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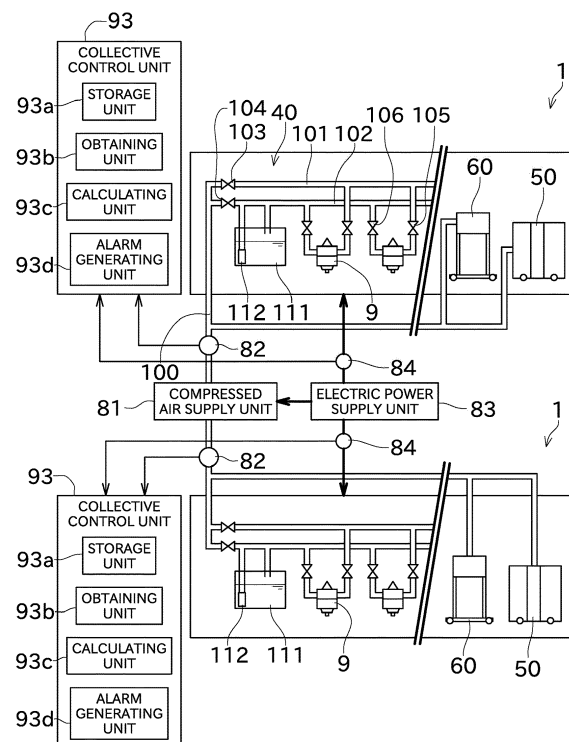
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(54) **AIR CONSUMPTION CALCULATING DEVICE, SPINNING MACHINE, SPINNING SYSTEM, AND METHOD FOR CALCULATING AIR CONSUMPTION**

(57) A collective control unit (air consumption calculating device) 93 includes an obtaining unit 93b and a calculating unit 93c, and executes a method for calculating an air consumption. The obtaining unit 93b obtains operation information of an air spinning device 9 configured to inject air through a spinning nozzle to generate a swirling airflow to produce a spun yarn from a fiber bundle, the operation information including a time period in which the air is injected from the spinning nozzle. The calculating unit 93c calculates an air consumption of a spinning machine 1 that includes the air spinning device 9, based on the operation information of the air spinning device 9 obtained by the obtaining unit 93b.

Fig. 4



Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention primarily relates to an air consumption calculating device for calculating a used air amount, which is an amount of compressed air (air) used by a spinning machine that includes an air spinning device.

2. Description of the Related Art

[0002] Japanese Unexamined Patent Application Publication No. 2002-138346 (hereinafter, referred to as PTL 1) discloses an air jet loom.

[0003] In the air jet loom of PTL 1, a nozzle is disposed on a sley swung in a front-rear direction of the loom. PTL 1 discloses calculating a flow rate of air injected from the nozzle based on information inputted to the air jet loom.

SUMMARY OF THE INVENTION

[0004] The air spinning device consumes a large amount of air, and therefore is required to obtain an accurate air consumption.

[0005] A primary object of the present invention is to provide an air consumption calculating device capable of obtaining, at a low cost, an accurate air consumption (air consumption amount) of a spinning machine that includes an air spinning device.

[0006] In view of a first aspect of the present invention, provided is an air consumption calculating device including the following features. That is, the air consumption calculating device includes an obtaining unit and a calculating unit. The obtaining unit is configured to obtain operation information of an air spinning device, which is configured to inject air through a spinning nozzle to generate a swirling airflow to produce a spun yarn from a fiber bundle, the operation information including a time period in which the air is injected from the spinning nozzle. The calculating unit is configured to calculate an air consumption of a spinning machine that includes the air spinning device, based on the operation information of the air spinning device obtained by the obtaining unit.

[0007] In this manner, the air consumption is calculated. Therefore, this configuration does not essentially need the measurement device. Consequently, it is possible to obtain the air consumption at a low cost. In addition, the air consumption of the air spinning device accounts for most of the air consumption of the spinning machine. Therefore, by calculating at least the air consumption of the air spinning device, it is possible to obtain an accurate air consumption of the spinning machine.

[0008] The above-described air consumption calculating device preferably has the following features. That is, the obtaining unit obtains the number of times of operation or an air using time period of at least one of a doffing unit and a yarn joining unit. The doffing unit is configured to perform, with use of air, a doffing preparation operation of discharging a package formed as a result of winding of the spun yarn and preparing for formation of a new package. The yarn joining unit is configured to perform, with use of air, a catching and joining operation of catching and joining the spun yarn, in a case where disconnection occurs in the spun yarn. The calculating unit calculates an air consumption of the spinning machine further based on the number of times of operation or the air using time period of the at least one of the doffing unit and the yarn joining unit.

[0009] With this configuration, not only the air consumption of the air spinning device but also the air consumption(s) of the doffing unit and/or the yarn joining unit is calculated. Consequently, it is possible to obtain a more accurate air consumption of the spinning machine.

[0010] The above-described air consumption calculating device preferably has the following features. That is, the obtaining unit obtains the number of times of operation or an air using time period of the additive supply device, which is configured to supply an additive with use of air. The calculating unit calculates an air consumption of the spinning machine further based on the number of times of operation or the air using time period of the additive supply device.

[0011] With this configuration, not only the air consumption of the air spinning device but also the air consumption of the additive supply device is calculated. Consequently, it is possible to obtain a more accurate air consumption of the spinning machine.

[0012] In the above-described air consumption calculating device, the calculating unit preferably further calculates an air consumption efficiency, which is an air consumption per mass of the spun yarn having been produced.

[0013] This can show the air consumption corresponding to the amount of air having been consumed to produce (manufacture) the spun yarn in an easier-to-understand format.

[0014] In the above-described air consumption calculating device, the calculating unit calculates a mass of the spun yarn having been produced, based on a yarn count of the spun yarn produced by the spinning machine and a yarn speed, which is a winding speed of the spun yarn wound by the spinning machine, and the calculating unit calculates the air consumption efficiency based on the mass.

[0015] Consequently, it is possible to obtain an air consumption per production quantity of the spun yarn by a simple process.

[0016] In the above-described air consumption calculating device, the calculating unit preferably further calculates a lot air consumption, which is an amount of air consumed to produce one lot of spun yarn.

[0017] The production cost of the spun yarn is often managed per lot. Thus, by calculating an air consumption

per lot, it is possible to obtain a value that is easy for an administrator to use.

[0018] In the above-described air consumption calculating device, the obtaining unit preferably obtains a measurement value of an electric power meter, which is configured to measure an electric power consumption of the spinning machine.

[0019] This configuration can obtain not only the air consumption but also the electric power consumption. Thus, with the air consumption calculating device or an external device, it is possible to generate information enabling more precise management of the production cost of the spun yarn.

[0020] The above-described air consumption calculating device preferably has the following features. That is, the electric power consumption detected by the electric power meter does not include an amount of electric power used to generate compressed air that is to be supplied to the spinning machine. The calculating unit converts the air consumption of the spinning machine into an electric power consumption.

[0021] With this configuration, the air consumption calculated by the calculating unit can be handled in the form of electric power. In addition, this makes it easier to manage the production cost of the spun yarn.

[0022] The above-described air consumption calculating device preferably has the following features. That is, the air consumption calculating device includes a display unit configured to display the air consumption calculated by the calculating unit. The calculating unit calculates air consumptions for each of constituent elements of the spinning machine, the constituent elements including at least the air spinning device. The display unit displays the air consumptions for each of the constituent elements.

[0023] This makes it easier to manage the air consumptions for each of the constituent elements.

[0024] In view of a second aspect of the present invention, provided is a spinning machine including the above-described air consumption calculating device, a draft device, the above-described air spinning device, and a winding device. The draft device is configured to draft a sliver to produce a fiber bundle. The winding device is configured to wind the spun yarn to form a package.

[0025] With this configuration, the spinning machine itself can calculate the air consumption.

[0026] The above-described spinning machine preferably has the following features. That is, the spinning machine includes a flowmeter and an alarm generating unit. The flowmeter is configured to measure an air consumption. The alarm generating unit is configured to generate an alarm, in a case where a difference between an air consumption calculated by the calculating unit and a measurement value of the flowmeter satisfies a determination condition.

[0027] With this configuration, it is possible to generate an alarm based on the result of the calculation of the air consumption, if an abnormality occurs.

[0028] In view of a third aspect of the present invention, provided is a spinning system including: a management device functioning as the above-described air consumption calculating device; and spinning machines. Each of the spinning machines includes a draft device configured to draft a sliver to produce a fiber bundle, the air spinning device, and a winding device configured to wind the spun yarn to form a package. The management device receives, from the spinning machines, operation information of at least the air spinning devices, and calculates air consumptions of the spinning machines based on the operation information.

[0029] Consequently, it is possible to manage the air consumptions of the spinning machines collectively with the management device.

[0030] In view of a fourth aspect of the present invention, provided is a method for calculating an air consumption having the following features. That is, the method for calculating an air consumption includes the steps of obtaining and calculating. The obtaining step obtains operation information of an air spinning device, which is configured to inject air through a spinning nozzle to generate a swirling airflow to produce a spun yarn from a fiber bundle, the operation information including a time period in which the air is injected from the spinning nozzle. The calculating step calculates an air consumption of a spinning machine that includes the air spinning device, based on the operation information of the air spinning device obtained in the obtaining step.

[0031] In this manner, the air consumption is calculated. Therefore, this configuration does not essentially need the measurement device. Consequently, it is possible to obtain the air consumption at a low cost. In addition, the air consumption of the air spinning device accounts for most of the air consumption of the spinning machine. Therefore, by calculating at least the air consumption of the air spinning device, it is possible to obtain an accurate air consumption of the spinning machine.

BRIEF DESCRIPTION OF THE DRAWINGS

[0032]

FIG. 1 is a front view illustrating an overall structure of a spinning machine, whose air consumption is to be calculated, according to one embodiment of the present invention.

FIG. 2 is a side view of a spinning unit.

FIG. 3 is a cross-sectional view illustrating a configuration of an air spinning device.

FIG. 4 is a view illustrating a flow of compressed air.

FIG. 5 is a flowchart showing processes for calculating and displaying an air consumption.

FIG. 6 is a graph being displayed on a display unit and showing air consumptions of constituent elements of the spinning machine.

FIG. 7 is a graph being displayed on the display unit and showing an air consumption efficiency and lot

air consumptions of the spinning machine.

FIG. 8 is a graph being displayed on the display unit and showing an electric power consumption of the spinning machine.

FIG. 9 is a flowchart showing processes for detecting an air leakage based on a calculated air consumption.

FIG. 10 is a view schematically illustrating a spinning system including an air consumption calculating device according to another embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0033] With reference to the drawings, the following will describe a spinning machine 1 including an air spinning device 9 according to one embodiment of the present invention. The spinning machine 1 illustrated in FIG. 1 includes multiple spinning units 2 arranged side by side, a yarn joining cart (yarn joining unit) 50, a doffing cart (doffing unit) 60, and a machine control device 90.

[0034] The machine control device 90 is configured to manage elements in the spinning machine 1 in a centralized manner. The machine control device 90 includes a display unit 91, input keys 92, and a collective control unit (air consumption calculating device) 93. When an operator operates the input keys 92 as appropriate, the collective control unit 93 executes a process in response to the operation. In this manner, it is possible to perform a setting(s) on a certain one of or all of the spinning units 2 and/or to display, on the display unit 91, information such as a setting(s) and a state(s) of a certain one of or all of the spinning units 2.

