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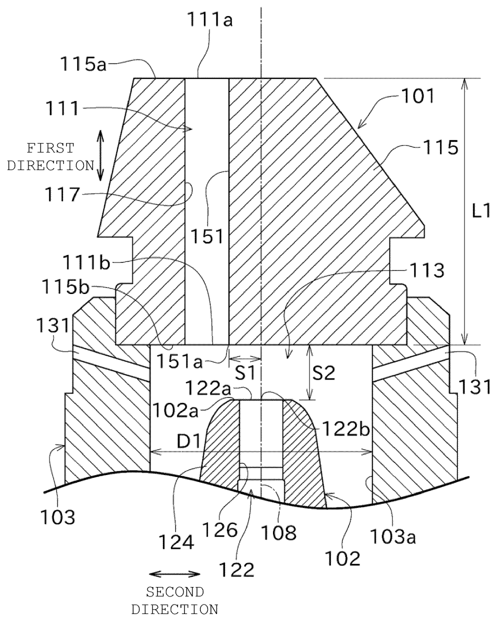
(54) **PNEUMATIC SPINNING DEVICE AND PNEUMATIC SPINNING MACHINE**

(57) A pneumatic spinning device includes a fiber guide (101) and a spindle (102). The fiber guide (101) has a linear first passage (111) through which a fiber bundle passes. The spindle (102) has a second passage (122 through which the fiber bundle having passed through the first passage (111) is guided. An inner surface of the first passage (111) has a flat plane portion (151) arranged along the first direction in which the first passage (111) extends between an upstream end (111a) and a downstream end (111b) of the first passage (111). The interval (S1) in the second direction between the downstream end (151a) of the plane portion (151) and the center (122b) of the upstream end (122a) of the second passage (122) is equal to or greater than 0.8 mm and equal to or less than 3.4 mm.

FIG. 4



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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a pneumatic spinning device and a pneumatic spinning machine including the same.

2. Description of the Related Art

[0002] Conventionally, there is known a pneumatic spinning device that twists fibers by the action of whirling airflow formed in a spinning chamber and forms a spun yarn. Japanese Patent Laid-Open No. 2003-268636 (Patent Document 1) discloses a device for producing a spun yarn from a staple fiber bundle as this type of pneumatic spinning device. Japanese Unexamined Patent Publication No. 2004-509243 (Patent Document 2) discloses a device that produces a spun yarn from a fiber sliver as this type of pneumatic spinning device.

[0003] The device of Patent Document 1 includes a fiber guide element having a fiber-guiding surface and a spindle having a yarn guide passage. The fiber-guiding surface includes a direction-changing position. The direction-changing position causes the directional change of the staple fiber bundle when the staple fiber bundle is guided by the fiber-guiding surface. The fiber-guiding surface ends at a fiber passing edge. The spindle is arranged downstream of this fiber passing edge. The yarn guide passage of the spindle has an inlet opening facing the fiber passing edge. A fluid device for forming a swirl flow around the inlet opening is provided between the fiber guide element and the inlet opening. With this configuration, when the fluidic device generates a swirl flow around the inlet opening or the spindle, the generated swirl flow can cause a free fiber end of the staple fiber bundle to be positioned around the inlet opening. The free fiber end performs a relative rotation motion about the inlet opening and thus the staple fiber bundle. Accordingly, the device forms a spun yarn from the staple fiber bundle.

[0004] The device of Patent Document 2 includes a fiber conveyance element having a fiber-guiding surface and a spindle having a yarn guide channel. A fiber outlet edge is arranged at an end of the fiber-guiding surface in the conveyance direction. An intake port of the yarn guide channel is arranged in close proximity to the fiber outlet edge. Patent Document 2 describes that a set distance between an imaginary plane parallel to a center line of the yarn guide channel including the fiber outlet edge and the center line is preferably a value within the order range of 10 to 30% of the diameter of the intake port. With this configuration, the device guides the fibers to the fiber-guiding surface and, from there, into the intake port of the yarn guide channel. Then, the device generates a vortex airflow around the intake port of the yarn guide channel, and causes the vortex airflow to swirl a free rear end of the fibers whose front end is already positioned in the yarn guide channel, thereby producing a yarn.

BRIEF SUMMARY OF THE INVENTION

[0005] A fiber bundle used as a raw material for spun yarn is composed of a multitude of fibers. When the fiber bundle is introduced into the spinning chamber for pneumatic spinning, focusing on each fiber, a downstream end positioned downstream in the travelling direction of the fiber is twisted into a twisted core portion (twisted by swirling of the reversal portion described later), and provided as a fixed end. On the other hand, an upstream end positioned upstream of the fibers in the travelling direction is a free end, and the upstream end separates so as to open from the core portion when entering the spinning chamber and reverses the direction of the end. This reversal portion is subjected to action of the whirling airflow, whereby each fiber is wound around the core portion. In this manner, pneumatic spinning is performed.

[0006] The pneumatic spinning device is desired to increase spinning speed. With an increase in spinning speed, the time in which the fiber bundle is subjected to the action of the whirling airflow in the spinning chamber becomes shorter. Therefore, in order to realize high-speed spinning while sufficiently twisting the fibers, it is necessary to reliably reverse the free end portion of the fibers in the spinning chamber (in other words, increase the amount of the fibers to be reversed). On the other hand, when the amount of the reversed fibers increases, the twist tends to propagate from the reversed fibers to the fibers upstream of the reversed fibers in the travelling direction. The fibers in which the twist has propagated are not sufficiently reversed even if subjected to the action of the whirling airflow. Therefore, it has been difficult to perform stable spinning at high speed.

[0007] In the configuration of Patent Document 1, in case the spinning speed is high, when the swirl flow causes the free fiber end to perform relative rotation motion, the twist propagates to the staple fiber bundle positioned on the fiber-guiding surface side, whereby the relative rotation motion of the free fiber end is highly likely to become unstable.

