**[0063]** The yarn splicing cart 41 includes a yarn splicing device 93, a suction pipe 94, and a suction mouth 95, as shown in FIG. 1 and FIG. 2. If a yarn breakage or a yarn disconnection occurs in a spinning unit 2, the yarn splicing cart 41 travels on a rail (not shown) and stops at or near the spinning unit 2. The suction pipe 94 swings upward about a shaft to catch a spun yarn 10 outputted from the air spinning device 9, and swings downward about the shaft, thus guiding the spun yarn 10 to the yarn splicing device 93. The suction mouth 95 swings downward about a shaft to catch a spun yarn 10 from the package 28, and swings upward about the shaft, thus guiding the spun yarn 10 to the yarn splicing device 93. The yarn splicing device 93 splices yarns of the guided spun yarns 10 to each other. This enables the winding device 13 to resume winding of the spun yarn 10.

**[0064]** The doffing cart 42 performs a bobbin setting work of feeding a bobbin 48 to the cradle arm 46 and preparing to wind the spun yarn 10, and a doffing work of removing a fully wound package 28 from the cradle arm 46. Upon receiving an instruction to perform the bobbin setting work and/or the doffing work on a spinning unit 2, the doffing cart 42 travels on a travelling path to the spinning unit 2, the travelling path being outside a region where the spinning units 2 are juxtaposed. The doffing cart 42 stops in front of the spinning unit 2 associated with the instruction, and performs the bobbin setting work or the doffing work (or both of the works). The package 28 doffed by the doffing cart 42 is placed in a package placement part 47.

**[0065]** In this embodiment, the package placement part 47 has a function as a conveyor, and the package 28 is conveyed in a direction in which the spinning units 2 are juxtaposed, and is automatically sent to the next

process. It however may be acceptable that the package placement part 47 has no conveyor function and the operator collects the package 28 from the package placement part 47 by hand. The doffing work is performed in the above-described manner.

**[0066]** A passage 44 where the operator passes is provided on a side opposite to the spinning unit 2 across the package placement part 47. In other words, the passage 44 is provided on a front side of the fine spinning machine 1 (for example, the side where the machine display part 50 or the unit display panel 53 is arranged) (machine front side).

**[0067]** The fine spinning machine 1 has the sliver storage part 5 arranged on the machine rear side (right side in FIG. 2), and the passage 44 provided on the opposite side which means the machine front side (left side in FIG. 2). In a region therebetween, the passage 44, the spinning unit 2, the guide devices 6, and the sliver storage part 5 are arranged in this order from the machine front side. Since a number of members are interposed between the passage 44 and the sliver storage part 5, the operator passing through the passage 44 cannot directly visually observe a remaining length of the sliver 15 of the sliver storage part 5. This involves a problem of difficulty in grasping a timing for replenishing the sliver 15. The fine spinning machine 1 of this embodiment has a configuration for enabling the operator to easily observe the remaining length of the sliver 15.

**[0068]** Processes for calculating and displaying information about replenishment of the sliver 15 will now be described with reference to FIG. 5 to FIG. 9. These processes are executed by the machine control part 101, the unit control part 102, and the portable terminal 200. In the description below, the machine control part 101 and the unit control part 102 may be collectively referred to as control part 100. In the description below, an overall work of producing the package 28 from the sliver 15 will be referred to as "spinning operation". Thus, the spinning operation is an operation including drafting by the draft device 7 and spinning by the air spinning device 9.

**[0069]** First, a process executed by the unit control part 102 will be described with reference to flowcharts of FIG. 5 and FIG. 6. As described above, the unit control part 102 is able to acquire the cumulative number of rotations of the first motor 81 based on the number of pulses that are transmitted to the first motor control part 85, the pulses indicating rotation of the back roller 16. Since the ratio between the number of rotations of the first motor 81 and the number of rotations of the back roller 16 is fixed, the cumulative number of rotations of the back roller 16 can be calculated (acquired) based on the cumulative number of rotations of the first motor 81 (S101). When the ratio between the number of rotations of the back roller 16 and the number of rotations of the first motor 81 is one, the cumulative number of rotations of the first motor 81 is equal to the cumulative number of rotations of the back roller 16.

**[0070]** Then, the unit control part 102 calculates a con-

summed length of the sliver 15 based on the cumulative number of rotations of the back roller 16 acquired in step S101 (S102). More specifically, the unit control part 102 multiplies the cumulative number of rotations of the back roller 16 by the diameter of the back roller 16 and pi, thereby calculating a length of the sliver 15 sent out by the back roller 16 (that is, a consumed length of the sliver 15). In consideration of slippage between the sliver 15 and the back roller 16, further multiplication by a correction factor or the like may be executed.

**[0071]** Then, the unit control part 102 acquires the consumed length of the sliver 15 calculated in step S102, a fiber travelling speed set value (a set travelling speed of any of the sliver 15, the fiber bundle 8, and the spun yarn 10), and information of an initial length of the sliver 15. As for the amounts of slivers 15 stored in the respective sliver storage parts 5, their lengths are basically the same when they are in full volume states which are states before the slivers 15 start to be consumed in the respective spinning units 2. Thus, the information of the initial length of the sliver 15 is a constant value. The fiber travelling speed set value and the information of the initial length of the sliver 15 are preliminarily inputted by the operator, and stored in the machine control part 101 or in the unit control part 102. Alternatively, these types of information may be acquired by the machine control part 101 communicating with another apparatus. For example, the information of the initial length of the sliver 15 may be acquired from a storage part of the sliver storage part 5 or from the drawing frame.

**[0072]** The unit control part 102 calculates a remaining length of the sliver 15 and a remaining time before the sliver 15 runs out, based on the cumulative number of rotations of the back roller 16, the fiber travelling speed set value, and the information of the initial length of the sliver 15 (S103). The remaining length of the sliver 15 can be calculated by subtracting the consumed length of the sliver 15 from the information of the initial length of the sliver 15. The consumed length of the sliver 15 per unit time can be calculated by using the fiber travelling speed set value, and thus the remaining time before the sliver 15 runs out can be calculated. It may be also acceptable to perform the processing of step S103 by using a fiber travelling speed (for example, an average travelling speed of the sliver 15 over a predetermined time period in the past) that is calculated not based on the fiber travelling speed set value but based on the rotation speed of the back roller 16.

**[0073]** As shown in FIG. 9, the unit control part 102 displays, on the unit display part 55, the remaining length of the sliver 15 or the remaining time calculated in step S103 (S104). Since the unit display part 55 is a segment display, a numeral corresponding to the remaining length or the remaining time is displayed. In a case of displaying the remaining length, the remaining length may be indicated as a specific numerical value (e.g., "2" meters), or may be indicated as the percentage (e.g., "15" %) of the remaining length in the initial length. Instead of the re-

maining length, the remaining time may be indicated. In a case where the unit display part 55 is capable of displaying many orders of magnitude or in a case where the unit display part 55 is a dot-matrix type display, both the remaining length and the remaining time can be displayed. The unit display part 55 may be configured such that which of the remaining length and the remaining time is to be displayed is switchable.

**[0074]** Then, the unit control part 102 determines whether or not the remaining length calculated in step S103 is equal to or less than a stop length (S105). The stop length is a numerical value for prescribing a timing for stopping the spinning operation. Conventionally, in a case of the sliver 15 running out, a spinning operation is stopped upon detecting that the fiber bundle 8 is fully fed to the air spinning device 9 or that the spun yarn 10 is no longer outputted from the air spinning device 9. In this configuration, a work of placing a sliver 15 onto the guide devices 6 is necessary to resume the spinning operation after replenishment of the sliver 15. In addition, the draft device cradle 21 supports the facing rollers of two spinning units 2 together as described above, and therefore it is also necessary to separate the facing rollers away from the draft rollers and to redo the setting of the sliver 15 to the draft device 7. It therefore is necessary to stop a spinning operation of an adjacent spinning unit 2, too. In this respect, this embodiment stops the spinning operation if the remaining length becomes equal to or less than the stop length (S106). Set as the stop length is such a value that an upstream end portion of the sliver 15 is located at a position upstream of the guide devices 6 (that is, upstream of the draft device 7) after the spinning operation is stopped. This eliminates the need of a work of placing (letting) the sliver 15 onto (through) the guide devices 6 and a work of operating the draft device cradle 21, which can reduce labor of the operator. Since the labor of the operator can be reduced, resumption of the spinning operation can be implemented quickly, and in addition a spinning operation of the adjacent spinning unit 2 need not be stopped, thus providing an improved production efficiency. Processing executed after the spinning operation is stopped will be described later.

**[0075]** If the calculated remaining length is longer than the stop length, the unit control part 102 determines whether or not the remaining length is equal to or less than a caution length (predetermined length) (S107). The caution length, which is longer than the stop length, is a length for determining a timing for prompting the operator to replenish the sliver 15. If the calculated remaining length is equal to or less than the caution length, the unit control part 102 turns on the alarm lamp 54 (S108). At this time, an error code indicating that the sliver 15 is running short may be displayed on the unit display part 55. In addition to or instead of the alarm lamp 54, an alarm sound may be outputted. Instead of turning on the alarm lamp 54 based on the remaining length, the alarm lamp 54 may be turned on upon the remaining time becoming equal to or less than a caution time (predeter-

mined time).