[0035] As illustrated in FIG. 2, each spinning unit 2 includes a draft device 7, an air spinning device 9, a yarn accumulation device 14, and a winding device 96, which are arranged in this order from upstream to downstream. The terms "upstream" and "downstream" used herein mean upstream and downstream with respect to a traveling direction of a sliver, a fiber bundle 8, and a spun yarn 10 during spinning. Each spinning unit 2 spins, with the air spinning device 9, a fiber bundle 8 fed from the draft device 7 to produce a spun yarn 10, and winds the spun yarn 10 with the winding device 96 to form a package 28.

[0036] The draft device 7 includes four roller pairs, namely, a pair of back rollers 21, a pair of third rollers 22, a pair of middle rollers 24 around which an apron belt 23 is laid, and a pair of front rollers 25, which are arranged in this order from upstream. The draft device 7 drafts a sliver fed from a sliver case (not illustrated) via a sliver guide 20 (stretches a fiber bundle 8) until the sliver attains a predetermined thickness. The fiber bundle 8 drafted by the draft device 7 is fed to the air spinning device 9.

[0037] The air spinning device 9 produces a spun yarn 10 from the fiber bundle 8 fed from the draft device 7. More specifically, as shown in FIG. 3, the air spinning device 9 includes a fiber guide member 31, a needle-

shaped member 32, a nozzle block 33, and a hollow guide shaft member 35.

[0038] The fiber guide member 31 guides the fiber bundle 8 drafted by the draft device 7 toward the inside of the air spinning device 9. The needle-shaped member 32 is attached to the fiber guide member 31. The fiber bundle 8 drafted by the draft device 7 is guided into the fiber guide member 31 and is guided while being guided over the needle-shaped member 32.

[0039] A space between the fiber guide member 31 and the hollow guide shaft member 35 functions as a spinning chamber 34. The nozzle block 33, which surrounds the spinning chamber 34, is disposed downstream of the fiber guiding member 31. The nozzle block 33 has a spinning nozzle 33a. The spinning nozzle 33a is formed such that an air-injecting side faces the spinning chamber 34. The air spinning device 9 is configured to inject air (compressed air) into the spinning chamber 34 through the spinning nozzle 33a such that a swirling airflow is acted on the fiber bundle 8 in the spinning chamber 34. The air to be injected through the spinning nozzle 33a may contain an additive added by an additive supply device 40 (details thereof will be given later).

[0040] The hollow guide shaft member 35 has a second passage 35a formed in its shaft center. When being subjected to the air injected from the spinning chamber 34, trailing ends of fibers of the fiber bundle 8 swing around the distal end of the hollow guide shaft member 35. The fiber bundle 8 twisted in this manner passes through the second passage 35a, and is outputted outside the air spinning device 9 through a downstream yarn outlet (not illustrated).

[0041] A yarn quality measuring device 12 and a spinning sensor 13 are provided downstream of the air spinning device 9. The spun yarn 10 spun by the air spinning device 9 passes through the yarn quality measuring device 12 and the spinning sensor 13.

[0042] The yarn quality measuring device 12 monitors a thickness of the traveling spun yarn 10 with an optical sensor (not illustrated). If the yarn quality measuring device 12 detects a yarn defect in the spun yarn 10 (a portion of the spun yarn 10 having an abnormality in thickness or the like), the yarn quality measuring device 12 transmits a yarn defect detection signal to a unit controller (not illustrated). The yarn quality measuring device 12 is not limited to the optical sensor. Alternatively, for example, an electrostatic capacitance type sensor may be adopted to monitor the thickness (fiber amount) of the spun yarn 10. The yarn quality measuring device 12 may detect, as a yarn defect, a foreign object included in the spun yarn 10.

[0043] The spinning sensor 13 is disposed downstream of and close to the yarn quality measuring device 12. The spinning sensor 13 can detect a tension of a portion of the spun yarn 10 between the air spinning device 9 and the yarn accumulation device 14. The spinning sensor 13 transmits, to the unit controller, a detection signal indicating the detected tension. The unit controller

monitors the tension detected by the spinning sensor 13 to detect an abnormal portion, such as a weak yarn. Alternatively, the spinning unit 2 may not include the spinning sensor 13.

[0044] The yarn accumulation device 14 is disposed downstream of the yarn quality measuring device 12 and the spinning sensor 13. As illustrated in FIG. 2, the yarn accumulation device 14 includes a yarn accumulation roller 15 and a motor 16 for rotationally driving the yarn accumulation roller 15.

[0045] The yarn accumulation roller 15 is configured to have a certain amount of spun yarn 10 wound on its outer peripheral surface for temporary accumulation. Rotating the yarn accumulation roller 15 at a predetermined rotation speed with the spun yarn 10 wound on its outer peripheral surface enables the spun yarn 10 to be drawn out from the air spinning device 9 and conveyed downstream at a predetermined speed. Since the yarn accumulation device 14 is configured to allow the spun yarn 10 to be temporarily stored on the outer peripheral surface of the yarn accumulation roller 15, the yarn accumulation device 14 can function as a kind of buffer. Accordingly, the yarn accumulation device 14 can resolve a trouble (for example, a slackening 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 speed of the spun yarn 10 wound around the package 28) do not match for some reason.

[0046] The winding device 96 includes a cradle arm 97, a winding drum 98, a traverse guide 99, and a winding drum drive motor (not illustrated). The cradle arm 97 can rotatably support a bobbin 29 around which the spun yarn 10 is to be wound. The winding drum 98 receives a drive force transmitted from the winding drum drive motor to be rotated while being in contact with an outer peripheral surface of the package 28 or the bobbin 29. The traverse guide 99 is capable of guiding the spun yarn 10. The winding device 96 drives the winding drum 98 by the winding drum drive motor while reciprocating the traverse guide 99 by drive means (not illustrated). Thereby, the winding device 96 rotates the package 28 which is in contact with the winding drum 98. The winding device 96 winds the spun yarn 10 around the package 28 while traversing the spun yarn 10.

[0047] In a case where disconnection occurs in the spun yarn 10, the yarn joining cart 50 performs a catching and joining operation of catching and joining the spun yarn 10. Specific examples of the case where the disconnection occurs in the spun yarn 10 are: a case where the spun yarn 10 is broken due to a load applied to the spun yarn 10; and a case where the spun yarn 10 is cut due to, e.g., stop of the air spinning device 9 for eliminating a yarn defect detected by the yarn quality measuring device 12 and/or the spinning sensor 13. The catching and joining operation includes a catching operation of catching the spun yarn 10 and a joining operation of joining the spun yarn 10.

[0048] The yarn joining cart 50 is controlled by the col-

lective control unit 93. As illustrated in FIGs. 1 and 2, the yarn joining cart 50 includes a suction pipe 51, a suction mouth 52, and a yarn joining device 53. If disconnection occurs in a spun yarn 10 in one of the spinning units 2, the yarn joining cart 50 travels to and stops at the one of the spinning units 2. The suction pipe 51 swings upward about an axis to catch the spun yarn 10 outputted from the air spinning device 9 (catching operation). The suction pipe 51 swings downward about an axis, thus guiding the spun yarn 10 to the yarn joining device 53. The suction mouth 52 swings downward about the axis to catch the spun yarn 10 from the package 28 (catching operation). The suction mouth 52 swings upward about the axis, thus guiding the spun yarn 10 to the yarn joining device 53. The yarn joining device 53 joins the guided spun yarns 10 together (joining operation).

[0049] In the present embodiment, the catching and joining operation is performed with use of air. More specifically, the yarn joining device 53 includes two untwisting pipes. The yarn joining device 53 injects compressed air to the untwisting pipes to generate a swirling airflow. When being subjected to the swirling airflow, yarn ends of the spun yarns 10 are untwisted. The yarn joining device 53 further includes a twisting nozzle for connecting the untwisted yarn ends together. Compressed air is injected also to the twisting nozzle to generate a swirling airflow.

[0050] The suction pipe 51 and the suction mouth 52 are connectable to a suction airflow generation source (not illustrated) to catch a spun yarn 10 by a suction airflow. The suction pipe 51 may be provided with a twisting nozzle for twisting the caught spun yarn 10.

[0051] The yarn joining device 53 may be configured to be movable between a standby position and a joining position with a pneumatic actuator, such as an air cylinder. In such a configuration, compressed air is further used to move the yarn joining device 53.

[0052] The foregoing usages of air have been described merely by way of examples. Air may be used for another process (e.g., cleaning). In a case where air is used for the catching and joining operation, part of the above-described usages of air may be omitted. For example, the suction pipe 51 may not include the twisting nozzle.

[0053] The doffing cart 60 is controlled by the collective control unit 93. The doffing cart 60 performs a doffing preparation operation of discharging the package 28 and preparing for formation of a new package 28. The doffing preparation operation includes a doffing operation of detaching a package 28 having completed winding of the spun yarn 10 (a package 28 having achieved a predetermined diameter) from the cradle arm 97 and discharging the package 28 and a winding preparation operation of preparing for winding of the spun yarn 10 by feeding a bobbin 29 to the cradle arm 97.

[0054] As illustrated in FIGs. 1 and 2, the doffing cart 60 includes a cradle operation arm 61, a yarn sucking unit 62, and a bobbin supply unit 63. When winding of

the spun yarn 10 in a certain one of the spinning units 2 is ended, the doffing cart 60 travels to and stops at the certain one of the spinning units 2. The cradle operation arm 61 can operate the cradle arm 97 of the corresponding one of the spinning units 2 to release the state where the bobbin 29 is sandwiched and held by the cradle arm 97. This allows detachment of the package 28 held by the cradle arm 97. The package 28 thus detached is guided to a placement part 72 along an inclined surface 71.

[0055] The yarn sucking unit 62 stretches toward the air spinning device 9, generates a suction airflow to catch the spun yarn 10 fed from the air spinning device 9, and then moves downward. Before, after, or during this operation, the bobbin supply unit 63 holds a bobbin 29 stocked in the doffing cart 60, and then turns toward the winding device 96 to supply the bobbin 29 to the cradle arm 97. Thereafter, the spun yarn 10 caught by the yarn sucking unit 62 is wound around the new bobbin 29 by a yarn guide mechanism and a bunch winding mechanism (each not illustrated), and then the winding device 96 starts winding.

[0056] In the present embodiment, the doffing preparation operation is performed with use of air. More specifically, the yarn sucking unit 62 may include a twisting nozzle to twist the caught spun yarn 10. In a configuration in which the cradle operation arm 61, the yarn sucking unit 62, and the bobbin supply unit 63 are driven by a pneumatic actuator such as an air cylinder, compressed air is also used. The foregoing usages of air have been described merely by way of examples. Air may be used for another process (e.g., cleaning). In a case where air is used for the doffing preparation operation, part of the above-described usage of air may be omitted. For example, the twisting nozzle may be omitted.

[0057] Next, with reference to FIG. 4, the following will describe a flow of compressed air, a configuration of the additive supply device 40, and the like. In a factory including spinning machines 1, a compressed air supply unit 81 is installed. The compressed air supply unit 81 is a compressor, for example. The compressed air supply unit 81 is configured to generate compressed air and supply the compressed air to the plurality of spinning machines 1. Instead of this configuration, compressed air supply units 81 may be respectively provided to the spinning machines 1.