[0008] In Patent Document 2, in case the spinning speed is high, when the vortex airflow causes the free rear end of the fibers to rotate, the twist propagates to the fibers on the fiber-guiding surface side, whereby the rotation of the free rear end of the fibers is highly likely to become unstable. Patent Document 2 discloses that direction-changing and guiding of the fibers along the fiber outlet edge prevents twist propagation, but the effect is unknown for spinning at high speed.

[0009] An object of the present invention lies in that in a pneumatic spinning device, when fibers are twisted by whirling airflow, propagation of the twist to the fibers positioned upstream of the twisted fibers in the travelling direction is effectively reduced.

[0010] According to a first aspect of the present invention, a pneumatic spinning device configured as follows is provided. That is, this pneumatic spinning device twists, by whirling airflow, the fibers passing through the spinning chamber and forms a yarn. The pneumatic spinning device includes a fiber guiding section and a hollow guide shaft body. The fiber guiding section has a first passage through which a fiber bundle passes. The hollow guide shaft body has a second passage through which the fiber bundle having passed through the first passage is guided, and the hollow guide shaft body is provided so as to face the fiber guiding section across the spinning chamber. The first passage is provided so as to extend linearly. The second passage is provided so as to extend along a shaft center of the hollow guide shaft body with the shaft center as a center. A downstream end where the first passage opens into the spinning chamber and an upstream end where the second passage opens into the spinning chamber are arranged with an interval in the direction of the shaft center of the hollow guide shaft body. An inner surface of the first passage has a flat plane portion on the side close to the shaft center of the hollow guide shaft body. An angle of a linear portion obtained by cutting the plane portion with any plane perpendicular to a first direction in which the first passage extends with respect to the first direction is constant between an upstream end and a downstream end of the first passage. The plane portion is arranged to deviate with respect to the shaft center of the hollow guide shaft body in a second direction perpendicular to the direction of the shaft center of the hollow guide shaft body. The interval in the second direction between the downstream end of the plane portion and the shaft center of the hollow guide shaft body is equal to or greater than 0.8 mm and equal to or less than 3.4 mm.

[0011] Accordingly, the fiber bundle having been supplied to the first passage is restrained by coming into contact with the flat plane portion before reaching the spinning chamber. Since the plane portion is arranged to deviate with respect to the shaft center of the hollow guide shaft body, when the fiber bundle is appropriately bent between the first passage and the second passage, the fiber bundle is pressed well with respective to the plane portion. Therefore, even when the fiber bundle is twisted by the whirling airflow in the spinning chamber, it is possible to effectively reduce propagation of the twist to the upstream in the travelling direction. Thus, since the fibers are not twisted upstream of the spinning chamber, separation and reversal of the fibers in the spinning chamber can be performed satisfactorily. As a result, spinning can be stably performed.

[0012] In the pneumatic spinning device described above, the interval in the second direction between the downstream end of the plane portion and the shaft center of the hollow guide shaft body is preferably equal to or greater than 0.9 mm and equal to or less than 1.5 mm.

[0013] Accordingly, since the fiber bundle can be appropriately bent between the first passage and the second passage, the propagation of the twist described above can be particularly effectively reduced.

[0014] In the pneumatic spinning device described above, the plane portion is preferably arranged at a position where the plane portion and an opening formed by the second passage in the spinning chamber do not appear to overlap each other when viewed in the first direction.

[0015] Accordingly, since the fiber bundle can be reliably bent between the first passage and the second passage, propagation of the twist to the upstream can be reduced well.

[0016] In the pneumatic spinning device described above, in a cross-sectional shape of the first passage when the fiber guiding section is cut with a plane perpendicular to the first direction, provided that a distance in a direction orthogonal to the linear portion corresponding to the plane portion between the linear portion and a contour on the opposite side of the linear portion across the first passage is called a gap length, the gap length is preferably constant over the entire longitudinal direction of the linear portion, or the gap length at the longitudinal center of the linear portion is larger than the gap length at longitudinal ends.

[0017] Accordingly, the fiber bundle can pass smoothly while being restrained by the plane portion in the first passage.

[0018] In the pneumatic spinning device described above, the cross-sectional shape of the first passage is preferably a quadrangle shape or a D shape.

[0019] Accordingly, a simple configuration of the first passage can be realized.

[0020] In the pneumatic spinning device described above, the length of the plane portion in the first direction is preferably equal to or greater than 3 mm and equal to or less than 12 mm.

[0021] Accordingly, the plane portion can reliably exert the restraining action on the fiber bundle.

[0022] In the pneumatic spinning device described above, the plane portion is preferably arranged so as to be in parallel to the shaft center direction of the hollow guide shaft body or to be inclined at an angle of equal to or less than 10° with respect to the direction of the shaft center of the hollow guide shaft body.

[0023] Accordingly, the fiber bundle can be guided in the first passage well to the spinning chamber.

[0024] The pneumatic spinning device described above preferably has the following configuration. That is, the downstream end of the plane portion is positioned in the first passage and upstream of the downstream end of the first passage. The inner surface of the first passage has the plane portion and a downstream portion that is inclined or curved with respect to the plane portion and extends from the downstream end of the plane portion to the downstream end of the first passage towards the upstream end of the second passage. The length of the plane portion in the first direction is equal to or greater than half the length of the first passage in the first direction.

[0025] Accordingly, the fiber bundle can be guided in the first passage well to the spinning chamber.

[0026] In the pneumatic spinning device described above, the passage area of the first passage when the fiber guiding section is cut with a plane perpendicular to the first direction is preferably equal to or greater than 4 mm^2 and equal to or less than 7 mm^2.

[0027] Accordingly, the fiber bundle can pass through the first passage well.

[0028] In the pneumatic spinning device described above, the interval in the first direction between the downstream end of the first passage and the upstream end of the second passage is preferably equal to or greater than 0.3 mm and equal to or less than 7 mm.

[0029] Accordingly, the fiber bundle can be guided well to the second passage. When the fiber bundle is guided to the second passage, the fibers can be reliably reversed and swirled by the whirling airflow in the spinning chamber.