**[0076]** Then, the unit control part 102 transmits the calculated remaining length of the sliver 15 and the calculated remaining time to the machine control part 101 (S109). The transmission in step S109 may be either wired or wireless. Then, the unit control part 102 executes the processing of step S101 again.

**[0077]** In the following, a process that the unit control part 102 executes after the spinning operation is stopped will be described with reference to FIG. 6. After the spinning operation is stopped, the unit control part 102 determines whether or not the reset operation part 56 is operated (S110). If the reset operation part 56 is operated, the unit control part 102 resets the consumed length of the sliver 15. By the reset operation part 56 being operated after replenishment of the sliver 15, therefore, the unit control part 102 is allowed to appropriately calculate the consumed length of the sliver 15 with replenishment of the sliver 15 taken into account. Specifically, the consumed length of the sliver 15 managed by the unit control part 102 is zeroed, and the remaining length of the sliver 15 is matched to the information of the initial length of the sliver 15.

**[0078]** A sliver 15 remaining in the sliver storage part 5 after the spinning operation is stopped is likely to have a poor quality. The operator, therefore, discards the remaining sliver 15, and joins a downstream end portion of the replenished sliver 15 to the sliver 15 set in the spinning unit 2, the joining being implemented at a position upstream of the guide devices 6. Here, the operator may not necessarily discard the remaining sliver 15.

**[0079]** Then, the unit control part 102 determines the presence or absence of an instruction to resume the spinning operation (S112). If the instruction to resume the spinning operation is given, the unit control part 102 resumes the spinning operation (S113), and executes the processing of step S101 again. If the instruction to resume the spinning operation is not given, the unit control part 102 waits until the resumption instruction is given.

**[0080]** In the following, a process executed by the machine control part 101 will be described with reference to FIG. 7.

**[0081]** The machine control part 101 acquires (receives) the information (specifically, the remaining length of the sliver 15 and the remaining time in each spinning unit 2) transmitted by the unit control part 102 in step S109 as described above (S201).

**[0082]** Then, the machine control part 101 compares the remaining times received from the unit control parts 102 of the plurality of spinning units 2 against one another, selects the shortest remaining time, and displays it on the machine display part 50 as "Time until replenishment is required" as shown in FIG. 10 (S202). The operator seeing this display can grasp a timing when the sliver 15 needs to be replenished.

**[0083]** Then, the machine control part 101 displays, on the machine display part 50, information indicating the spinning unit 2 for which the remaining time selected and

displayed in step S202 has been calculated (S203). The operator seeing this display can grasp which spinning unit 2 needs next replenishment of the sliver 15. Here, not only the spinning unit 2 having the shortest remaining time but also any spinning unit 2 that needs replenishment of the sliver 15 in a predetermined time may be displayed on the machine display part 50.

**[0084]** Then, the machine control part 101 calculates the total quantity (for example, the number of slivers 15, the number of sliver storage parts) of sliver 15 required to be replenished in a predetermined time based on the acquired remaining time, and displays a calculation result on the machine display part 50 (S204). The operator seeing this display can grasp how much quantity of sliver 15 is required.

**[0085]** Then, the machine control part 101 transmits the information displayed on the machine display part 50 (specifically, the time until replenishment is required, information indicating the spinning unit 2 that needs next replenishment, and the total quantity of sliver required to be replenished in a predetermined time) to the portable terminal 200 via the antenna 103 (S205). Information transmitted to the portable terminal 200 may include one or two of the three types of information mentioned above, or may include information about each spinning unit 2 that the machine control part 101 has acquired from the unit control part 102. The information transmitted to the portable terminal 200 may be information calculated separately for the purpose of being transmitted to the portable terminal 200, as long as it is sliver replenishment information which means information related to replenishment of the sliver 15. The operator seeing this display can grasp the quantity of sliver 15 required. As for a timing of transmission from the machine control part 101 to the portable terminal 200, for example, the timing may be each time the contents of information displayed on the machine display part 50 are updated as shown in FIG. 7, or may be upon receiving a request from the portable terminal 200. Any other timings may be acceptable.

**[0086]** In the following, a process executed by the portable terminal 200 will be described with reference to FIG. 8.

**[0087]** The portable terminal 200 receives the information displayed on the machine display part 50 (specifically, the time until replenishment is required, information indicating the spinning unit 2 that needs next replenishment, and the total quantity of sliver required to be replenished in a predetermined time) from the machine control part 101 (S301; receiving step).

**[0088]** Then, the portable terminal 200 displays, on a display screen of the portable terminal 200, the information received from the machine control part 101 (S302; display step). The operator carrying this portable terminal 200 can grasp the status of consumption of the sliver 15 without the need to see the unit display panel 53 of the machine display part 50, which enables the sliver 15 to be replenished more efficiently.

**[0089]** The information transmitted by the machine

control part 101 may be another type of information as described above. In such a case, the portable terminal 200 displays information different from the above-described information. The portable terminal 200 may be configured to receive and store various types of information related to replenishment of the sliver 15, which are possessed by the machine control part 101, and to display a type of information in response to an operator's operation. The portable terminal 200 may be configured to access the machine control part 101 in response to an operator's operation and acquire corresponding information.

**[0090]** As thus far described, the fine spinning machine 1 of this embodiment includes the back roller 16, the air spinning device 9, the first motor 81, and the control part 100. The back roller 16 feeds the sliver 15. The air spinning device 9 produces the spun yarn 10 by twisting the fiber bundle 8 made from the sliver 15 with airflow. The first motor 81 drives the back roller 16, and has its rotation amount controlled in accordance with a command signal (specifically, the number of pulses). The control part 100 calculates a consumed length of the sliver 15 based on the command signal.

**[0091]** With this configuration, the consumed length of the sliver 15 can be calculated without using a sensor that directly detects the rotation amount of the draft rollers or the like. This can avoid a cost increase and complication of the configuration of the fine spinning machine 1 which may otherwise be caused by addition of a sensor. Moreover, the calculation is performed based on the rotation amount of the draft rollers that feed the sliver 15, and therefore the consumed length of the sliver 15 can be more precisely calculated as compared to when the consumed length of the sliver 15 is calculated based on, for example, the spinning speed.

**[0092]** The fine spinning machine 1 of this embodiment includes the plurality of spinning units 2 each having at least the back roller 16 and the air spinning device 9.

**[0093]** In the fine spinning machine 1 including the plurality of spinning units 2, it is difficult for the operator to grasp a consumed length of the sliver 15 in each spinning unit 2. Accordingly, the effects of the present invention can be exerted more effectively.

**[0094]** In the fine spinning machine 1 of this embodiment, the control part 100 calculates at least either the remaining time before the sliver 15 runs out in any of the plurality of spinning units 2 or the total quantity of sliver 15 required to be replenished in a predetermined time, based on the information of the initial length of the sliver 15 and the fiber travelling speed.

**[0095]** Since information that assists in replenishment of the sliver 15 is calculated, for example, replenishment of the sliver 15 can be implemented efficiently.

**[0096]** The fine spinning machine 1 of this embodiment includes the machine display part 50 that displays information about the plurality of spinning units 2. The machine display part 50 displays at least either the remaining time before the sliver 15 runs out in any of the plurality

of spinning units 2 or the total quantity of sliver 15 required to be replenished in a predetermined time.

**[0097]** With this configuration, the operator replenishing the sliver 15 observes the display of the machine display part 50, which makes it easy for the operator to efficiently replenish the sliver 15 or to complete replenishment before the sliver 15 runs out.

**[0098]** The fine spinning machine 1 of this embodiment includes the alarm lamps 54 individually disposed in the respective spinning units 2, each of the alarm lamps 54 being configured to be switchable between the alarm state and the non-alarm state. The alarm lamp 54 switches to the alarm state in a case where the spinning unit 2 where the alarm lamp 54 is disposed satisfies at least either a condition that the remaining length of the sliver 15 in the spinning unit 2 be equal to or less than the caution length or a condition that the remaining time for which the spinning unit 2 is able to perform spinning by using the currently remaining sliver 15 be equal to or less than the caution time.

**[0099]** With this configuration, the operator replenishing the sliver 15 observes details of alarming given by the alarm lamp 54 (whether or not it is turned on, its lighting color, whether or not it is flashing, etc.), which enables the operator to identify the spinning unit 2 that needs replenishment of the sliver 15 at an early stage. Accordingly, replenishment of the sliver 15 can be implemented efficiently.

**[0100]** The fine spinning machine 1 of this embodiment includes the unit display parts 55 individually disposed in the respective spinning units 2, each of the unit display parts 55 being capable of displaying at least a numeral. The unit display part 55 displays at least either the remaining length of the sliver 15 or the remaining time before the sliver 15 runs out in the spinning unit 2 where this unit display part 55 is disposed.

**[0101]** With this configuration, the status of usage of the sliver 15 in each spinning unit 2 is displayed in detail, which enables the operator replenishing the sliver 15 to efficiently replenish the sliver 15 by observing the display.

**[0102]** The fine spinning machine 1 of this embodiment includes the antenna 103 that transmits, to outside, at least either the quantity of sliver 15 required to be replenished or a timing when replenishment of the sliver 15 is required, for the plurality of spinning units 2.

**[0103]** With this configuration, as compared to a configuration in which an operator observes a display part or the like of the fine spinning machine 1, information about replenishment of the sliver 15 can be observed in various places.