[0058] Flowmeters 82 are respectively disposed in passages through which compressed air is supplied from the compressed air supply unit 81 to the spinning machines 1. The detection values from the flowmeters 82 are outputted to the collective control units 93 of the machine control devices 90. As will be described later, in the present embodiment, an air consumption is calculated without use of the flowmeters 82, and therefore the flowmeters 82 may be omitted.

[0059] The compressed air supplied from the compressed air supply unit 81 is supplied to the air spinning devices 9, the additive supply devices 40, the yarn joining carts 50, the doffing carts 60, and/or the like. A main air

tube (pipe) 100 toward each of the air spinning devices 9 is branched to a first air tube (pipe) 101 and a second air tube (pipe) 102.

[0060] Each first air tube 101 is a passage through which air containing no additive (hereinafter, referred to as dry air) is supplied to a corresponding one of the air spinning devices 9. Between the main air tube 100 and the first air tubes 101, first valves 103 are disposed. Each first air tube 101 is further branched before reaching the air spinning device 9 of a corresponding one of the spinning units 2. Between the first air tubes 101 and the air spinning devices 9, first spinning valves 105 are disposed. In a configuration in which dry air is supplied to the air spinning devices 9 through the second air tubes 102, the first air tubes 101 and/or the like may be omitted.

[0061] Each second air tube 102 is a passage through which air containing an additive (hereinafter, referred to as wet air) is supplied to a corresponding one of the air spinning devices 9. Between the main air tube 100 and the second air tubes 102, second valves 104 are disposed. Each second air tube 102 is further branched before reaching the air spinning device 9 of a corresponding one of the spinning units 2. Between the second air tubes 102 and the air spinning devices 9, second spinning valves 106 are disposed.

[0062] By selectively opening either of the first valves 103 and the second valves 104, it is possible to select which of dry air and wet air is to be supplied to the air spinning devices 9. By selectively opening or closing the first spinning valves 105, it is possible to permit or inhibit supply of dry air to the air spinning devices 9. By selectively opening or closing the second spinning valves 106, it is possible to permit or inhibit supply of wet air to the air spinning devices 9. The opening/closing operations of these valves are controlled by the collective control unit 93. Alternatively, the opening/closing operations of these valves may be performed by an operator.

[0063] Each additive supply device 40 is configured to supply an additive to a corresponding one of the second air tubes 102. The additive supply device 40 includes an additive storage tank 111 and a mist generating nozzle 112.

[0064] In the additive storage tank 111, a liquid additive is stored. For example, the additive may be an agent, water, or the like for preventing deposition of an oil agent in the air spinning devices 9. Specific examples of the additive are an agent capable of giving the spun yarn 10 at least one of effects such as an antibacterial effect, a deodorant effect, an anti-odor effect, and a waxing effect.

[0065] To the mist generating nozzle 112, compressed air whose pressure is regulated by a non-illustrated pressure regulating device (e.g., a booster valve or an electric compressor) is supplied. The mist generating nozzle 112 generates mists of the additive by bubbling the additive with the compressed air. The additive storage tank 111 has an upper portion connected to the second air tube 102, and the mists of the additive are supplied to the second air tube 102. As described above, the additive

supply device 40 uses compressed air to generate the mists of the additive. The above-described operation of the pressure regulating device is controlled by the collective control unit 93.

[0066] An electric power supply unit 83 is configured to supply electric power to the plurality of spinning machines 1 and the compressed air supply unit 81, for example. The electric power supply unit 83 is connectable to plugs of power cables of the spinning machines 1 and/or the like. For example, the electric power supply unit 83 supplies, to the spinning machines 1 and/or the like, electric power from the outside of the factory.

[0067] Electric power meters 84 are respectively disposed in passages through which the electric power supply unit 83 supplies electric power to the plurality of spinning machines 1. The electric power meters 84 output detection values to the collective control units 93 of the machine control devices 90. Each electric power meter 84 is configured to detect an electric power consumption of a corresponding one of the spinning machines 1. However, since the compressed air supply unit 81 is disposed outside the spinning machines 1, the amount of electric power used to generate compressed air is not included in each of the detection values of the electric power meters 84.

[0068] Next, mainly with reference to FIG. 5, the following will describe processes for calculating and displaying an air consumption. The flowchart shown in FIG. 5 will be described merely by way of an example. Some of the processes may be performed simultaneously, a part of the processes may be omitted, a content of a part of the processes may be changed, and/or a new process may be added.

[0069] The processes shown in FIG. 5 are processes for calculating an air consumption during a predetermined measurement time period based on, e.g., operation of the spinning machine 1 during the measurement time period and for displaying the result on the display unit 91. These processes are performed every time when the measurement time period elapses, for example. With this configuration, it is possible to display the air consumption of the spinning machine 1 in real time. An alternative configuration may accumulate data on operation of the spinning machine 1 (e.g., data on operation of the spinning machine 1 for one day or data on operation of the spinning machine 1 during a time period corresponding to one working shift of an operator) and then collectively calculate an air consumption per measurement time period, while considering the measurement time period as a single unit.

[0070] The processes shown in FIG. 5 are executed mainly by the collective control unit 93. The collective control unit 93 includes a storage unit 93a. The storage unit 93a is a storage device, such as a flash memory or a hard disk, and stores various programs, control data, and/or setting values. The collective control unit 93 includes a non-illustrated processing device (e.g., CPU). The processing device can read out various programs

and/or the like from the storage unit 93a and execute them to control various parts/elements of the spinning machine 1. In this manner, the collective control unit 93 can function as an obtaining unit 93b, a calculating unit 93c, and an alarm generating unit 93d.

[0071] The obtaining unit 93b obtains, from the storage unit 93a, setting values of the type of the spinning nozzle 33a, the yarn count, and the yarn speed (S101). These pieces of information are preliminarily inputted, e.g., by the operator's operation on the input keys 92, and are stored in the storage unit 93a. Different types of the spinning nozzles 33a have different nozzle shapes (passages through which compressed air passes) or different numbers of nozzles, for example. Thus, depending on the type of the spinning nozzle 33a, the amount of compressed air to be used varies. Instead of the configuration in which the type of the spinning nozzle 33a is manually inputted, the setting on the type of the spinning nozzle 33a may be performed automatically according to the raw material of the fiber bundle having been inputted by the operator. Instead of the configuration in which the setting value of the yarn count is read out, the information on the yarn count may be detected by a sensor (e.g., the yarn quality measuring device 12) for detecting the thickness of the yarn, for example. Instead of the configuration in which the setting value of the yarn speed is read out, the information on the yarn speed may be detected by a yarn speed sensor, the yarn quality measuring device 12, or a rotation speed sensor of the winding drum 98, for example.

[0072] Next, the obtaining unit 93b obtains an injecting time period, which is a time period in which air has been injected from the spinning nozzle 33a, out of the measurement time period, based on control executed on the air spinning device 9 by the collective control unit 93 (S102). The injecting time period can be obtained based on control on the first spinning valve 105 and/or the second spinning valves 106, for example. The spinning machine 1 includes the plurality of air spinning devices 9. The present embodiment aims to calculate an air consumption of the entire spinning machine 1. Thus, the present embodiment obtains a value obtained by adding up injecting time periods of the plurality of air spinning devices 9. Hereinafter, the term "operation information" refers to information on operation of the air spinning devices 9, such as the types and the injecting time periods of the spinning nozzles 33a of the air spinning devices 9.

[0073] The calculating unit 93c calculates air consumptions of the air spinning devices 9 based on the operation information (the types and the injecting time periods of the spinning nozzles 33a) (S103). Depending on the type of the spinning nozzle 33a, an air injecting amount per injecting time period varies, naturally. The storage unit 93a stores estimation values of injecting amounts per injecting time period in association with the respective types of the spinning nozzles 33a. The estimation values can be obtained based on experiments or simulations performed in advance, for example. Thus,

the calculating unit 93c can calculate an air consumption of each air spinning device 9 by multiplying, by an injecting time period, the estimation value associated with the type of the spinning nozzle 33a. The air consumption calculated in this process corresponds to the sum of air consumptions of the plurality of air spinning devices 9 included in a single spinning machine 1.

[0074] Next, the obtaining unit 93b obtains the number of times of joining performed during the measurement time period based on control on the yarn joining cart 50 (S104). The calculating unit 93c calculates an air consumption of the yarn joining cart 50 based on the number of times of joining (S105). More specifically, an estimation value of an air consumption per catching and joining operation is obtained based on an experiment or a simulation performed in advance, and is stored in the storage unit 93a. The calculating unit 93c calculates an air consumption of the yarn joining cart 50 by multiplying the estimation value by the number of times of joining.

[0075] Next, the obtaining unit 93b obtains the number of times of doffing performed during the measurement time period, based on control on the doffing cart 60 (S106). The calculating unit 93c calculates an air consumption of the doffing cart 60 based on the number of times of doffing (S107). More specifically, an estimation value of an air consumption per doffing preparation operation is obtained based on an experiment or a simulation performed in advance, and is stored in the storage unit 93a. The calculating unit 93c calculates an air consumption of the doffing cart 60 by multiplying the estimation value by the number of times of doffing.

[0076] Next, the obtaining unit 93b obtains the number of times of adding performed during the measurement time period, based on control on the additive supply device 40 (S108). The calculating unit 93c calculates an air consumption of the additive supply device 40 based on the number of times of adding (S109). More specifically, an estimation value of an air consumption per adding operation (bubbling performed by the mist generating nozzle 112) is obtained based on an experiment or a simulation performed in advance, and is stored in the storage unit 93a. The calculating unit 93c calculates an air consumption of the additive supply device 40 by multiplying the estimation value by the number of times of adding.

[0077] Alternatively, each of the air consumptions of the yarn joining cart 50, the doffing cart 60, and the additive supply device 40 can be calculated based on an air using time period (i.e., a period of time during which compressed air is injected), rather than the number of times of operation. That is, the estimation value of the air consumption per unit time may be stored in the storage unit 93a in advance. By multiplying the estimation value by the air using time period, it is possible to calculate an air consumption.

[0078] In the above-described manner, it is possible to calculate air consumptions of each of the air spinning devices 9, the yarn joining cart 50, the doffing cart 60,

and the additive supply device 40. By adding up these air consumptions, it is possible to calculate an air consumption of the spinning machine 1 in the measurement time period.

[0079] Next, the calculating unit 93c calculates a mass of the spun yarn 10 produced in the measurement time period, based on the working states of the spinning units 2, the yarn count, and the yarn speed (S110). More specifically, the calculating unit 93a first calculates a total working time period by adding up the working time periods of the plurality of spinning units 2 (i.e., the time periods during which the spinning units 2 are performing winding). Next, the calculating unit 93c calculates a yarn length of the produced spun yarn 10 by multiplying the total working time period by the yarn speed (winding speed). Lastly, the calculating unit 93c multiplies the yarn length of the produced spun yarn 10 by the yarn count to calculate a mass of the spun yarn 10 produced in the measurement time period.

[0080] The calculating unit 93c calculates an air consumption per mass of the produced spun yarn 10 (hereinafter, referred to as an air consumption efficiency) (S111). More specifically, the calculating unit 93c can calculate the air consumption efficiency by dividing the air consumption of the spinning machine 1 by the mass of the produced spun yarn 10. For example, in a case of a long measurement time period, the mass of the produced spun yarn 10 may be calculated based on, e.g., the number of formed packages 28.