[0030] In the pneumatic spinning device described above, the interval in the first direction between the downstream end of the first passage and the upstream end of the second passage can be equal to or greater than 1.1 mm and equal to or less than 2.5 mm.

[0031] Accordingly, the fibers can be reliably reversed and swirled in the spinning chamber even if the spinning speed is high.

[0032] In the pneumatic spinning device described above, the interval in the first direction between the downstream end of the first passage and the upstream end of the second passage can be equal to or greater than 4.2 mm and equal to or less than 7 mm.

[0033] In this case, spinning can be performed while the fibers are reversed well.

[0034] The pneumatic spinning device described above preferably has the following configuration. That is, the pneumatic spinning device includes a casing having a spinning nozzle through which air can pass and arranged so as to form the spinning chamber together with the fiber guiding section and the hollow guide shaft body. The casing has an inner surface facing the spinning chamber. The inner surface of the casing is circular when viewed in a direction along the shaft center of the hollow guide shaft body. An inner diameter of the casing in the inner surface portion is equal to or greater than 3 mm and equal to or less than 9 mm.

[0035] Accordingly, spinning can be performed well.

[0036] The pneumatic spinning device described above preferably has the following configuration. That is, the hollow guide shaft body is formed with a passage hole through which air can pass. The passage hole opens into the second passage.

[0037] Accordingly, air can be supplied to the second passage through the passage hole such that the fiber bundle can travel through the second passage.

[0038] In the pneumatic spinning device described above, a plurality of the passage holes are preferably provided around the second passage.

[0039] Accordingly, airflow can act on the fiber bundle in the second passage in a well-balanced manner.

[0040] According to a second aspect of the present invention, a pneumatic spinning machine configured as follows is provided. That is, this pneumatic spinning machine includes the pneumatic spinning device described above. This pneumatic spinning machine includes a first catching device, a winding device, a second catching device, and a yarn joining device. The first catching device catches a yarn formed by the pneumatic spinning device at the time of yarn discharge spinning. The winding device winds the yarn formed by the pneumatic spinning device. The second catching device catches the wound yarn. The yarn joining device joins the yarn caught by the first catching device and the yarn caught by the second catching device.

[0041] Thus, in the pneumatic spinning machine that performs yarn discharge spinning, even when the fibers are twisted by the whirling airflow, it is possible to effectively reduce propagation of the twist to the fibers located upstream of the twisted fibers in the travelling direction.

BRIEF DESCRIPTION OF THE DRAWINGS

[0042]

FIG. 1 is a front view illustrating the overall configuration of a pneumatic spinning machine including a pneumatic spinning device according to an embodiment of the present invention;

FIG. 2 is a side view of a spinning unit and a yarn joining cart;

FIG. 3 is a partial cross-sectional view illustrating a configuration of the spinning device;

FIG. 4 is a partially enlarged view of FIG. 3;

FIG. 5 is a perspective view illustrating a positional relationship between a first passage and a second passage formed in the spinning device;

FIGS. 6A and 6B are views illustrating a cross-sectional shape of the first passage;

FIGS. 7A and 7B are views illustrating another example of the cross-sectional shape of the first passage;

FIG. 8 is a partial cross-sectional view illustrating another example of the configuration of the pneumatic spinning device; and

FIG. 9 is a partial cross-sectional view illustrating another example of the configuration of the pneumatic spinning device.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0043] Next, a pneumatic spinning machine 1 including a pneumatic spinning device 23 according to an embodiment of the present invention will be described with reference to FIGS. 1 and 2.

[0044] As illustrated in FIG. 1, the pneumatic spinning machine 1 includes a blower box 3, a motor box 5, a plurality of spinning units 7, and a yarn joining cart 9. The plurality of spinning units 7 are arranged in a predetermined direction.

[0045] In the blower box 3, a blower 11 that functions as a negative pressure source is arranged.

[0046] In the motor box 5, a drive source (not illustrated), a central control section 13, a display section 15, and an operation section 17 are arranged. The drive source provided in the motor box 5 includes a motor commonly used by the plurality of spinning units 7.

[0047] The central control section 13 intensively manages and controls each section of the pneumatic spinning machine 1. As illustrated in FIG. 2, the central control section 13 is connected via a signal line not illustrated to a unit control section 19 included in each spinning unit 7. While in the present embodiment, each spinning unit 7 includes the unit control section 19, a predetermined number (e.g., two or four) of spinning units 7 may share one unit control section 19.

[0048] The display section 15 can display, for example, setting contents for the spinning units 7 and/or information regarding the state of each spinning unit 7. When the display section 15 is constituted with a touch-screen display, the display section 15 and the operation section 17 may be integrally configured.

[0049] Each spinning unit 7 mainly includes a draft device 21, the pneumatic spinning device 23, a yarn accumulating device 25, and a winding device 27 arranged in order from upstream to downstream. The "upstream" and "downstream" here mean upstream and downstream in the travelling direction of a sliver 32, a fiber bundle 34, and a spun yarn 30 at the time of winding of the spun yarn (yarn) 30.

[0050] The draft device 21 is provided in a vicinity of an upper end of a frame 36 included in the pneumatic spinning machine 1. As illustrated in FIG. 2, the draft device 21 includes four draft roller pairs. The four draft roller pairs are a back roller pair 41, a third roller pair 43, a middle roller pair 45, and a front roller pair 47, which are arranged in order from upstream to downstream. The middle roller pair 45 is provided with an apron belt 49 for each roller.

[0051] By sandwiching and conveying the sliver 32 supplied from a sliver case not illustrated between rollers of each draft roller pair, the draft device 21 stretches (drafts) the sliver 32 to a predetermined fiber amount (or thickness) to form the fiber bundle 34. The fiber bundle 34 formed by the draft device 21 is supplied to the pneumatic spinning device 23.

[0052] By applying whirling airflow to the fiber bundle 34 formed by the draft device 21, the pneumatic spinning device 23 twists the fiber bundle 34 to form the spun yarn 30. The detailed configuration of the pneumatic spinning device 23 will be described later.