**[0104]** The fine spinning machine 1 of this embodiment includes the guide devices 6 that guide the sliver 15, and the draft device 7 that forms the fiber bundle 8 from the sliver 15 guided by the guide devices 6 and feeds the fiber bundle 8 to the air spinning device 9. Of the guide devices 6 and the draft device 7, the draft device 7 is provided with the back roller 16 serving as a conveyor roller.

**[0105]** With this configuration, the effects of the present invention can be exerted in an air spinning machine including the guide devices 6 and the draft device 7.

**[0106]** In the fine spinning machine 1 of this embodiment, the control part 100 executes the process of calculating the remaining length of the sliver 15 based on the consumed length of the sliver 15. The control part 100 is capable of performing a control that stops the draft device 7 for each spinning unit 2 based on the calculated remaining length of the sliver 15. In this control, the draft device 7 is stopped in such a manner that the upstream end portion of the sliver 15 in the fiber travelling direction is located at a position upstream of the guide devices 6.

**[0107]** With this configuration, for example, at a time of replenishing the sliver 15 (replacing a sliver can), a work for setting the sliver 15 on the guide devices 6 is not required, and therefore replenishment of the sliver 15 can be implemented in a short time. Accordingly, a reduction in operation efficiency of the fine spinning machine 1 as a whole can be avoided.

**[0108]** In the fine spinning machine 1 of this embodiment, the control part 100 stores the stop length which is a threshold for the remaining length of the sliver 15, and stops the draft device 7 upon the remaining length of the sliver 15 becoming equal to or less than the stop length.

**[0109]** This configuration can prevent a portion of the sliver 15 near its terminal, which is likely to have a poor quality, from being used to produce the spun yarn 10.

**[0110]** The fine spinning machine 1 of this embodiment includes the draft device cradle 21 that presses the plurality of facing rollers included respectively in two adjacent spinning units 2 to the plurality of draft rollers, or that presses the plurality of draft rollers included respectively in two adjacent spinning units 2 to the plurality of facing rollers. The control part 100 stops the draft device 7 of one of the two spinning units 2 while the draft device cradle 21 is pressing the draft rollers and the draft devices 7 of the two spinning units 2 are holding slivers 15.

**[0111]** In this configuration, one of the spinning units 2, whose draft device 7 is stopped with the sliver 15 held thereon, can resume the spinning operation without cancelling the pressing applied by the draft device cradle 21. Since one of the spinning units 2 can resume the spinning operation while the other of the spinning units 2 keeps performing the spinning operation, a reduction in production efficiency can be prevented.

**[0112]** The fine spinning machine 1 of this embodiment includes the sliver storage part 5 and the package placement part 47. The sliver storage part 5 stores a sliver 15 to be guided by the guide devices 6. In the package placement part 47, a package obtained after the spun yarn 10 spun by the air spinning device 9 is wound is placed. In a plan view, the package placement part 47, the spinning unit 2, the guide devices 6, and the sliver storage part 5 are arranged in this order with respect to a direction perpendicular to the direction in which the spinning units 2 are juxtaposed, and a passage extending in the juxtapo-

sition direction is provided on the side opposite to the spinning unit 2 relative to the package placement part 47.

**[0113]** In such a layout, the sliver storage part 5 is arranged on the side opposite to the passage relative to the spinning unit 2, which usually would make it difficult for an operator working on the passage to visually observe the remaining length of the sliver 15. As a result, replenishment of the sliver 15 is often implemented after the sliver 15 runs out, and therefore the production efficiency is reduced. In this respect, adoption of the present invention can make it easy for an operator to grasp the consumed length of the sliver 15 even in the above-described layout. Consequently, replenishment of the sliver 15 is more likely to be implemented before the sliver 15 runs out. Accordingly, the production efficiency can be increased.

**[0114]** The fine spinning machine 1 of this embodiment includes the sliver storage part 5 that stores the sliver 15 to be guided by the guide devices 6. A sensor for detecting the sliver 15 is not provided between the sliver storage part 5 and the air spinning device 9.

**[0115]** In the fine spinning machine 1 of this embodiment, a sensor for detecting a rotation amount of the draft rollers or a length over which the sliver 15 is fed is not provided between the upstream end portion of the draft device 7 and the upstream end portion of the guide devices 6.

**[0116]** Since the sensors are not required, the configuration of the fine spinning machine 1 can be simplified, and manufacturing costs can be lowered. Moreover, a situation in which the spinning operation of the fine spinning machine 1 is stopped for replacement of such sensors in cases of maintenance and failure does not occur. Thus, the running efficiency of the fine spinning machine 1 is not reduced. The fine spinning machine 1 of this embodiment enables information about the amount of sliver 15 to be grasped without providing any sensor for detecting the presence or absence of the sliver 15.

**[0117]** In the fine spinning machine 1 of this embodiment, the first motor 81 is a step motor.

**[0118]** With this configuration, a consumed sliver length can be calculated from a command signal through a simple arithmetic operation.

**[0119]** The fine spinning machine 1 of this embodiment includes the first holder 60 and the hollow guide shaft member 71. The first holder 60 jets air to generate a swirling flow in the spinning chamber 62, thereby twisting the fiber bundle 8. The hollow guide shaft member 71 guides the fiber bundle 8 twisted in the spinning chamber 62 to outside (outside of the hollow guide shaft member 71, which means outside of the air spinning device 9).

**[0120]** In general, the fine spinning machine 1 of the above-described type has a high spinning speed, and therefore a consumed length of a sliver 15 in a spinning unit 2 whose spinning operation is temporarily stopped for some reason is significantly smaller than consumed lengths of slivers 15 in the other spinning units 2. As a result, a timing for replenishing the sliver 15 largely differs

among the plurality of spinning units 2. Accordingly, the effects of the present invention can be exerted more effectively.

**[0121]** The fine spinning machine 1 of this embodiment includes the reset operation part 56 that enables implementation of an operation for resetting a result of calculation of the consumed length of the sliver 15 calculated by the control part 100.

**[0122]** With this configuration, for example, by operating the reset operation part 56 after replenishment of the sliver 15, a length of the sliver 15 consumed after the replenishment can be precisely calculated.

**[0123]** While a preferred embodiment of the present invention and some variations thereof have been described above, the configuration described above may be modified, for example, as follows.

**[0124]** In the embodiment described above, hardware that generates a pulse indicating rotation of the back roller 16 and hardware that calculates the cumulative number of rotations based on the number of pulses are the same. They, however, may be different from each other.

**[0125]** In the embodiment described above, the first motor 81 to the fourth motor 84 are provided for each spinning unit 2. Alternatively, the draft rollers of the plurality of spinning units 2 may be driven by a common motor. In such a configuration, the rotation speeds of the draft rollers of the respective spinning units 2 are equal. In this configuration, switching between transmission and non-transmission of power from the motor to the draft rollers can be implemented by using a clutch, and thereby whether or not to rotate the draft rollers can be switched for each spinning unit 2. In this configuration, therefore, a consumed sliver length can be calculated based on a rotation amount of the draft rollers and an operation state of the clutch. It may be acceptable that, for example, the third motor 83 and the fourth motor 84 are shared by the plurality of spinning units 2 and are disposed in the engine box 43.

**[0126]** In the embodiment described above, alarming by the alarm lamp 54 and displaying by the unit display part 55 are performed based on the remaining length of the sliver 15, but it may be performed based on the remaining time before the sliver 15 runs out.

**[0127]** In the embodiment described above, a consumed length of the sliver 15 is calculated based on the number of pulses used for rotating the first motor 81 that drives the back roller 16. Alternatively, a consumed length of the sliver 15 may be calculated based on the number of pulses used for rotating a motor that drives another draft roller (the third roller 17, the middle roller 19, the front roller 20). In other words, a draft roller other than the back roller 16 may serve as a conveyor roller of the present invention.

**[0128]** Furthermore, a roller other than the draft rollers may serve as a conveyor roller. For example, a drive roller other than the draft rollers which is disposed inside a region of the draft device 7 may serve as a conveyor roller. Being inside the region of the draft device 7 means

being supported by the draft device cradle 21 or being disposed near the draft rollers. A roller disposed upstream of the draft device 7 may serve as a conveyor roller. More specifically, a rotationally driven roller arranged as the guide device 6 may serve as a conveyor roller. In such a configuration, it is preferable that the rotation speed of this conveyor roller is exactly the same as or approximate to the rotation speed of the back roller 16. Alternatively, a rotationally driven roller disposed between the guide devices 6 and the draft device 7 may serve as a conveyor roller. Any of such conveyor rollers is a roller that rotates while being in contact with the sliver 15 and that feeds the sliver 15 along with the rotation. The shape of the conveyor roller may be a shape other than a columnar shape, as long as it is configured to rotate and feed the sliver 15.

**[0129]** Each of such conveyor rollers may be rotationally driven on a standalone basis, or may be rotationally driven together with another roller. In other words, an electric motor that drives the conveyor roller may be configured to rotationally drive the conveyor roller alone, to rotationally drive the conveyor roller together with another roller included in the same spinning unit 2, or to rotationally drive the conveyor roller together with a roller included in another spinning unit 2.