[0081] Next, the collective control unit 93 displays information about the air consumption of the spinning machine 1 on the display unit 91 in response to an instruction given by the operator (S112). Alternatively, the collective control unit 93 may display the information about the air consumption of the spinning machine 1 on the display unit 91 at a predetermined timing (e.g., at a timing when the work on the lot is ended), rather than in response to the instruction given by the operator. The usage of the information about the air consumption of the spinning machine 1 is not limited to display. Alternatively, this information can be used as source data for calculating another information. Further alternatively, the collective control unit 93 may transmit the information about the air consumption of the spinning machine 1 so that this information is displayed on an external display device. Still further alternatively, the information about the air consumption of the spinning machine 1 may be displayed by being outputted on paper.

[0082] Next, with reference to FIGs. 6 to 8, the following will describe the process in step S112, i.e., the process for displaying the information about the air consumption of the spinning machine 1.

[0083] FIG. 6 is a graph showing air consumptions of the constituent elements of the spinning machine 1. In this graph, the horizontal axis represents time (for example, one scale represents the above-described measurement time period), whereas the vertical axis represents an air consumption. This graph also shows details of the

air consumption. By referring to the graph, it is possible to see not only the air consumption of the entire spinning machine 1 but also the air consumptions of the constituent elements. Thus, for example, in a case where only a certain one of the constituent elements exhibits an extremely high air consumption, this can be easily seen from the graph. The graph may show information of a period ranging from one to several months.

[0084] FIG. 7 is a graph showing an air consumption efficiency of the spinning machine 1. In this graph, the horizontal axis represents time, whereas the vertical axis indicates an air consumption efficiency. The graph may show information of a period ranging from one to several months. Since the production cost of the spun yarn 10 is often managed on the basis of a cost taken per mass (per production quantity), the air consumption efficiency can be effective data. For example, although the air consumption per unit time (FIG. 6) is reduced when the spun yarn 10 is efficiently produced, the air consumption per unit time is reduced also when some of the spinning units 2 are stopped. Therefore, when the air consumption per unit time is low, it is impossible to see whether this has been caused by efficient production of the spun yarn 10 or a reduction in the number of working spinning units 2. On the other hand, use of the air consumption efficiency enables to manage the production cost of the spun yarn 10 without been affected by stopping of the spinning unit(s) 2 and/or the like.

[0085] The spinning machine 1 may produce a predetermined number of (e.g., one lot of) packages 28 (spun yarn 10) under a certain winding condition, and thereafter may further produce a predetermined number of (e.g., one lot of) packages 28 (spun yarn 10) under another winding condition changed from the certain one. Changing the winding condition may lead to an increase or a decrease in an air consumption required to produce a spun yarn 10 of the same mass and/or an increase or a decrease in the likelihood of disconnection of the spun yarn 10 (a frequency of occurrence of joining). Therefore, it is preferable to check an air consumption efficiency by lots. In order to meet this, the spinning machine 1 of the present embodiment can indicate an identification number of a lot on the graph. Consequently, if the air consumption efficiency is reduced as a result of changing of the lot, this can be easily confirmed from the graph shown in FIG. 7, for example. Based on the control performed by the collective control unit 93, it is possible to identify in which time period which lot was in production.

[0086] In addition, upon completion of production of one lot of packages, the spinning machine 1 of the present embodiment displays, on the graph, a lot air consumption, which is an amount of air consumed to produce the one lot of packages 28 (spun yarn 10). A time period from the start of production of a certain lot to the end of the production can be determined based on the control performed by the collective control unit 93. The calculating unit 93c can calculate a lot air consumption by adding up air consumptions during the time period.

[0087] FIG. 8 is a graph showing an electric power consumption of the spinning machine 1. In this graph, the horizontal axis represents time, whereas the vertical axis represents an electric power consumption. The graph may show information of a period ranging from one to several months. In the present embodiment, the compressed air is generated by the compressed air supply unit 81 that is electrically driven. Thus, the calculating unit 93c can convert a flow rate of compressed air into electric power according to a specification (e.g., electric power per flow rate) of the compressed air supply unit 81. As described above, electric power used to produce the spun yarn 10 is detected by the electric power meter 84, whereas electric power used to generate compressed air is not detected by the electric power meter 84. The electric power thus detected is outputted to the collective control unit 93. Thus, as illustrated in FIG. 8, the graph can show both of the electric power consumption related to the supply of the compressed air and the electric power consumption not related to the supply of the compressed air.

[0088] By referring to such a graph, it is possible to easily confirm not only the air consumption but also the magnitude of another energy (electric power) used by the spinning machine 1. In addition, it is possible to confirm further details of the cost required to produce the spun yarn 10.

[0089] The above-described graphs of FIGs. 6 to 8 are shown merely by way of examples, and can be modified as below. For example, the information may be displayed in a table format, rather than in a graph format. Instead of or in addition to the format in which the values of the constituent elements are shown with different patterns, the values of the constituent elements may be indicated with different colors. Alternatively, the values on the vertical axes in the graphs in FIGs. 6 to 8 may be moving averages of the values. Consequently, the changes in the air consumption, the air consumption efficiency, and the electric power consumption can be smoothed. Further alternatively, the values on the vertical axes in the graphs in FIGs. 6 to 8 may be averages of values obtained in time periods corresponding to working shifts, which have been described above. The graphs in FIGs. 7 and 8 may also show the details of the constituent elements. The graph in FIG. 8 may show an electric power consumption per mass of the spun yarn 10 having been calculated. The graph in FIG. 8 may be separate graphs respectively showing an electric power consumption related to supply of compressed air and an electric power consumption not related to the supply of the compressed air.

[0090] Next, mainly with reference to FIG. 9, the following will describe processes for detecting an air leakage using the calculated air consumption.

[0091] The obtaining unit 93b obtains a measurement value of the flowmeter 82 (S201). Next, the calculating unit 93c calculates a difference between the calculated air consumption and the measurement value of the flow-

meter 82 (S202). Needless to say, the measurement value of the flowmeter 82 used herein is the sum of flow rates obtained in the measurement time period having been used to calculate the air consumption.

[0092] Next, the collective control unit 93 determines whether or not the difference satisfies a determination condition (S203). The determination condition is a condition used to determine whether or not a great difference exists between the measurement value of the flowmeter and the calculated value due to an air leakage. One example of the determination condition may be a condition that the difference is equal to or higher than a threshold. Considering the possibility that the great difference may occur temporarily due to disturbance of some sort, the determination condition may alternatively be a condition that the difference stays equal to higher than the threshold for a predetermined time period.

[0093] If the difference satisfies the determination condition, the alarm generating unit 93d generates an alarm (S204). More specifically, the alarm generating unit 93d turns on a warning lamp, generates a warning sound, and/or causes the display unit 91 to display a warning. The alarm generating unit 93d may perform one or two of these actions.

[0094] The determination on an air leakage may be performed even while the spinning machine 1 is stopped. While the spinning machine 1 is not working, the air consumption is zero even without performing a calculation. Thus, in a case where the measurement value of the flowmeter 82 exceeds the threshold (for a predetermined time period), it can be determined that an air leakage has occurred.

[0095] In the present embodiment, the air consumption calculating device including the obtaining unit 93b and the calculating unit 93c is configured as a part of the spinning machine 1 (a part of the machine control device 90). Instead of this, the air consumption calculating device may be a small terminal provided separately from the spinning machine 1, for example. The air consumption calculating devices of this type may be provided to the spinning machines 1, respectively. Further alternatively, a single air consumption calculating device may be provided to the plurality of spinning machines 1. This will be specifically described hereinbelow with reference to FIG. 10.

[0096] FIG. 10 illustrates a spinning system 200. The spinning system 200 includes a plurality of spinning machines 1, a management device (air consumption calculating device) 201, and a processing terminal 202. The spinning machines 1 output pieces of data to be used to calculate air consumptions to the management device 201. For example, the spinning machines 1 output the pieces of data to the management device 201 through wireless communication or wired communication, for example. The management device 201 is configured to manage working states, production efficiencies, and the like of the spinning machines 1. The obtaining unit 93b of the management device 201 obtains these pieces of

data from the spinning machines 1. The calculating unit 93c of the management device 201 performs processes similar to those in the above-described embodiment to calculate air consumptions for each of the spinning machines 1. Information based on the air consumptions calculated by the calculating unit 93c can be displayed on a display unit of the processing terminal 202, which is used by an administrator, for example. The display unit of the processing terminal 202 is a display of a personal computer, a tablet computer, a smartphone, or the like or a display connected to any of these devices, for example. The management device 201 may be included in the processing terminal 202.

[0097] As described above, the collective control unit 93 that functions as the air consumption calculating device of the present embodiment includes the obtaining unit 93b and the calculating unit 93c, and is configured to execute the method for calculating an air consumption. The obtaining unit 93b obtains operation information of the air spinning device 9, which is configured to inject air through the spinning nozzle 33a to generate a swirling airflow to produce a spun yarn 10 from a fiber bundle 8, the operation information including a time period in which the air is injected from the spinning nozzle 33a (obtaining step). The calculating unit 93c calculates an air consumption of each spinning machine 1 that includes the air spinning device 9, based on the operation information of the air spinning device 9 obtained by the obtaining unit 93b (calculating step).

[0098] In this manner, the air consumption is calculated. Therefore, this configuration does not essentially need a measurement device (e.g., a flowmeter 82). Consequently, it is possible to obtain the air consumption at a low cost. In addition, the air consumption of the air spinning device 9 accounts for most of the air consumption of the spinning machine 1. Therefore, by calculating at least the air consumption of the air spinning device 9, it is possible to obtain an accurate air consumption of the spinning machine 1.

[0099] In the collective control unit 93 of the present embodiment, the obtaining unit 93b obtains the number of times of operation or an air using time period of at least one of the doffing cart 60 and the yarn joining cart 50. The doffing cart 60 performs, with use of air, the doffing preparation operation of discharging a package 28 formed as a result of winding of the spun yarn 10 and preparing for formation of a new package 28. In a case where disconnection occurs in the spun yarn 10, the yarn joining cart 50 performs, with use of air, the catching and joining operation of catching and joining the spun yarn 10. The calculating unit 93c calculates an air consumption of the spinning machine 1 further based on the number of times of operation or the air using time period of at least one of the doffing cart 60 and the yarn joining cart 50.

[0100] With this configuration, not only the air consumption of the air spinning device 9 but also the air consumption(s) of the doffing cart 60 and/or the yarn join-

ing cart 50 is calculated. Consequently, it is possible to obtain a more accurate air consumption of the spinning machine 1.

[0101] In the collective control unit 93 of the present embodiment, the obtaining unit 93b obtains the number of times of operation or an air using time period of the additive supply device 40 configured to supply an additive with use of air. The calculating unit 93c calculates an air consumption of the spinning machine 1 further based on the number of times of operation or the air using time period of the additive supply device 40.

[0102] With this configuration, not only the air consumption of the air spinning device 9 but also the air consumption of the additive supply device 40 is calculated. Consequently, it is possible to obtain a more accurate air consumption of the spinning machine 1.

[0103] In the collective control unit 93 of the present embodiment, the calculating unit 93c further calculates an air consumption efficiency, which is an air consumption per mass of the produced spun yarn 10.