[0053] The yarn accumulating device 25 is supplied with the spun yarn 30 formed by the pneumatic spinning device 23. As illustrated in FIG. 2, the yarn accumulating device 25 includes a yarn accumulating roller 53 and a motor 55.

[0054] The yarn accumulating roller 53 is rotationally driven by the motor 55. The yarn accumulating roller 53 winds the spun yarn 30 around its outer peripheral surface and temporarily accumulates the spun yarn 30. By rotating at a predetermined rotation speed with the spun yarn 30 wound around the outer peripheral surface thereof, the yarn accumulating roller 53 pulls out the spun yarn 30 from the pneumatic spinning device 23 at a predetermined speed and conveys it to the downstream.

[0055] As described above, the yarn accumulating device 25 can temporarily accumulate the spun yarn 30 on the outer peripheral surface of the yarn accumulating roller 53, and hence functions as a kind of buffer for the spun yarn 30. Accordingly, it is possible to eliminate a defect (such as slackening of the spun yarn 30) caused by difference between the spinning speed in the pneumatic spinning device 23 and the winding speed (travel speed of the spun yarn 30 to be wound on a package 73 described later) for some reason.

[0056] A yarn monitoring device 59 is provided between the pneumatic spinning device 23 and the yarn accumulating device 25. The spun yarn 30 formed by the pneumatic spinning device 23 passes through the yarn monitoring device 59 before being accumulated in the yarn accumulating device 25.

[0057] The yarn monitoring device 59 monitors the quality of the traveling spun yarn 30 by an optical sensor and detects a yarn defect included in the spun yarn 30. The yarn defect can be, for example, an abnormality in the thickness of the spun yarn 30 or a foreign substance contained in the spun yarn 30. When detecting a yarn defect in the spun yarn 30, the yarn monitoring device 59 transmits a yarn defect detection signal to the unit control section 19. The yarn monitoring device 59 may monitor the quality of the spun yarn 30 by using, for example, a capacitance sensor instead of the optical sensor. Instead of these examples, or in addition to these examples, the yarn monitoring device 59 may be configured to measure tension of the spun yarn 30 as the quality of the spun yarn 30.

[0058] Upon receiving the yarn defect detection signal from the yarn monitoring device 59, the unit control section 19 cuts the spun yarn 30 by stopping the driving of the pneumatic spinning device 23 and/or the draft device 21. That is, the pneumatic spinning device 23 functions as a cutting section that cuts the spun yarn 30 when the yarn monitoring device 59 detects a yarn defect. The spinning unit 7 may be provided with a cutter for cutting the spun yarn 30.

[0059] The winding device 27 includes a cradle arm 61, a winding drum 63, and a traverse guide 65. The cradle arm 61 is swingably supported about a supporting shaft 67 and can rotatably support a bobbin 71 (that is, the package 73) for winding the spun yarn 30. By rotating in a state of being in contact with the outer peripheral surface of the bobbin 71 or the package 73, the winding drum 63 rotationally drives the package 73 in the winding direction. While reciprocating the traverse guide 65 by a driving means not illustrated, the winding device 27 drives the winding drum 63 by an electric motor not illustrated. Accordingly, the winding device 27 winds the spun yarn 30 around the package 73 while traversing the spun yarn 30.

[0060] As illustrated in FIG. 1, on the frame 36 of the pneumatic spinning machine 1, a rail 81 is arranged along a direction in which the plurality of spinning units 7 are arranged. The yarn joining cart 9 is configured to be capable of traveling on the rail 81. Accordingly, the yarn joining cart 9 can move with respect to the plurality of spinning units 7. The yarn joining cart 9 travels to the spinning unit 7 where yarn breakage or yarn cutting has occurred, and performs yarn joining work for the spinning unit 7.

[0061] As illustrated in FIG. 1, the yarn joining cart 9 includes travel wheels 83, a yarn joining device 85, a suction pipe (first catching device) 87, and a suction mouth (second catching device) 89. The yarn joining cart 9 further includes a cart control section 91 illustrated in FIG. 2.

[0062] The suction pipe 87 can catch the spun yarn 30 formed by the pneumatic spinning device 23 at the time of yarn discharge spinning. Specifically, by generating a suction airflow at the tip of the suction pipe 87, the suction pipe 87 can suck and catch the spun yarn 30 discharged from the pneumatic spinning device 23.

[0063] The suction mouth 89 can catch the spun yarn 30 wound around the package 73 of the winding device 27. Specifically, by generating a suction airflow at the tip of the suction mouth 89, the suction mouth 89 can suck and catch the spun yarn 30 from the package 73 supported by the winding device 27.

[0064] By swinging in a state in which the spun yarn 30 is caught, for example, the suction pipe 87 and the suction mouth 89 guide the spun yarn 30 to a position where the spun yarn 30 can be introduced into the yarn joining device 85.

[0065] The yarn joining device 85 joins the spun yarn 30 from the pneumatic spinning device 23 and the spun yarn 30 from the package 73. In the present embodiment, the yarn joining device 85 is a splicer device that twists yarn ends together by whirling airflow. The yarn joining device 85 is not limited to the splicer device described above, and for example, a mechanical knotter and the like can be adopted.

[0066] The cart control section 91 (see FIG. 2) is configured as a known computer having a central processing unit (CPU), a read only memory (ROM), a random access memory (RAM), and the like that are not illustrated. By controlling the operation of each section included in the yarn joining cart 9, the cart control section 91 controls the yarn joining work performed by the yarn joining cart 9.

[0067] Next, the configuration of the pneumatic spinning device 23 will be described in detail with reference to FIG. 3.

[0068] As illustrated in FIG. 3, the pneumatic spinning device 23 includes a fiber guide (fiber guiding section) 101, a spindle (hollow guide shaft body) 102, and a nozzle block (casing) 103.

[0069] A fiber guide 101 has a first passage 111 through which the fiber bundle 34 can pass. The first passage 111 is connected to a spinning chamber 113 for performing pneumatic spinning. The fiber guide 101 is supplied with the fiber bundle 34 formed by the draft device 21. The fiber bundle 34 is introduced into the first passage 111 of the fiber guide 101 from its upstream end 111a, and is guided to the spinning chamber 113 through a downstream end 111b.