**[0130]** In the embodiment described above, a consumed length of the sliver 15 is detected based on the number of pulses indicating rotation of the first motor 81. A reference example shown in FIG. 11 can also exert the same effects. In the reference example, as shown in FIG. 11, a rotation sensor 89 that detects a rotation amount of the back roller 16 is provided, and the cumulative number of rotations of the back roller 16 is calculated based on a detection result from the rotation sensor 89. Referring to FIG. 11, in a case of driving the back roller 16 and the third roller 17 by the first motor 81, the back roller 16 and the third roller 17 are rotated in synchronization, because the ratio between the numbers of rotations of them is fixed though they have different rotation speeds. Detection of a rotation amount of the third roller 17, therefore, leads to an accurate estimate of a rotation amount of the back roller 16. Thus, the fine spinning machine 1 may include a sensor for detecting a rotation amount of the third roller 17 instead of a sensor for detecting a rotation amount of the back roller 16. Alternatively, for example, a gear that transmits power from an output shaft of the first motor 81 to a drive shaft of the back roller 16 or the third roller 17 is also rotated in synchronization with the back roller 16, and therefore the number of rotations of the gear may be detected.

**[0131]** In the embodiment described above, the reset operation part 56 is provided on the passage 44 side (machine front side) of the spinning unit 2, but it may be provided on the side (machine rear side, near the sliver storage part 5 and the guide devices 6) opposite to the passage 44 across the spinning unit 2. Such a configuration enables an operator to operate the reset operation part 56 without moving to the machine front side after

performing a work of replenishing the sliver 15. The fine spinning machine 1 may be configured to cause an automatic resetting after resuming a spinning operation that has been stopped as a result of a sliver remaining length becoming equal to or less than the stop length.

**[0132]** In the embodiment described above, the process of calculating information about replenishment of the sliver 15 is executed by the machine control part 101 or by the unit control part 102. In this respect, the process executed by the machine control part 101 in the above illustration may be partially executed by the unit control part 102, and vice versa. For example, the process of calculating a remaining time in each spinning unit 2 may be executed by the machine control part 101. The unit control part 102 may have a function for communicating with the portable terminal 200.

**[0133]** The air spinning device 9 may include, instead of the configuration described in the embodiment above, a pair of air-jet nozzles for twisting a fiber bundle in opposite directions.

**[0134]** Although the air spinning device 9 of the embodiment described above is an air-jet fine spinning machine, the present invention is applicable to an open-end fine spinning machine, too. An open-end fine spinning machine is provided with a feed device instead of a draft device. The feed device includes a feed roller (conveyor roller) that feeds a sliver guided by a guide device to an air spinning device (specifically, to a fiber opening chamber for opening a fiber and a spinning chamber for bundling and twisting the opened fibers). The feed roller may not be provided with a facing roller. A command signal indicating a rotation amount of an electric motor that drives the feed roller can be used to calculate a consumed sliver length, etc., similarly to the embodiment described above. The variation illustrated above is applicable not only to an air-jet fine spinning machine but also to an open-end fine spinning machine, unless incompatible therewith.

**[0135]** In the embodiment described above, a consumed length of the sliver 15, etc. is calculated based on a command signal (the number of pulses) given to the first motor 81 which is a step motor. An electric motor that drives the conveyor roller need not be a step motor but may be a servo motor for example, as long as a rotation amount of the motor is controlled in accordance with a command signal.

**[0136]** In the embodiment described above, a travelling path through which the spun yarn 10 travels from the draft device 7 to the winding device 13 at a time of being wound around the package 28 is set so as to extend from up to down with respect to a height direction of the fine spinning machine 1, and the sliver storage part 5 is provided on the machine rear side. In this respect, however, the travelling path may be set so as to extend from down to up, and the sliver storage part 5 may be disposed at a position on the machine front side and below the draft device 7.

## Claims

1. An air spinning machine (1) comprising:

5 a conveyor roller (16, 17, 19, 20) configured to feed a sliver (15);  
an air spinning device (9) configured to produce a spun yarn (10) by twisting a fiber bundle (8) made from the sliver (15) with airflow;  
10 an electric motor (81, 82, 83, 84) configured to drive the conveyor roller (16, 17, 19, 20), and that has a rotation amount thereof controlled in accordance with a command signal; and  
15 a control part (100) configured to calculate a consumed length of the sliver (15) based on the command signal.

2. The air spinning machine (1) according to claim 1, comprising a plurality of spinning units (2) each having at least the conveyor roller (16, 17, 19, 20) and the air spinning device (9).

3. The air spinning machine (1) according to claim 2, wherein  
25 the control part (100) is configured to calculate at least either a remaining time before the sliver (15) runs out in any of the plurality of spinning units (2) or a total quantity of sliver (15) required to be replenished in a predetermined time, based on information of an initial length of the sliver (15) and a fiber travelling speed.

4. The air spinning machine (1) according to claim 3, comprising a first display part (50) configured to display information about the plurality of spinning units (2), wherein  
35 the first display part (50) is configured to display at least either the remaining time or the quantity calculated by the control part (100).

5. The air spinning machine (1) according to any one of claims 2 to 4, comprising an alarm part (54) individually disposed in each of the spinning units (2), the alarm part (54) being configured to be switchable between an alarm state and a non-alarm state, wherein  
45 the alarm part (54) is configured to switch to the alarm state in a case where the spinning unit (2) where the alarm part (54) is disposed satisfies at least either a condition that a remaining length of the sliver (15) in the spinning unit (2) is equal to or less than a predetermined length or a condition that a remaining time for which the spinning unit (2) is able to perform spinning by using the currently remaining sliver (15) is equal to or less than a predetermined time.

6. The air spinning machine (1) according to any one of claims 2 to 5, comprising a second display part

- (55) individually disposed in each of the spinning units (2), the second display part being capable of displaying at least a numeral, wherein the second display part (55) is configured to display at least either a remaining length of the sliver (15) or a remaining time before the sliver (15) runs out in the spinning unit (2) where the second display part (55) is disposed.
7. The air spinning machine (1) according to any one of claims 2 to 6, comprising a transmitter (103) configured to transmit, to outside, at least either the quantity of sliver (15) required to be replenished or a timing when replenishment of the sliver (15) is required, for the plurality of spinning units (2).
8. The air spinning machine (1) according to any one of claims 2 to 7, comprising:
- a guide device (6) configured to guide the sliver (15); and
  - a feed device (7) configured to form the fiber bundle (8) from the sliver (15) guided by the guide device (6) and to feed the fiber bundle (8) to the air spinning device (9), wherein the conveyor roller (16, 17, 19, 20) is provided in the guide device (6) or in the feed device (7), or the conveyor roller (16, 17, 19, 20) is disposed between the guide device (6) and the feed device (7) with respect to a fiber travelling direction in which a fiber of the sliver (15) travels.
9. The air spinning machine (1) according to claim 8, wherein the control part (100) is configured to
- execute a process of calculating a remaining length of the sliver (15) based on the consumed length of the sliver (15),
  - be capable of performing a control that stops the feed device (7) for each of the spinning units (2) based on the calculated remaining length of the sliver (15), and
  - in the control, stop the feed device (7) in such a manner that an upstream end portion of the sliver (15) in the fiber travelling direction is located at a position upstream of the guide device (6).
10. The air spinning machine (1) according to claim 8 or 9, wherein the control part (100) is configured to store a stop length that is a threshold for the remaining length of the sliver (15), and to stop the feed device (7) upon the remaining length of the sliver (15) becoming equal to or less than the stop length.
11. The air spinning machine (1) according to claim 10, wherein
- the feed device (7) is a draft device that is configured to form a fiber bundle (8) by drafting a sliver (15) guided by the guide device (6), the conveyor roller (16, 17, 19, 20) is formed of a plurality of draft rollers and a plurality of facing rollers included in the draft device, the air spinning machine (1) comprises a draft device cradle (21) configured to press the plurality of facing rollers included respectively in adjacent two of the spinning units (2) to the plurality of draft rollers, or to press the plurality of draft rollers included respectively in adjacent two of the spinning units (2) to the plurality of facing rollers, and the control part (100) is configured to stop the draft device of one of the two spinning units (2) while the draft device cradle (21) is pressing the draft rollers or the facing rollers and the draft devices of the two spinning units (2) are holding the slivers (15).
12. The air spinning machine (1) according to any one of claims 8 to 11, comprising:
- a sliver storage part (5) configured to store the sliver (15) to be guided by the guide device (6); and
  - a package placement part (47) where a package obtained after the spun yarn (10) produced by the air spinning device (9) is wound is placed, wherein in a plan view, the package placement part (47), the spinning unit (2), the guide device (6), and the sliver storage part (5) are arranged in this order with respect to a direction perpendicular to a direction in which the spinning units (2) are juxtaposed, and a passage extending in the juxtaposition direction is provided on a side opposite to the spinning unit (2) relative to the package placement part (47).
13. The air spinning machine (1) according to any one of claims 9 to 11, comprising a sliver storage part (5) configured to store the sliver (15) to be guided by the guide device (6), wherein a sensor for detecting the sliver (15) is not provided between the sliver storage part (5) and the air spinning device (9).
14. The air spinning machine (1) according to any one of claims 8 to 13, wherein a sensor for detecting a rotation amount of the conveyor roller (16, 17, 19, 20) or a length over which the sliver (15) is fed is not provided between an upstream end portion of the feed device (7) and an upstream end portion of the guide device (6).
15. The air spinning machine (1) according to any one of claims 1 to 14, wherein the electric motor (81, 82, 83, 84) is a step motor.