[0104] This makes it possible to show the air consumption corresponding to the amount of air having been consumed to produce (manufacture) the spun yarn 10 in an easier-to-understand format.

[0105] In the collective control unit 93 of the present embodiment, the calculating unit 93c calculates a mass of the produced spun yarn 10 based on a yarn count of the spun yarn 10 produced by the spinning machine 1 and a yarn speed, which is a speed of the spun yarn 10 wound by the spinning machine 1, and calculates an air consumption efficiency based on the mass.

[0106] Consequently, it is possible to obtain an air consumption per production quantity of the spun yarn 10 by a simple process.

[0107] In the collective control unit 93 of the present embodiment, the calculating unit 93c further calculates a lot air consumption, which is an amount of air consumed to produce one lot of spun yarn 10.

[0108] The production cost of the spun yarn 10 is often managed per lot. Thus, by calculating an air consumption per lot, it is possible to obtain a value that is easy for an administrator to use.

[0109] In the collective control unit 93 of the present embodiment, the obtaining unit 93c obtains a measurement value of the electric power meter 84, which is configured to measure an electric power consumption of the spinning machine 1.

[0110] This configuration can obtain not only the air consumption but also the electric power consumption. Thus, with the collective control unit 93 or an external device, it is possible to generate information enabling more precise management of the production cost of the spun yarn 10.

[0111] In the collective control unit 93 of the present embodiment, the electric power consumption detected by the electric power meter 84 does not include an amount of electric power used to generate air that is to be supplied to the spinning machine 1. The calculating

unit 93c converts the air consumption of the spinning machine 1 into an electric power consumption.

[0112] With this configuration, the air consumption calculated by the calculating unit 93c can be handled in the form of electric power. In addition, it is possible to easily manage the production cost of the spun yarn 10.

[0113] The collective control unit 93 of the present embodiment includes the display unit 91 for displaying an air consumption calculated by the calculating unit 93c. The calculating unit 93c calculates air consumptions for each of the constituent elements of the spinning machine 1, the constituent elements including at least the air spinning device 9. The display unit 91 displays the air consumptions for each of the constituent elements.

[0114] This makes it easier to manage the air consumptions for each of the constituent elements.

[0115] The spinning machine 1 of the present embodiment includes the collective control unit 93, the draft device 7, the air spinning device 9, and the winding device 96. The draft device 7 drafts a sliver to produce a fiber bundle 8. The winding device 96 winds a spun yarn 10 to form a package 28.

[0116] With this configuration, the spinning machine 1 itself can calculate an air consumption.

[0117] The spinning machine 1 of the present embodiment includes the flowmeter 82 and the alarm generating unit 93d. The flowmeter 82 is configured to measure an air consumption. The alarm generating unit 93d is configured to generate an alarm, if a difference between an air consumption calculated by the calculating unit 93c and a measurement value of the flowmeter 82 satisfies a determination condition.

[0118] With this configuration, it is possible to generate an alarm based on the result of a calculation of an air consumption, if an abnormality occurs.

[0119] The spinning system shown in FIG. 10 includes the management device 201 and the spinning machines 1. The spinning machines 1 each include the draft device 7 configured to draft a sliver to form a fiber bundle 8, the air spinning device 9, and the winding device 96 configured to wind the spun yarn 10 to form a package 28. The management device 201 receives, from the spinning machines 1, operation information of at least the air spinning devices 9, and calculates air consumptions of the spinning machines 1 based on the operation information.

[0120] This configuration enables the management device 201 to collectively manage the air consumptions of the spinning machines 1.

[0121] Although preferred embodiments of the invention have been described above, the above-described configurations can be modified as below, for example. The modifications below may be adopted in combination as appropriate.

[0122] In the above-described embodiment, the sum of the air consumptions of the air spinning devices 9 of all of the spinning units 2 is calculated. Instead of this configuration, air consumptions of the air spinning devices 9 of the spinning units 2 may be calculated.

[0123] Each air spinning device 9 may include a hollow guide shaft member 35 having a nozzle opened to a second passage 35a. In a configuration in which compressed air is injected from this nozzle, the amount of such compressed air may also be calculated as the air consumption.

[0124] The needle-shaped member 32 may be omitted, and a downstream end of the fiber guide member 31 may function as the needle-shaped member 32.

[0125] Instead of or in addition to the yarn accumulation device 14, a delivery roller, which is configured to be rotationally driven, and a nip roller, which is configured to be pressed onto the delivery roller, may be provided downstream of the air spinning device 9. In this configuration, a spun yarn 10 is fed downstream while being sandwiched by the delivery roller and the nip roller. In a configuration in which the spinning unit 2 includes the delivery roller and the nip roller, a slack tube using a suction airflow and/or a mechanical compensator may be provided downstream of the roller pair.

[0126] The spinning machine 1 may not include the yarn joining cart 50. In this case, each spinning unit 2 may include a suction pipe 51, a suction mouth 52, and a yarn joining device 53. In this case, each spinning unit 2 includes a yarn joining unit.

[0127] The spinning machine 1 may not include the yarn joining device 53. In this case, a disconnected spun yarn 10 may be connected by reversely conveying the spun yarn 10 from a package 28 into the air spinning device 9 and resuming a draft operation with the draft device 7 and a spinning operation with the air spinning device 9 (so-called piecing). In the spinning machine 1 configured to join the spun yarn 10 by piecing, a device related to piecing (a device for catching the spun yarn 10 from the package 28, a device for reversely conveying the caught spun yarn 10 at least to the air spinning device 9) corresponds to the yarn joining unit. Yarn joining units may be respectively provided to the spinning units 2. Alternatively, a yarn joining unit may be provided in the yarn joining cart.

[0128] The draft device 7 and/or the winding device 96 in each spinning unit 2 may be driven independently of those of other spinning units 2.

[0129] In each spinning unit 2, the devices are arranged such that a fiber passing direction is directed from the upper side toward the lower side. Alternatively, the devices in each spinning unit 2 may be arranged such that the fiber passing direction is directed from the lower side toward the upper side.

[0130] The destination of the additive to be fed by the additive supply device 40 is not limited to the spinning nozzle 33a of the air spinning device 9. The destination of the additive to be fed by the additive supply device 40 may be another portion located between the pair of front rollers 25 and the outlet port of the air spinning device 9. Each spinning unit 2 may be configured to have two or more portions receiving the additive. The spinning machine 1 may include additive supply devices 40 provided

respectively to a predetermined number of spinning units 2. Alternatively, the spinning machine 1 may not include the additive supply device 40.

[0131] The spinning machine 1 may include the electric power meter 84. Alternatively, the spinning machine 1 may not include the electric power meter 84.

[0132] The air spinning device 9 may be configured to produce a roving as a spun yarn 10.

Claims

1. An air consumption calculating device (93) comprising:

an obtaining unit (93b) configured to obtain operation information of an air spinning device (9) configured to inject air through a spinning nozzle (33a) to generate a swirling airflow to produce a spun yarn (10) from a fiber bundle (8), the operation information including a time period in which the air is injected from the spinning nozzle (33a); and

a calculating unit (93c) configured to calculate an air consumption of a spinning machine (1) that includes the air spinning device (9), based on the operation information of the air spinning device (9) obtained by the obtaining unit (93b).

2. The air consumption calculating device (93) according to claim 1, wherein

the obtaining unit (93b) obtains the number of times of operation or an air using time period of at least one of a doffing unit (60) and a yarn joining unit (50), the doffing unit (60) is configured to perform, with use of air, a doffing preparation operation of discharging a package (28) formed as a result of winding of the spun yarn (10) and preparing for formation of a new package (28),

the yarn joining unit (50) is configured to perform, with use of air, a catching and joining operation of catching and joining the spun yarn (10), in a case where disconnection occurs in the spun yarn (10), and

the calculating unit (93c) calculates an air consumption of the spinning machine (1) further based on the number of times of operation or the air using time period of said at least one of the doffing unit (60) and the yarn joining unit (50).

3. The air consumption calculating device (93) according to claim 1 or 2, wherein

the obtaining unit (93b) obtains the number of times of operation or an air using time period of an additive supply device (40), which is configured to supply an additive with use of air, and

the calculating unit (93c) calculates an air consumption of the spinning machine (1) further based on the

number of times of operation or the air using time period of the additive supply device (40).

4. The air consumption calculating device (93) according to any one of claims 1 to 3, wherein the calculating unit (93c) further calculates an air consumption efficiency, which is an air consumption per mass of the spun yarn (10) having been produced. 5
5. The air consumption calculating device (93) according to claim 4, wherein the calculating unit (93c) calculates a mass of the spun yarn (10) having been produced, based on a yarn count of the spun yarn (10) produced by the spinning machine (1) and a yarn speed, which is a winding speed of the spun yarn (10) wound by the spinning machine (1), and the calculating unit (93c) calculates the air consumption efficiency based on the mass. 10 15 20
6. The air consumption calculating device (93) according to claim 4 or 5, wherein the calculating unit (93c) further calculates a lot air consumption, which is an amount of air consumed to produce one lot of spun yarn (10). 25
7. The air consumption calculating device (93) according to any one of claims 1 to 6, wherein the obtaining unit (93b) obtains a measurement value of an electric power meter (84), which is configured to measure an electric power consumption of the spinning machine (1). 30
8. The air consumption calculating device (93) according to claim 7, wherein the electric power consumption detected by the electric power meter (84) does not include an amount of electric power used to generate compressed air that is to be supplied to the spinning machine (1), and the calculating unit (93c) converts the air consumption of the spinning machine (1) into an electric power consumption. 35 40
9. The air consumption calculating device (93) according to any one of claims 1 to 8, further comprising: 45
 - a display unit (91) configured to display the air consumption calculated by the calculating unit (93c), wherein 50
 - the calculating unit (93c) calculates air consumptions for each of constituent elements of the spinning machine (1), the constituent elements including at least the air spinning device (9), and 55
 - the display unit (91) displays the air consumptions for each of the constituent elements.

10. A spinning machine (1) comprising:

an air consumption calculating device (93) according to any one of claims 1 to 9;
a draft device (7) configured to draft a sliver to produce a fiber bundle (8);
the air spinning device (9); and
a winding device (96) configured to wind the spun yarn (10) to form a package (28).

11. The spinning machine (1) according to claim 10, further comprising:

a flowmeter (82) configured to measure an air consumption; and
an alarm generating unit (93d) configured to generate an alarm, in a case where a difference between an air consumption calculated by the calculating unit (93c) and a measurement value of the flowmeter (82) satisfies a determination condition.

12. A spinning system comprising:

a management device (201) functioning as an air consumption calculating device (93) according to any one of claims 1 to 9; and
spinning machines (1) each including a draft device (7) configured to draft a sliver to produce a fiber bundle (8), the air spinning device (9), and a winding device (96) configured to wind the spun yarn (10) to form a package (28), wherein the management device (201) receives, from the spinning machines (1), operation information of at least the air spinning devices (9), and calculates air consumptions of the spinning machines (1) based on the operation information.

13. A method for calculating an air consumption, comprising the steps of:

obtaining operation information of an air spinning device (9), which is configured to inject air through a spinning nozzle (33a) to generate a swirling airflow to produce a spun yarn (10) from a fiber bundle (8), the operation information including a time period in which the air is injected from the spinning nozzle (33a); and
calculating an air consumption of a spinning machine (1) that includes the air spinning device (9), based on the operation information of the air spinning device (9) obtained in the step of obtaining.