[0070] The fiber guide 101 includes a body 115 formed in a block shape. The body 115 is arranged such that its upstream end surface 115a faces the draft device 21 and its downstream end surface 115b faces the spindle 102. The first passage 111 is composed of a hole 117 formed so as to penetrate the body 115. The hole 117 is arranged so as to extend linearly from the upstream end surface 115a to the downstream end surface 115b of the body 115. Hereinafter, the direction in which the first passage 111 extends may be referred to as the first direction. In the present embodiment, the first direction is parallel to a shaft center 108 of the spindle 102 described below.

[0071] The fiber guide 101 constitutes a part of the spinning chamber 113. Specifically, the spinning chamber 113 is formed by arranging the downstream end surface 115b of the body 115 to face an internal space of the nozzle block 103 described later.

[0072] The spindle 102 is arranged downstream with respect to the fiber guide 101. The spindle 102 is formed in an elongated round bar shape along the travelling direction of the fiber bundle 34. The spindle 102 is arranged such that its upstream end surface 102a faces the fiber guide 101 across the spinning chamber 113.

[0073] The spindle 102 has a second passage 122 through which the fiber bundle 34 having passed through the first passage 111 is guided. The second passage 122 is connected to the spinning chamber 113. The second passage 122 is composed of a circular hole 126 formed in the spindle 102. The second passage 122 extends linearly inside the spindle 102 along the longitudinal direction of the spindle 102. An upstream end 122a of the second passage 122 opens into the upstream end surface 102a of the spindle 102. The center of the second passage 122 coincides with the shaft center 108 of the spindle 102.

[0074] A conical taper portion 124 is formed on the outer peripheral surface of the upstream end of the spindle 102. The taper portion 124 is provided so that the outer diameter becomes smaller from the downstream to the upstream.

[0075] The spindle 102 constitutes a part of the spinning chamber 113. Specifically, the spinning chamber 113 is formed by arranging the outer peripheral surface of the taper portion 124 in the internal space of the nozzle block 103. The upstream end surface 102a of the spindle 102 is arranged at an appropriate interval with respect to the body 115 of the fiber guide 101.

[0076] The spinning chamber 113 is composed of a space surrounded by the downstream end surface 115b of the body 115 of the fiber guide 101, the outer peripheral surface of the taper portion 124 of the spindle 102, and an inner surface 103a of the nozzle block 103 described later.

[0077] The upstream end 122a of the second passage 122 is arranged at an appropriate interval with respect to the downstream end 111b of the first passage 111 in the travelling direction of the fiber bundle 34. The spinning chamber 113 described above is configured to include a portion with this interval.

[0078] The downstream end 111b of the first passage 111 and the upstream end 122a of the second passage 122 open into the spinning chamber 113. In the present embodiment, the opening surface of the downstream end 111b of the first passage 111 and the opening surface of the upstream end 122a of the second passage 122 are substantially parallel. In the body 115, the surface (downstream end surface 115b) at which the downstream end 111b of the first passage 111 opens is a flat surface facing the spinning chamber 113 and is perpendicular to the shaft center 108 of the spindle 102.

[0079] The opening area of the downstream end 111b of the first passage 111 is substantially the same as or the same as a passage area of the first passage 111. The passage area refers to an area of a cross section of the passage cut with a plane perpendicular to the longitudinal direction. The opening area of the upstream end 122a of the second passage 122 is substantially the same as or the same as a passage area of a portion of the second passage 122 corresponding to the taper portion 124.

[0080] After coming out from the downstream end 111b of the first passage 111, the fiber bundle 34 enters the upstream end 122a of the second passage 122 via the spinning chamber 113. The fiber bundle 34 passes through the second passage 122 and is sent out to the outside of the pneumatic spinning device 23.

[0081] The nozzle block 103 is arranged downstream of the fiber guide 101. The nozzle block 103 is arranged so as to cover the spindle 102. Between the nozzle block 103 and the spindle 102, a gap is formed in the radial direction of the spindle 102.

[0082] A circular hole is formed in the nozzle block 103. A shaft center of the circular hole coincides with the shaft center 108 of the spindle 102. The inner surface 103a of the nozzle block 103 is formed to have a circular shape when viewed in the direction of the shaft center 108 of the spindle 102.

[0083] The nozzle block 103 has the spinning nozzle 131 through which air can pass. The pneumatic spinning device 23 can eject air (compressed air) from the spinning nozzle 131 into the spinning chamber 113. The spinning nozzle 131 is formed as a through hole extending in a direction inclined with respect to the shaft center 108 of the spindle 102. One longitudinal end of the spinning nozzle 131 is connected to a compressed air supplying section not illustrated, and the other longitudinal end opens into the spinning chamber 113. When compressed air is jetted from the spinning nozzle 131 into the spinning chamber 113, whirling airflow is generated in the spinning chamber 113.

[0084] In the present embodiment, a plurality of the spinning nozzles 131 are formed in the nozzle block 103. The plurality of spinning nozzles 131 are arranged at equal intervals in the circumferential direction. However, the number of the spinning nozzles 131 is not limited, and it is sufficient that one or more spinning nozzles 131 are arranged.

[0085] The spindle 102 has an auxiliary nozzle (passage hole) 135 through which air can pass. The pneumatic spinning device 23 can eject air (compressed air) from the auxiliary nozzle 135 to the second passage 122. The auxiliary nozzle 135 is formed as a through hole extending in a direction perpendicular to the shaft center 108 of the spindle 102. One longitudinal end of the auxiliary nozzle 135 is connected to the compressed air supplying section not illustrated, and the other longitudinal end opens into the second passage 122.

[0086] A plurality of the auxiliary nozzles 135 are provided around the second passage 122. The plurality of auxiliary nozzles 135 are arranged at equal intervals in the circumferential direction.