16. The air spinning machine (1) according to any one of claims 1 to 15, wherein the air spinning device (9) includes a nozzle block (60) configured to jet air to generate a swirling flow in a spinning chamber (62), to twist the fiber bundle (8); and a hollow guide shaft member (71) configured to guide the fiber bundle (8) twisted in the spinning chamber (62) to outside. 5 10
17. The air spinning machine (1) according to any one of claims 1 to 16, comprising a reset operation part (56) configured to enable implementation of an operation for resetting a result of calculation of the consumed length of the sliver (15) calculated by the control part (100). 15
18. A display control method for controlling a display of sliver replenishment information, the method comprising: 20
- a receiving step (S301) of receiving at least either a consumed length of a sliver (15) calculated based on a command signal or information calculated based on the consumed length of the sliver (15); and 25
- a display step (S302) of displaying a content received in the receiving step on an external apparatus, 30
- the external apparatus being disposed outside an air spinning machine (1), the external apparatus being capable of communicating with the air spinning machine (1), 35
- the air spinning machine (1) including
- a conveyor roller (16, 17, 19, 20) that feeds the sliver (15),
- an air spinning device (9) that produces a spun yarn (10) by twisting a fiber bundle (8) made from the sliver (15) with airflow, and 40
- an electric motor (81, 82, 83, 84) that drives the conveyor roller (16, 17, 19, 20), and that has a rotation amount thereof controlled in accordance with the command signal received. 45