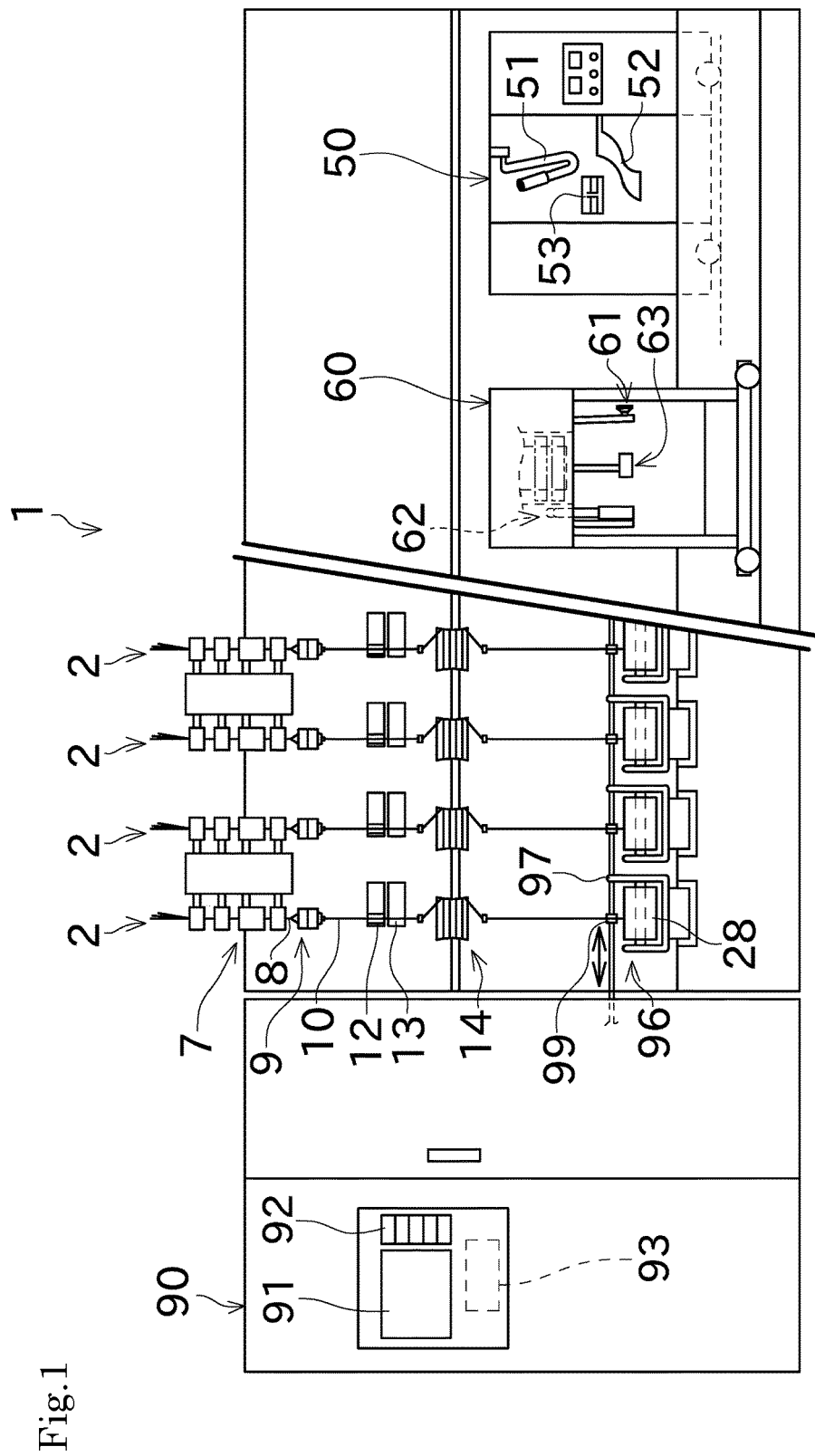


Fig.2

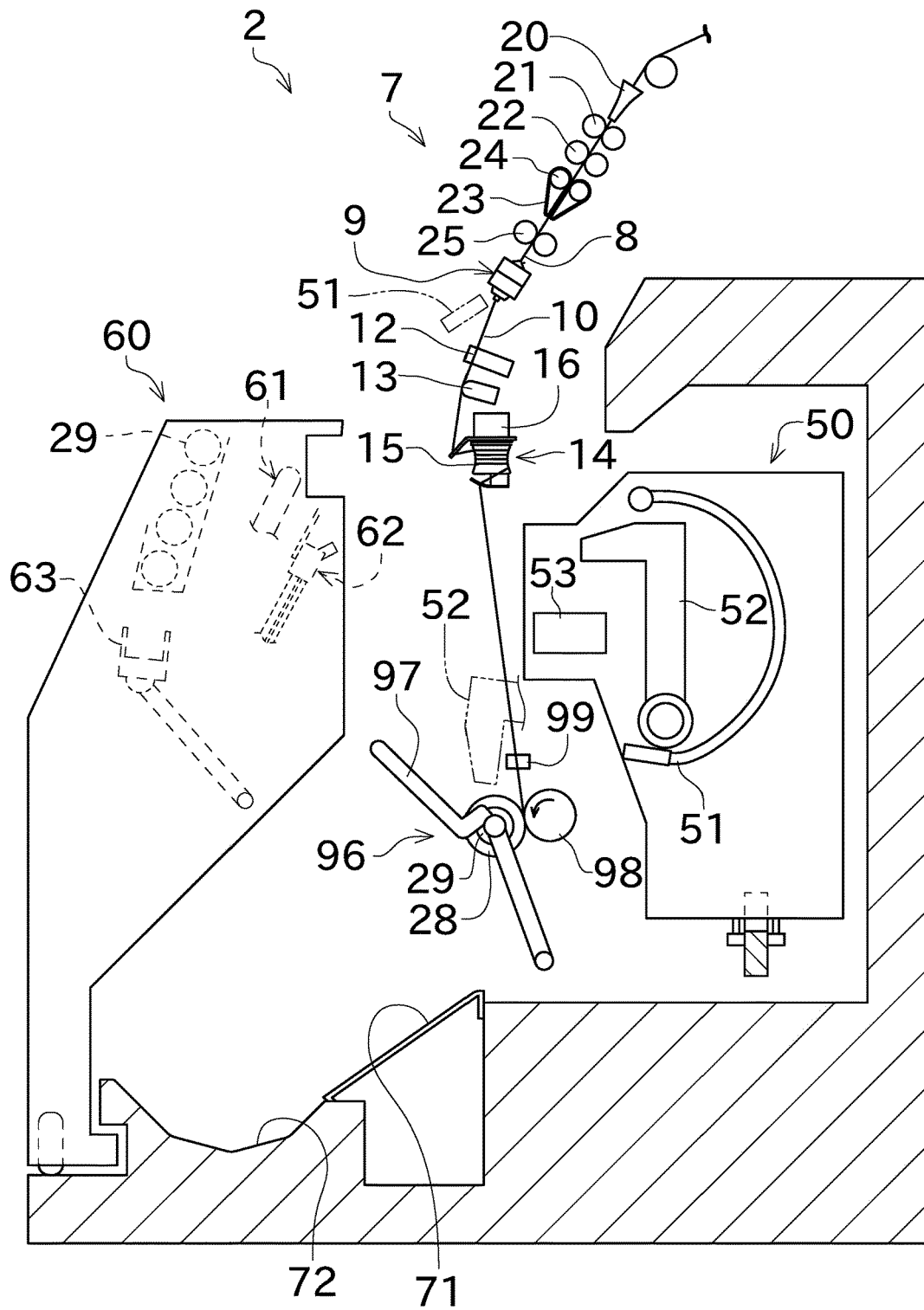


Fig.3

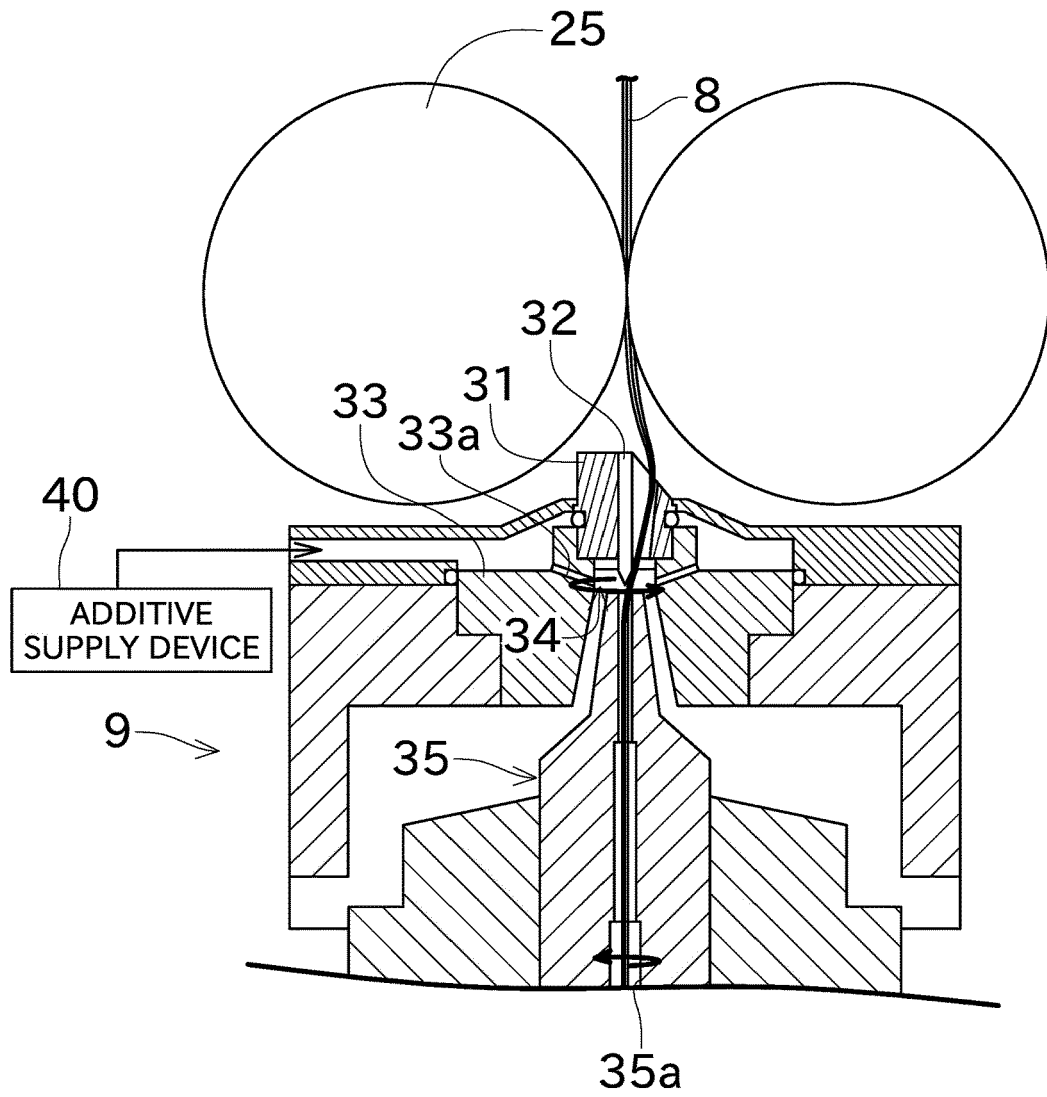


Fig.4

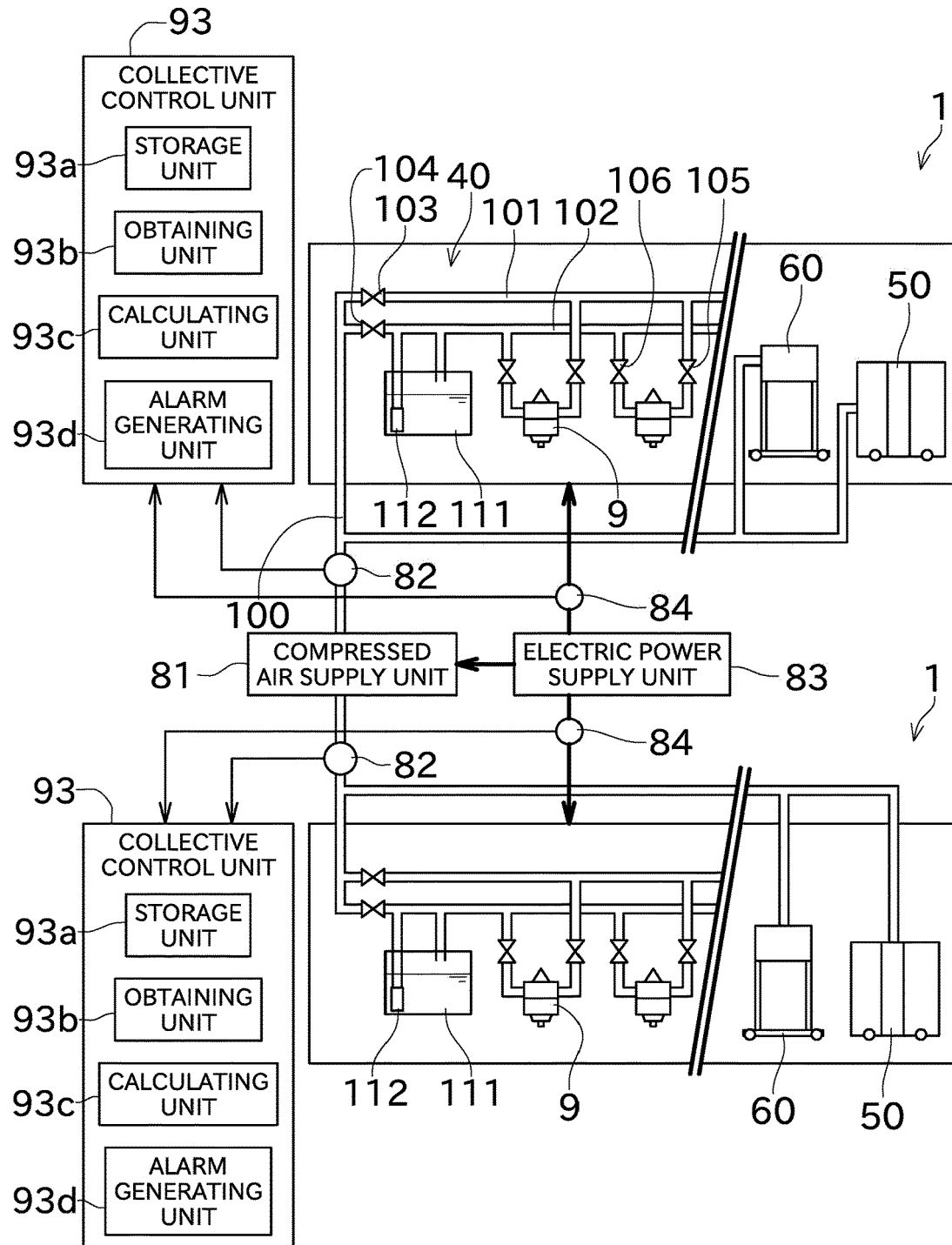


Fig.5

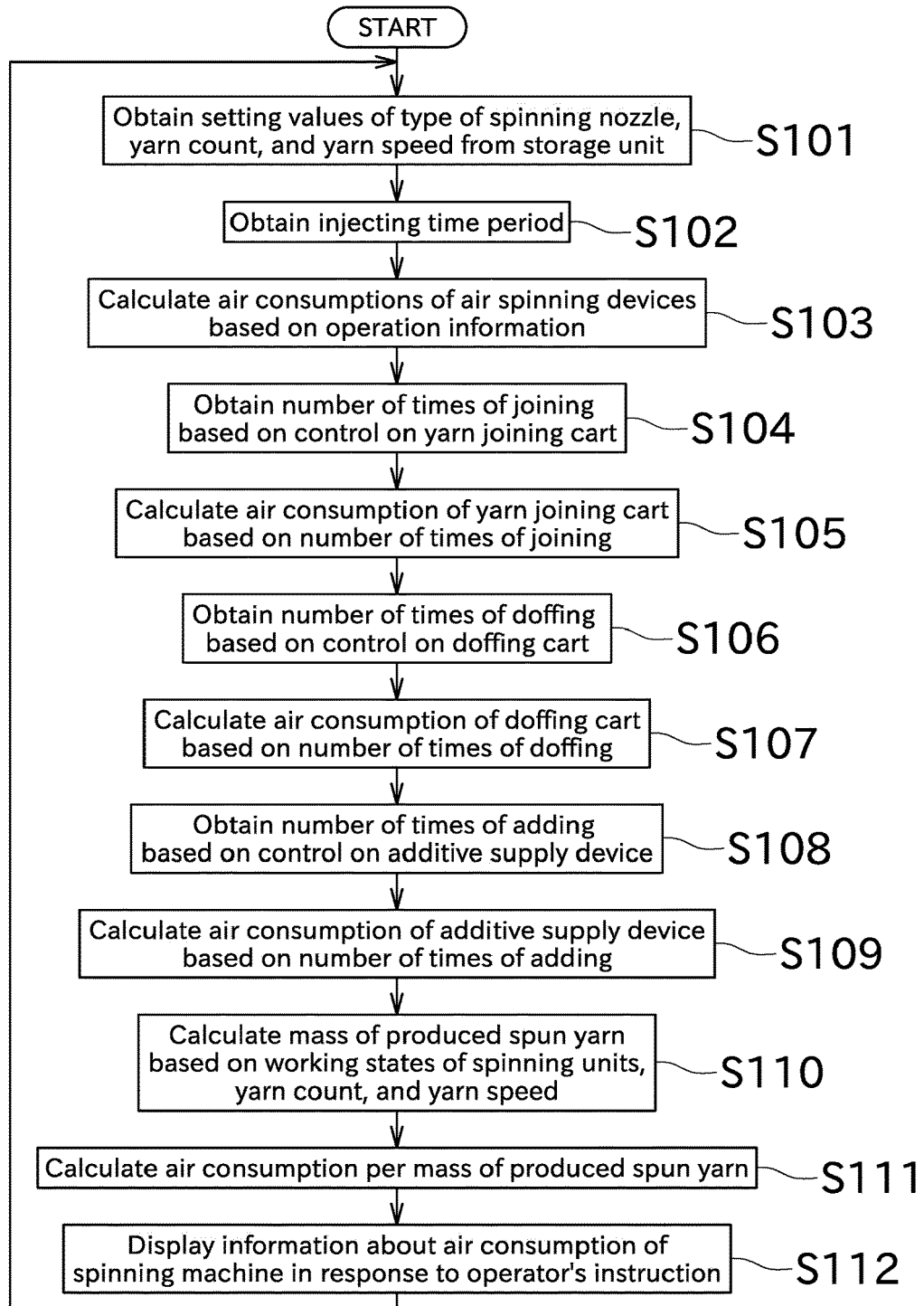


Fig.6

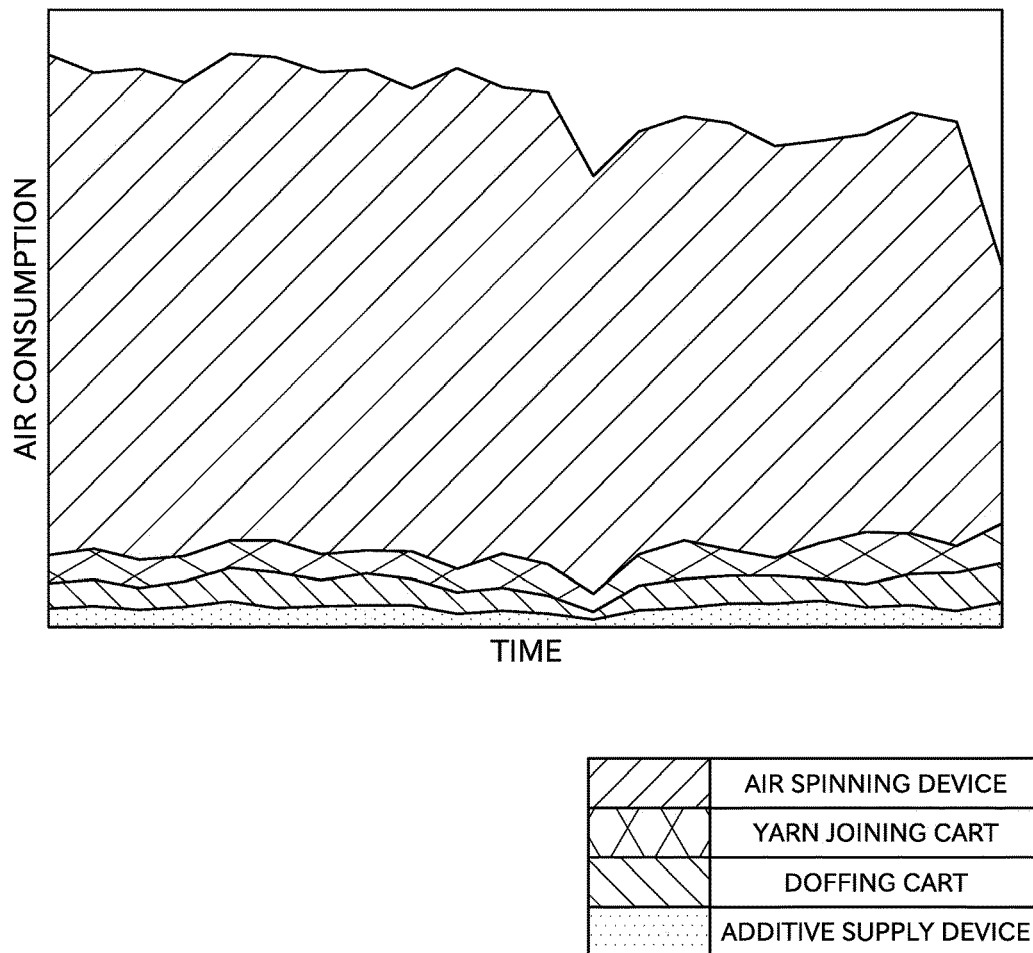


Fig. 7

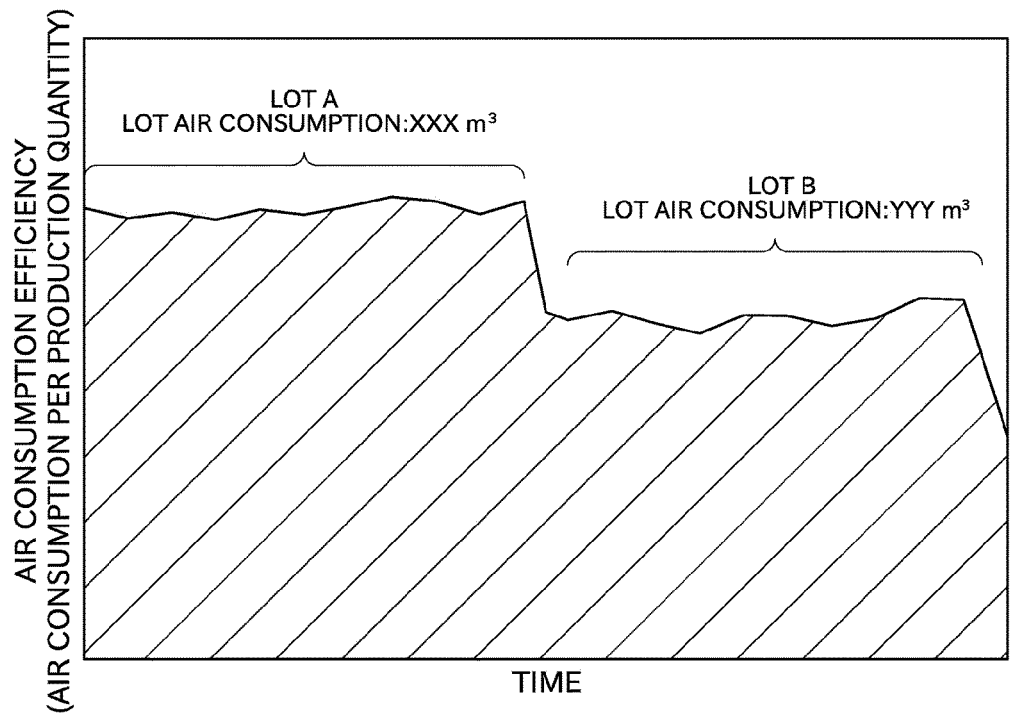
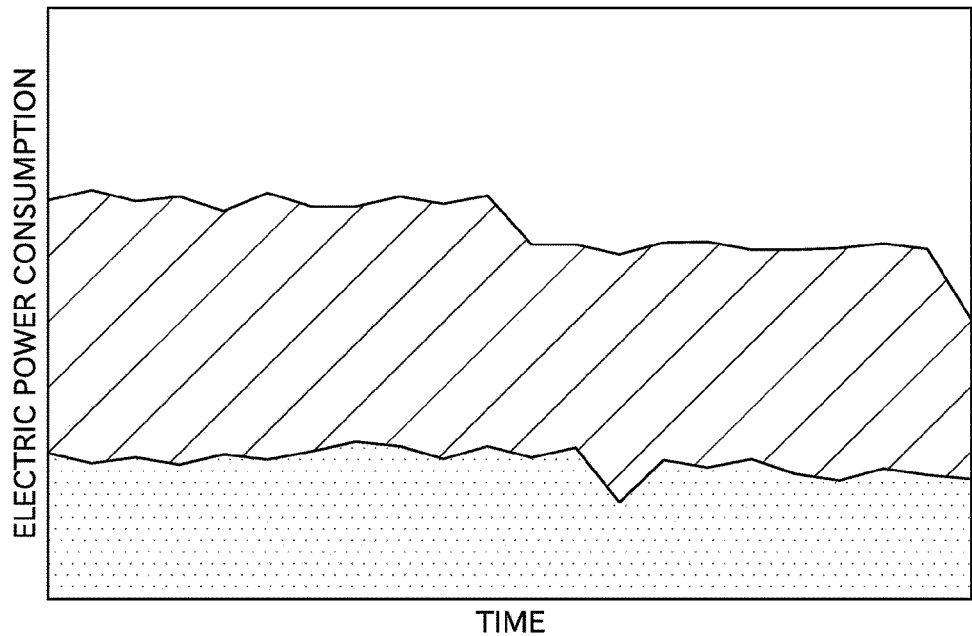


Fig. 8



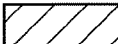
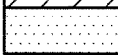
	ELECTRIC POWER CONSUMPTION NOT RELATED TO COMPRESSED AIR SUPPLY
	ELECTRIC POWER CONSUMPTION RELATED TO COMPRESSED AIR SUPPLY