[0087] When compressed air is jetted from the auxiliary nozzle 135 to the second passage 122, whirling airflow is generated in the second passage 122. When viewed in a direction along the shaft center 108 of the spindle 102, the direction of this whirling airflow is opposite to the direction of the whirling airflow generated by the jetting of compressed air from the spinning nozzle 131.

[0088] The pneumatic spinning device 23 can perform two types of spinning, one is normal spinning and the other is yarn discharge spinning. The normal spinning is spinning performed while winding the spun yarn 30 downstream of the pneumatic spinning device 23. The yarn discharge spinning is a temporary spinning performed at the stage before the normal spinning, and is started in a state where the spun yarn 30 is not discharged to the downstream of the pneumatic spinning device 23. The yarn discharge spinning is sometimes called self-spinning because the pneumatic spinning device 23 performs spinning only by applying whirling airflow.

[0089] When the pneumatic spinning device 23 performs yarn discharge spinning, compressed air is jetted from the auxiliary nozzle 135 before the spinning nozzle 131. Since the second passage 122 is formed so that the passage area increases towards downstream, the whirling airflow flowing downstream is formed in the second passage 122 by the jetting of the compressed air from the auxiliary nozzle 135. When the fiber bundle 34 is supplied from the draft device 21 to the pneumatic spinning device 23 in this state, the fiber bundle 34 is guided from the first passage 111 through the spinning chamber 113 to the second passage 122. Due to the action of the whirling airflow formed by the jetting of the compressed air from the auxiliary nozzle 135, a portion of the fiber bundle 34 passing through the second passage 122 is twisted for some extent.

[0090] Subsequently, the compressed air is jetted from the spinning nozzle 131, and whirling airflow is formed in the spinning chamber 113. This whirling airflow acts on a portion of the fiber bundle 34 passing through the spinning chamber 113.

[0091] Hereinafter, the behavior of the fibers will be described by focusing on the portion of the fiber bundle 34 passing through the spinning chamber 113. The downstream end of the fibers in the travelling direction constituting such portion of the fiber bundle 34 is twisted into and fixed to the core portion of the fiber bundle 34 inside the second passage 122. On the other hand, since the upstream end in the travelling direction is not twisted, this free end is separated so as to open from the core portion by the whirling airflow in the spinning chamber 113, and swirls in the state where the direction is reversed along the outer peripheral surface of the taper portion 124. Accordingly, the fibers wind around the core portion, and the fiber bundle 34 is twisted. The spun yarn 30 thus formed travels downstream by the whirling airflow formed by the compressed air jetted from the auxiliary nozzle 135, and is discharged from the pneumatic spinning device 23.

[0092] In the normal spinning, the jetting of air from the auxiliary nozzle 135 is not performed. In the normal spinning, the spun yarn 30 is wound downstream of the pneumatic spinning device 23, thereby realizing travel of the spun yarn 30 in the pneumatic spinning device 23. The principle of the normal spinning is basically the same as that of the yarn discharge spinning, and the fiber bundle 34 is twisted by applying the whirling airflow formed by the spinning nozzle 131.

[0093] Next, the configuration of the pneumatic spinning device 23 will be described in more detail with reference to FIGS. 4 and 5 and the like.

[0094] As illustrated in FIGS. 4 and 5, in the fiber guide 101, a plane portion 151 is formed on a part of the inner surface of the first passage 111. In FIG. 5, the plane portion 151 is illustrated by being emphasized by hatching. Among the inner surface of the first passage 111, the plane portion 151 is arranged on a side closer to the shaft center 108 of the spindle 102.

[0095] The plane portion 151 is arranged along the first direction from the upstream end 111a to the downstream end 111b of the first passage 111. A downstream end 151a of the plane portion 151 constitutes a part of the contour of the opening formed in the spinning chamber 113 by the first passage 111.

[0096] The plane portion 151 has a flat shape without twist. In other words, the angle of the linear portion obtained by cutting the plane portion 151 with any plane perpendicular to the first direction with respect to the first direction is constant from the upstream end to the downstream end 151a of the plane portion 151.

[0097] The plane portion 151 is arranged to deviate (to be displaced) with respect to the shaft center 108 of the spindle 102 in the direction perpendicular to the direction of the shaft center 108 of the spindle 102. Hereinafter, the direction perpendicular to the direction of the shaft center 108 of the spindle 102 may be referred to as the second direction.

[0098] Regarding the size of the above deviation, an interval S1 in the second direction between the downstream end 151a of the plane portion 151 and a center 122b of the upstream end 122a of the second passage 122, i.e., interval S1 in the second direction between the downstream end 151a of the plane portion 151 and the shaft center 108 of the spindle 102 is equal to or greater than 0.8 mm and equal to or less than 3.4 mm.

[0099] In the pneumatic spinning device 23 of the present embodiment, a known needle-shaped member is not arranged in the spinning chamber 113.

[0100] As a result of an experiment using the pneumatic spinning device 23, as long as the above-mentioned interval S1 is equal to or greater than 0.8 mm and equal to or less than 3.4 mm, the pneumatic spinning device 23 was able to continuously form the spun yarn 30 even if the pneumatic spinning device 23 does not include a known needle-shaped member when spinning is performed at a high spinning speed such as 400 m/min, or even 450 m/min for example. On the other hand, when the interval S1 was less than 0.8 mm, the pneumatic spinning device 23 was not able to stably form the spun yarn 30 continuously. When the interval S1 was greater than 3.4 mm, the pneumatic spinning device 23 was not able to perform spinning.

[0101] Therefore, when the above-mentioned interval S1 is equal to or greater than 0.8 mm and equal to or less than 3.4 mm, the pneumatic spinning device 23 can perform yarn discharge spinning. On the other hand, when the interval S1 is less than 0.8 mm or more than 3.4 mm, the pneumatic spinning device 23 is not able to perform yarn discharge spinning.