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Fig.1

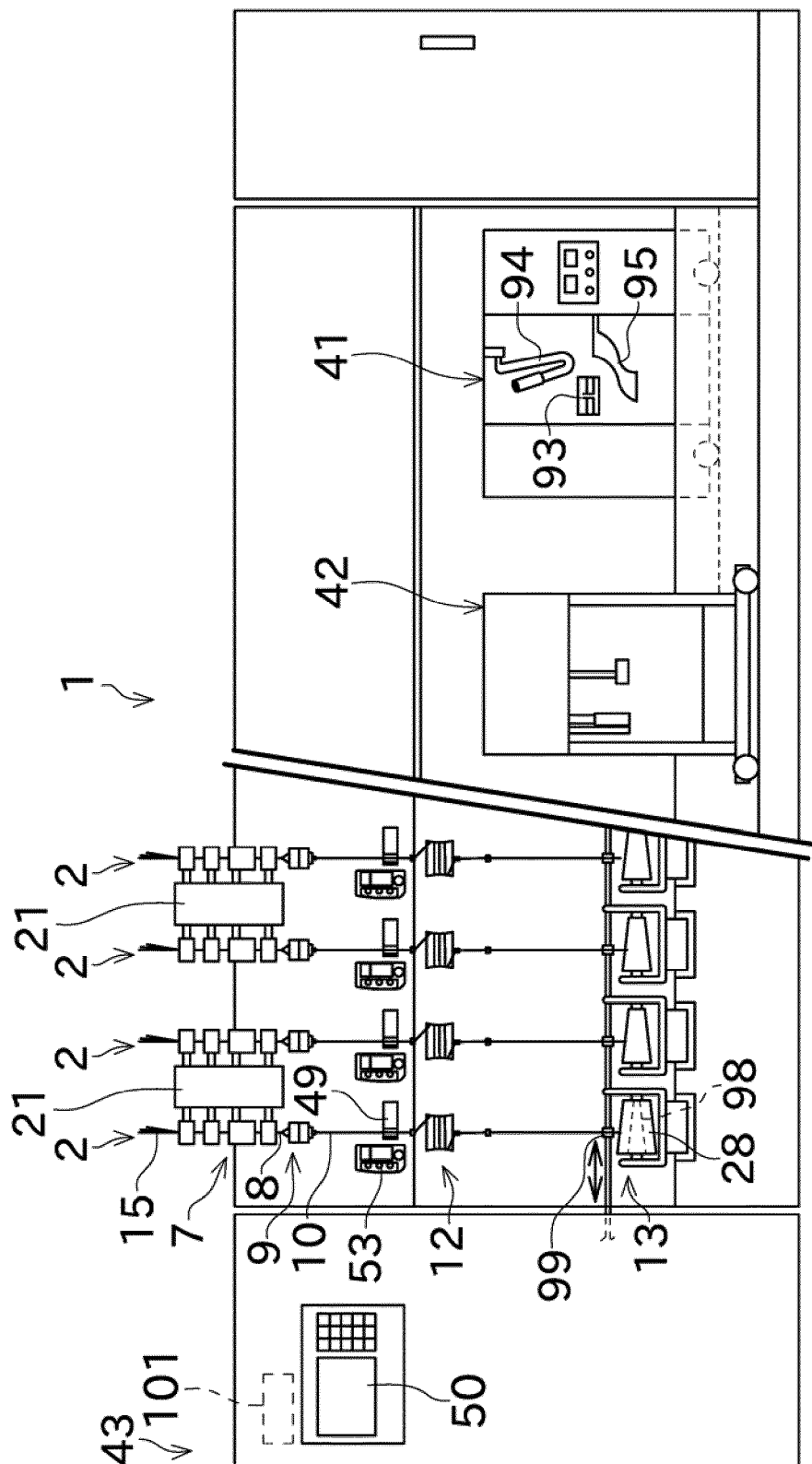


Fig.2

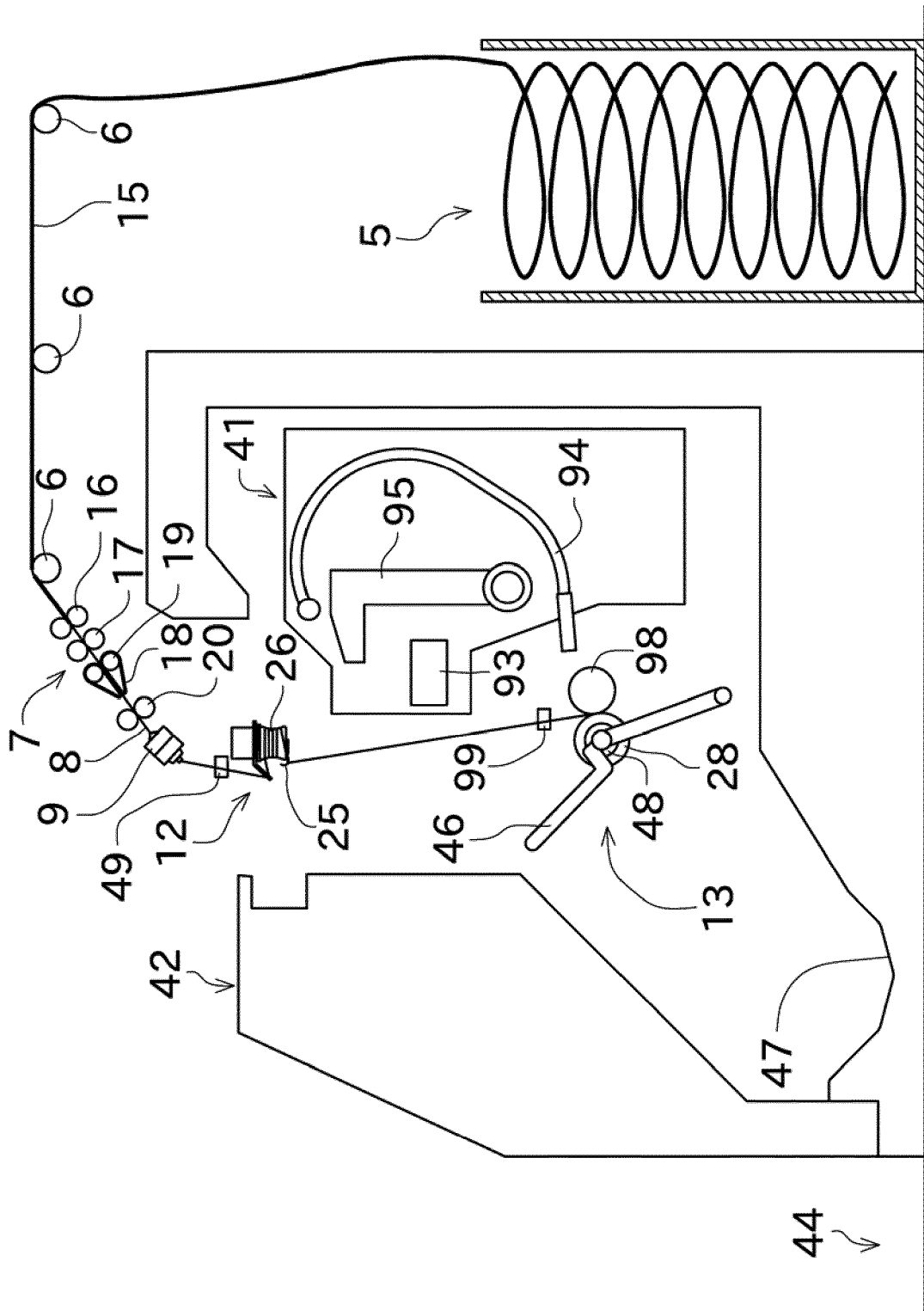


Fig.3

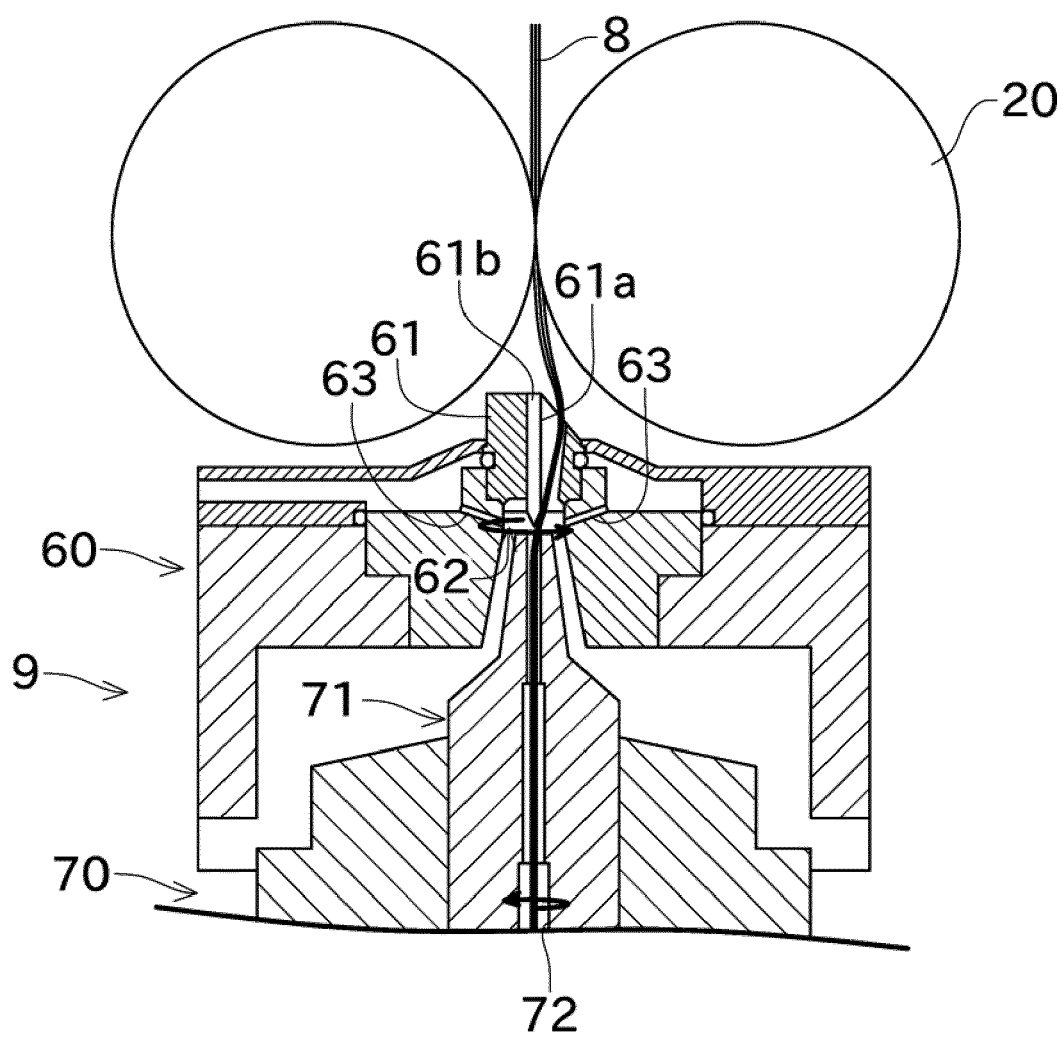


Fig.4

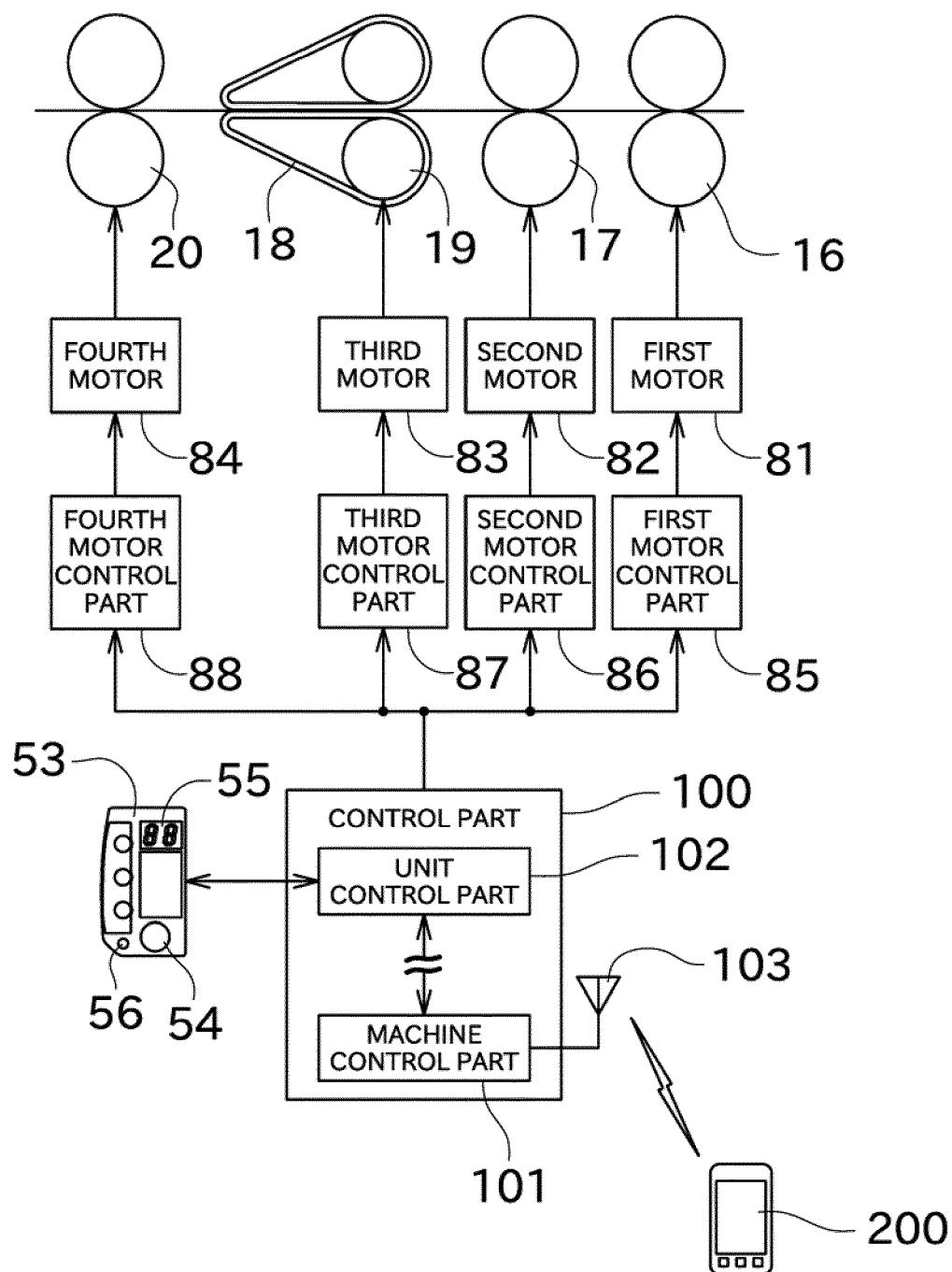


Fig.5

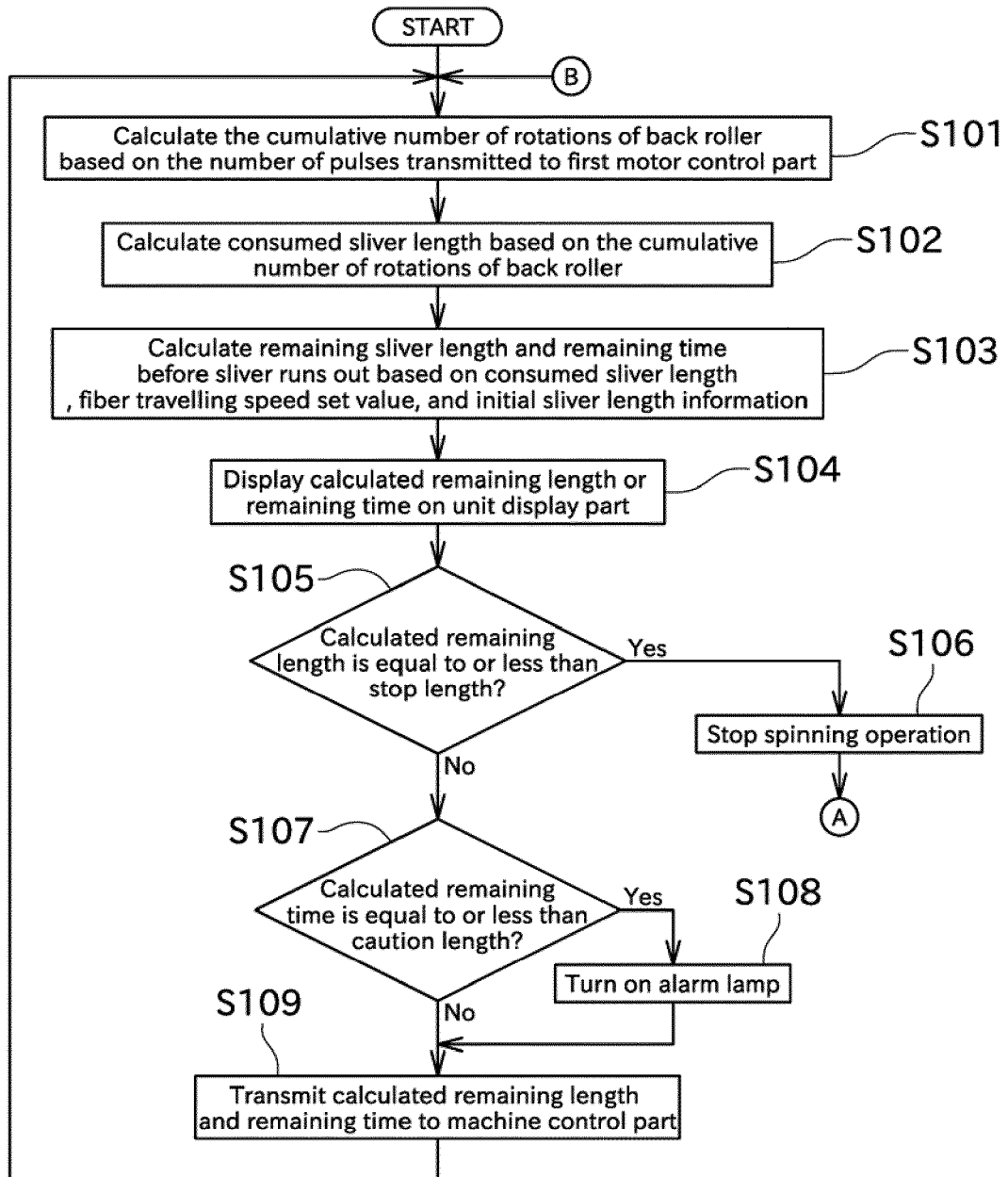


Fig.6

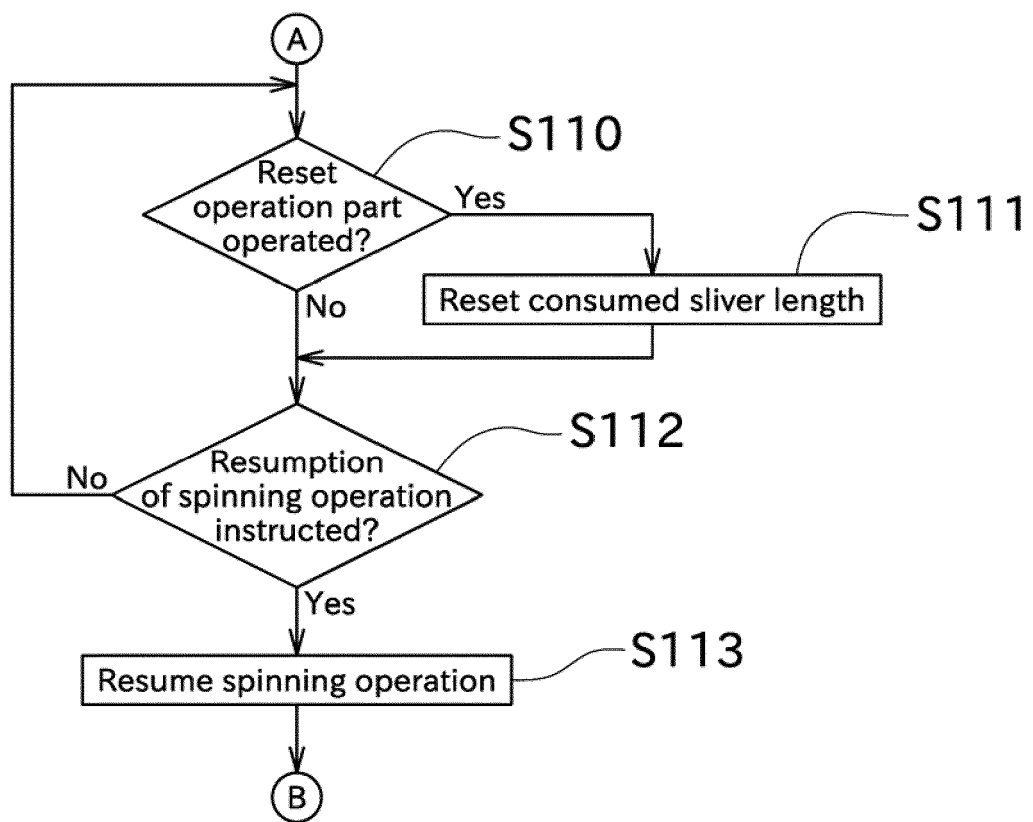


Fig.7

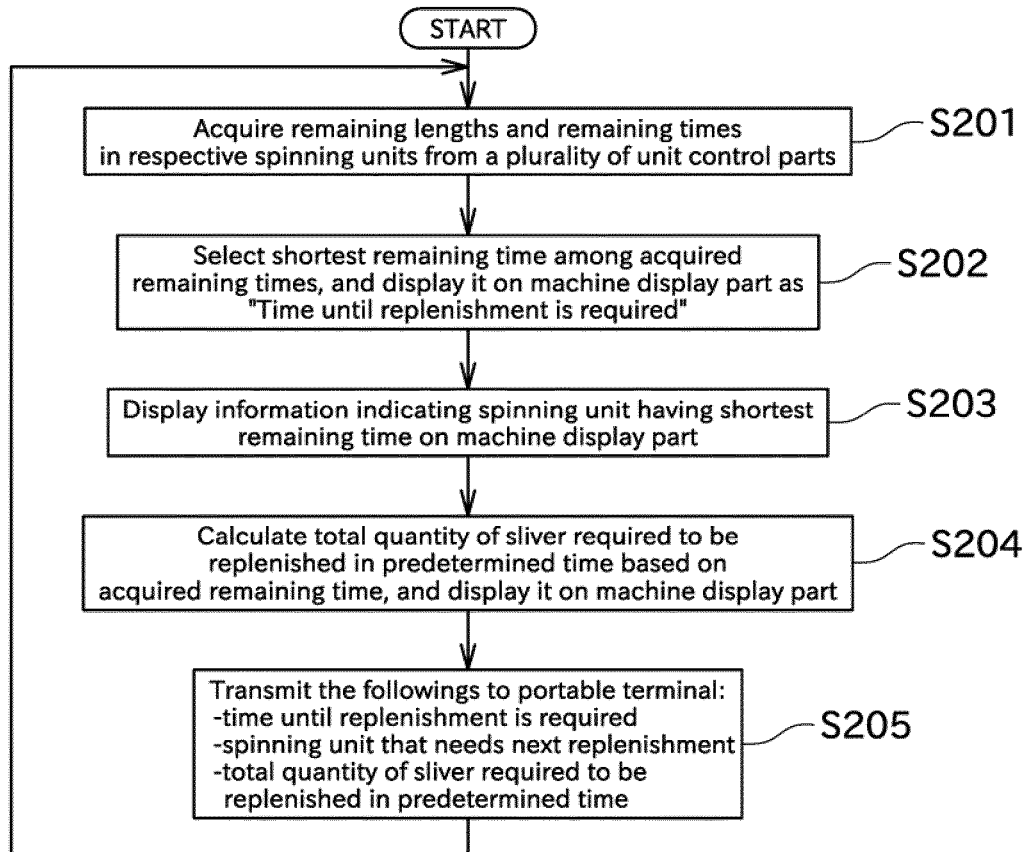


Fig.8

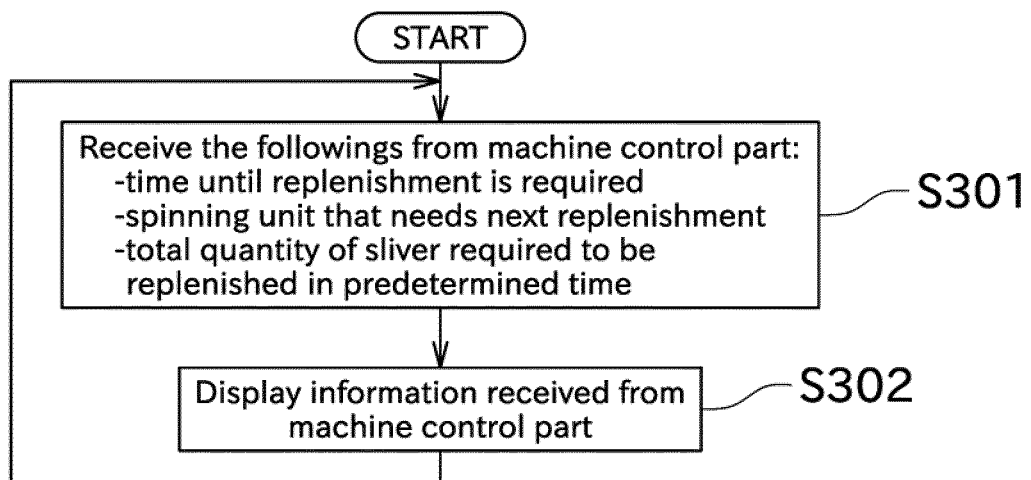


Fig.9

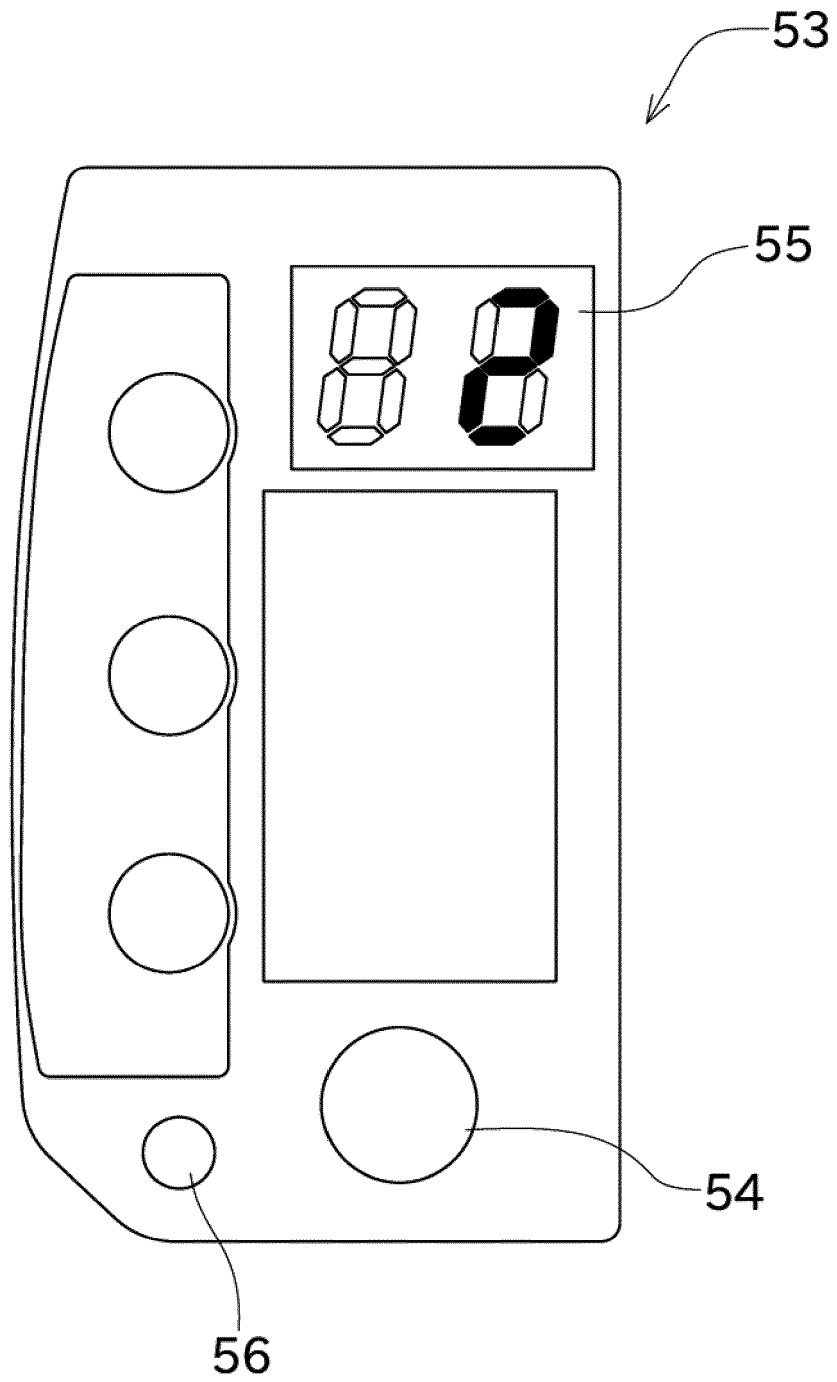


Fig.10

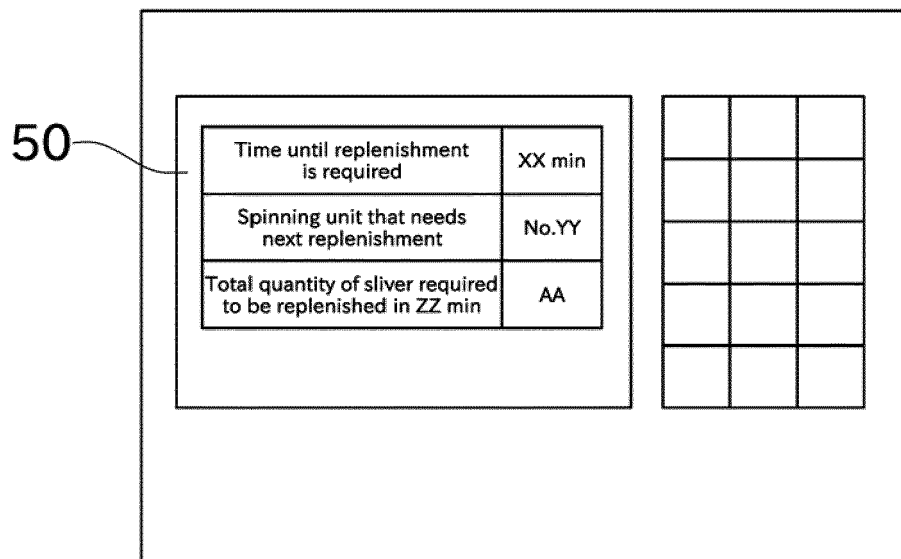
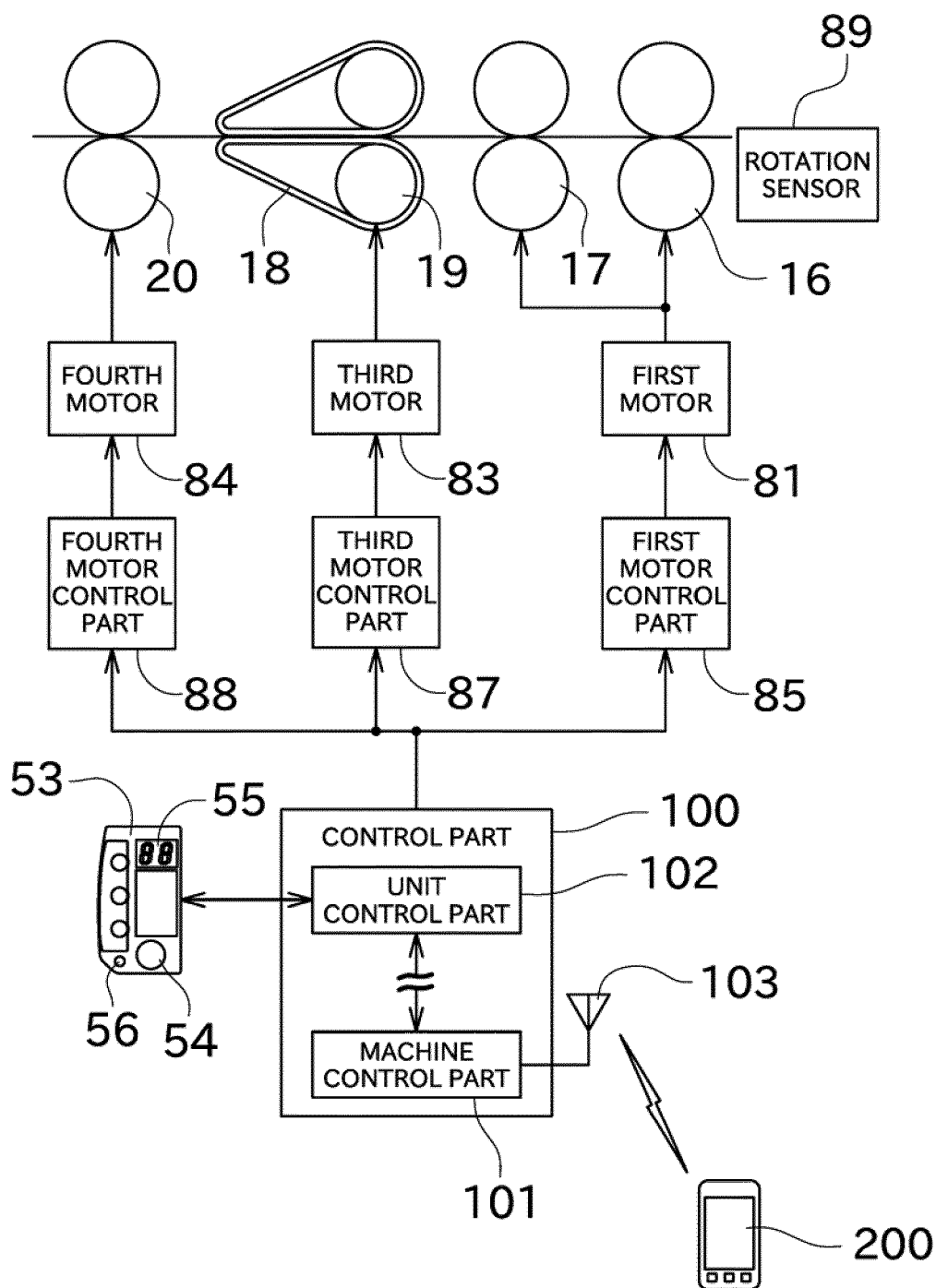


Fig.11





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Application Number  
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| DOCUMENTS CONSIDERED TO BE RELEVANT                                                                                                                                                                                                                    |                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                              |                                                 |
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| Place of search<br><b>Munich</b>                                                                                                                                                                                                                       |                                                                                                                                                                                                                            | Date of completion of the search<br><b>6 December 2018</b>                                                                                                                                                                                                                   | Examiner<br><b>Humbert, Thomas</b>              |
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The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

06-12-2018

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