Fig.9

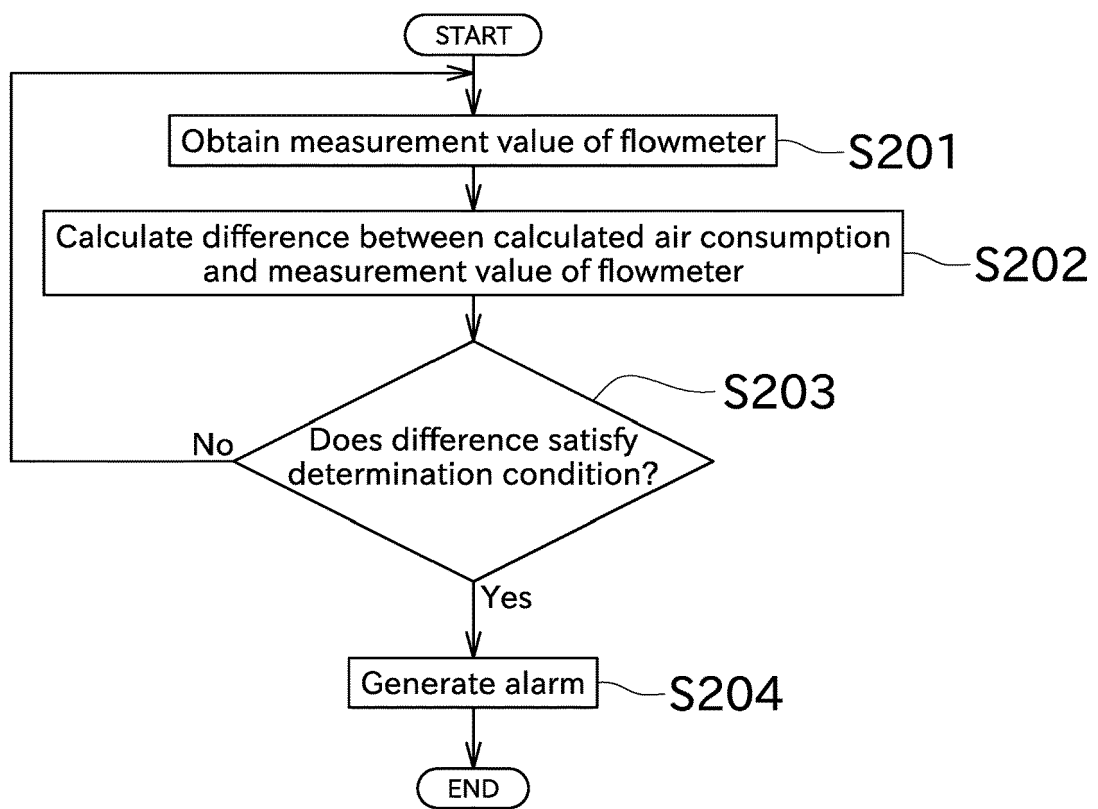
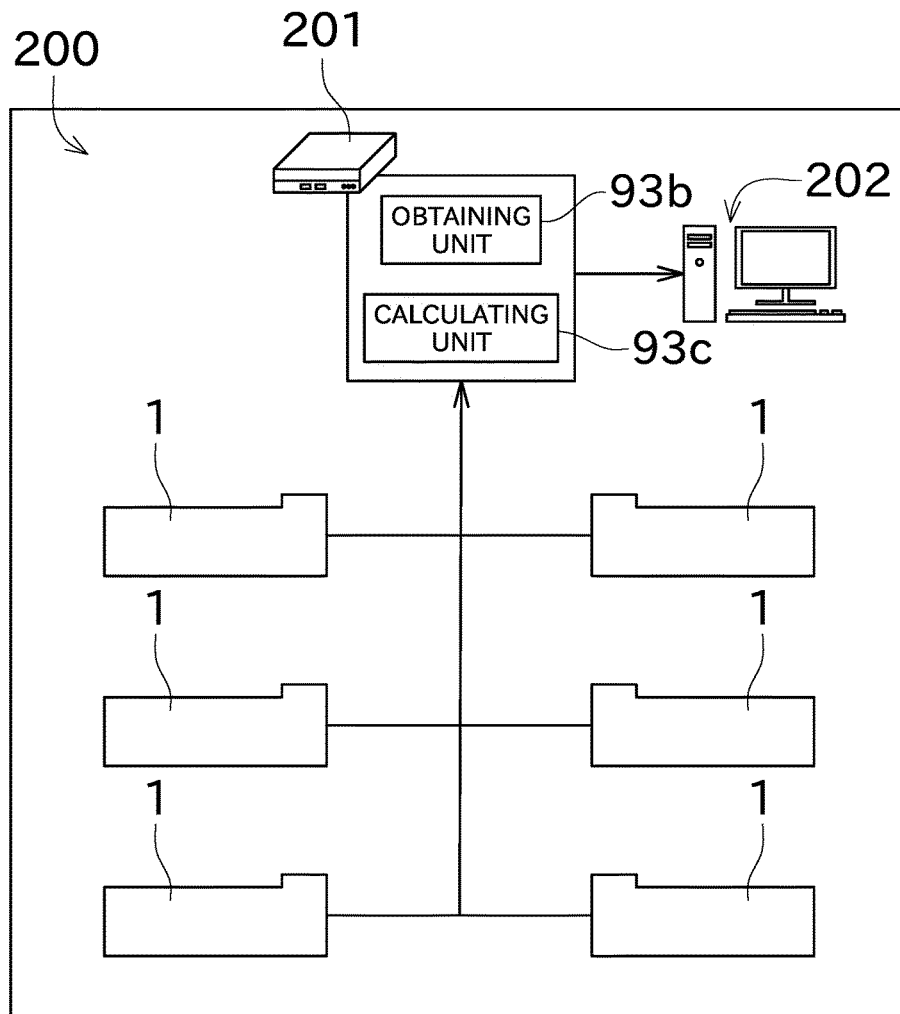


Fig.10





EUROPEAN SEARCH REPORT

 Application Number
 EP 20 16 0619

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X,D	JP 2002 138346 A (TOYOTA IND CORP) 14 May 2002 (2002-05-14)	1-9	INV.
A	* paragraph [0005] - paragraph [0016]; figure 2 *	10-13	D01H13/14 D01H13/32
	* paragraph [0022] *		

A	EP 2 733 243 A1 (TOYOTA JIDOSHOKKI KK [JP]) 21 May 2014 (2014-05-21)	1-13	
	* paragraph [0021] - paragraph [0034]; figures 2-4 *		

			TECHNICAL FIELDS SEARCHED (IPC)
			D01H D03D
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 3 July 2020	Examiner Todarello, Giovanni
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 20 16 0619

5

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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03-07-2020

10

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2002138346 A	14-05-2002	NONE	

EP 2733243 A1	21-05-2014	CN 103820921 A	28-05-2014
		EP 2733243 A1	21-05-2014
		JP 5958296 B2	27-07-2016
		JP 2014101591 A	05-06-2014

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Patent documents cited in the description

- JP 2002138346 A [0002]