[0102] The interval S1 is magnitude (length) of the distance in which the plane portion 151 is arranged to deviate with respect to the shaft center 108 of the spindle 102. If the interval S1 is too small, bending of a travelling path of the fiber bundle 34 becomes loose, and hence the force with which the fiber bundle 34 is pressed against the plane portion 151 upstream of the spinning chamber 113 becomes weak. As a result, the restraint of the fiber bundle 34 becomes insufficient, and the twist of the fiber bundle 34 in the spinning chamber 113 propagates to the fiber bundle 34 located in the first passage 111. The fibers of the fiber bundle 34 having been weakly twisted by the propagation of the twist from downstream is not sufficiently separated and reversed even if subjected to the action of the whirling airflow in the spinning chamber 113 after passing through the first passage 111. Therefore, it is difficult to apply twists to the fiber bundle 34 well. On the other hand, if the interval S1 is too large, the inclination of the path of the fiber bundle 34 in the spinning chamber 113 becomes too much, and it is sometimes difficult to apply well the whirling airflow to the fiber bundle 34. Accordingly, setting the interval S1 within the above range is preferable.

[0103] The interval S1 can be set arbitrarily as long as it is equal to or greater than 0.8 mm and equal to or less than 3.4 mm. However, in consideration of stably performing high-speed spinning, the interval S1 is preferably equal to or greater than 0.9 mm and equal to or less than 1.5 mm, and more preferably 1 mm.

[0104] The plane portion 151 is arranged at a position where the plane portion 151 and the opening formed by the second passage 122 in the spinning chamber 113 do not appear to overlap each other when viewed in the first direction. As illustrated in FIG. 4, the plane portion 151 is arranged outside with respect to an edge of the second passage 122 (on the side far from the shaft center 108 of the spindle 102). However, the plane portion 151 may be arranged at a position where the plane portion 151 and the second passage 122 appear to overlap each other when viewed in the first direction.

[0105] In the present embodiment, as illustrated in FIG. 6A, the cross-sectional shape of the first passage 111 when the fiber guide 101 is cut with a plane perpendicular to the first direction is a quadrangle having a linear portion corresponding to the plane portion 151 as one side. Specifically, the quadrangle of the cross-sectional shape is an elongated rectangle, and all four corners are rounded in an arc shape. The linear portion described above corresponds to one of the long sides of the rectangle. When considering a line segment connecting a point bisecting the linear portion and the shaft center 108 of the spindle 102, this line segment and the linear portion are perpendicular.

[0106] The cross-sectional shape is line symmetric with respect to the above line segment. Therefore, in the cross-sectional shape, in the direction orthogonal to the linear portion corresponding to the plane portion 151, provided that the distance between the linear portion and the contour on the opposite side of the linear portion across the first passage 111 is called a gap length G, the gap length G is constant over the entire longitudinal direction of the linear portion (G1 = G2 = G3) .

[0107] As an alternative embodiment, as illustrated in FIG. 6B, the cross-sectional shape may be a D shape formed by a linear portion formed by the plane portion 151 and an arcuate portion continuous with the linear portion. In this cross-sectional shape, the gap length G at the longitudinal center of the linear portion is larger than the gap length G at both longitudinal ends (G1 > G2, G1 > G3).

[0108] As illustrated in FIG. 7A, the cross-sectional shape of the first passage 111 may be a quadrangle without rounded corners. As illustrated in FIG. 7B, the cross-sectional shape of the first passage 111 may be a triangle.

[0109] In the present embodiment, as illustrated in FIG. 4, a length L1 of the plane portion 151 in the first direction is equal to or greater than 3 mm and equal to or less than 12 mm.

[0110] An inner diameter D1 of the nozzle block 103 (strictly speaking, the inner diameter of the portion of the nozzle block 103 surrounding the taper portion 124) is equal to or greater than 3 mm and equal to or less than 9 mm.

[0111] In the configurations illustrated in FIGS. 3 to 5, the plane portion 151 is arranged parallel to the shaft center 108 of the spindle 102. However, as an alternative embodiment, as illustrated in FIG. 8, the plane portion 151 may be arranged to be inclined at an angle $\theta 1$ equal to or less than 10° with respect to the shaft center 108 of the spindle 102. Although FIG. 8 illustrates an example of inclination to one side, the plane portion 151 may be arranged to be inclined at the angle $\theta 1$ equal to or less than 10 degrees towards a side opposite to the example of FIG. 8.

[0112] As an alternative embodiment, as illustrated in FIG. 9, the downstream end 151a of the plane portion 151 may be arranged upstream relative to the downstream end 111b of the first passage 111 in the travelling direction of the fiber bundle 34.

[0113] In order to ensure the restraint of the fiber bundle 34, the length L1 of the plane portion 151 in the first direction is preferably half or more of a length L2 of the first passage 111 in the first direction.

[0114] In the configuration of FIG. 9, a downstream portion 161 is formed in the vicinity of the downstream end 111b on the inner surface of the first passage 111. The downstream portion 161 is inclined with respect to the plane portion 151, and linearly extends from the downstream end 151a of the plane portion 151 to a part of the downstream end 111b of the first passage 111 (position constituting a part of the contour of the downstream opening of the first passage 111). The plane portion 151 and the downstream portion 161 are connected in a polygonal line shape as illustrated by a connection portion 165 in FIG. 9, but may be connected by a smoothly curve (e.g., in an arc shape). The downstream portion 161 may be formed into a smooth curved surface shape instead of a flat surface.

[0115] The upstream end of the plane portion 151 may be arranged so as to be located downstream relative to the upstream end 111a of the first passage 111 in the travelling direction of the fiber bundle 34. In this case, as illustrated by the chain line in FIG. 9, an upstream portion 162 is formed in the vicinity of the upstream end 111a on the inner surface of the first passage 111. The upstream portion 162 is inclined with respect to the plane portion 151 and linearly extends from the upstream end 111a of the first passage 111 to the upstream end of the plane portion 151. The upstream end of the upstream portion 162 constitutes a part of the contour of the opening of the upstream end 111a of the first passage 111. The upstream end of the upstream portion 162 is arranged so as to be located away from the fiber bundle 34 passing through the first passage 111, compared with the connection portion between the upstream portion 162 and the plane portion 151. The plane portion 151 and the upstream portion 162 may be connected in a polygonal line shape, or may be connected by a smooth curve. The upstream portion 162 may be formed in a smooth curved surface shape instead of a flat surface.

[0116] Regarding the width of the passage through which the fiber bundle 34 passes, the cross-sectional area (passage area) of the first passage 111 when the fiber guide 101 is cut with a plane perpendicular to the first direction is equal to or greater than 4 mm^2 and equal to or less than 7 mm^2.

[0117] In the present embodiment, an interval S2 in the direction of the shaft center 108 of the spindle between the downstream end 111b of the first passage 111 and the upstream end 122a of the second passage 122 is equal to or greater than 0.3 mm and equal to or less than 7 mm. The interval S2 can be made, for example, equal to or greater than 1.1 mm and equal to or less than 2.5 mm, or can be made equal to or greater than 4.2 mm and equal to or less than 7 mm.

[0118] As described above, the pneumatic spinning device 23 of the present embodiment twists by the whirling airflow the fiber passing through the spinning chamber 113, thereby forming the spun yarn 30. The pneumatic spinning device 23 includes the fiber guide 101 and the spindle 102. The fiber guide 101 has the first passage 111 through which the fiber bundle 34 passes. The spindle 102 has the second passage 122 through which the fiber bundle 34 having passed through the first passage 111 is guided, and the spindle 102 is provided so as to face the fiber guide 101 across the spinning chamber 113. The first passage 111 is provided so as to extend linearly. The second passage 122 is provided so as to extend along the shaft center 108 of the spindle 102 with the shaft center 108 as a center. The downstream end 111b where the first passage 111 opens into the spinning chamber 113 and the upstream end 122a where the second passage 122 opens into the spinning chamber 113 are arranged at the interval S2 in the direction of the shaft center 108 of the spindle 102. The inner surface of the first passage 111 has the flat plane portion 151 on the side close to the shaft center 108 of the spindle 102. The angle of the linear portion obtained by cutting the plane portion 151 with any plane perpendicular to the first direction in which the first passage 111 extends with respect to the first direction is constant between the upstream end 111a and the downstream end 111b of the first passage 111. The plane portion 151 is arranged to deviate with respect to the shaft center 108 of the spindle 102 in the second direction perpendicular to the direction of the shaft center 108 of the spindle 102. The interval S1 in the second direction between the downstream end 151a of the plane portion 151 and the shaft center 108 of the spindle 102 is equal to or greater than 0.8 mm and equal to or less than 3.4 mm.

[0119] Accordingly, the fiber bundle 34 to be supplied to the first passage 111 is restrained by coming into contact with the flat plane portion 151 before reaching the spinning chamber 113. Since the plane portion 151 is arranged to deviate with respect to the shaft center 108 of the spindle 102, when the fiber bundle 34 is appropriately bent between the first passage 111 and the second passage 122, the fiber bundle 34 is pressed well with respective to the plane portion 151. Therefore, even when the fiber bundle 34 is twisted by the whirling airflow in the spinning chamber 113, it is possible to effectively reduce propagation of the twist to the upstream in the travelling direction. Thus, since the fibers are not twisted upstream of the spinning chamber 113, separation and reversal of the fibers in the spinning chamber 113 can be performed satisfactorily. As a result, spinning can be stably performed.

[0120] In the pneumatic spinning device 23 of the present embodiment, the interval S1 in the second direction between the downstream end 151a of the plane portion 151 and the shaft center 108 of the spindle 102 is equal to or greater than 0.9 mm and equal to or less than 1.5 mm.

[0121] In this case, the propagation of the twist described above can be particularly effectively reduced.

[0122] In the pneumatic spinning device 23 of the present embodiment, the plane portion 151 is arranged at a position where the plane portion 151 and the opening formed by the second passage 122 in the spinning chamber 113 do not appear to overlap each other when viewed in the first direction.

[0123] Accordingly since the fiber bundle 34 can be reliably bent between the first passage 111 and the second passage 122, propagation of the twist to the upstream can be reduced well.

[0124] In the pneumatic spinning device 23 of the present embodiment, the cross-sectional shape of the first passage 111 when the fiber guide 101 is cut with a plane perpendicular to the first direction can be formed into the shape illustrated in FIGS. 6A or 6B, for example. In the cross-sectional shape illustrated in FIG. 6A, provided that the distance in the direction orthogonal to the linear portion corresponding to the plane portion 151 between the linear portion and the contour on the opposite side of the linear portion across the first passage 111 is called the gap length G, the gap length G is constant over the entire longitudinal direction of the linear portion ($G1 = G2 = G3$). In the cross-sectional shape illustrated in FIG. 6B, the gap length G at the longitudinal center of the linear portion corresponding to the plane portion 151 is larger than the gap length G at the longitudinal ends of the linear portion ($G1 > G2$, $G1 > G3$) .

[0125] Accordingly, the fiber bundle 34 can pass smoothly while being restrained by the plane portion 151 in the first passage 111.

[0126] In the pneumatic spinning device 23, the cross-sectional shape of the first passage 111 is a quadrangle shape or a D shape.

[0127] Accordingly, a simple configuration of the first passage 111 can be realized.

[0128] In the pneumatic spinning device 23, the length L1 of the plane portion 151 in the first direction is equal to or greater than 3 mm and equal to or less than 12 mm.

[0129] Accordingly, the plane portion 151 can reliably exert the restraining action on the fiber bundle 34.

[0130] In the pneumatic spinning device 23 of the present embodiment, the plane portion 151 is arranged to be parallel to the shaft center 108 of the spindle 102 or to be inclined at the angle $\theta 1$ equal to or less than 10° with respect to the shaft center 108 of the spindle 102.

[0131] Accordingly, the fiber bundle 34 can be guided in the first passage 111 well to the spinning chamber 113.

[0132] In the pneumatic spinning device 23 of the alternative embodiment of FIG. 9, the downstream end 151a of the plane portion 151 is positioned upstream the downstream end 111b of the first passage 111. The inner surface of the first passage 111 has the plane portion 151 and the downstream portion 161. The downstream portion 161 is inclined or curved with respect to the plane portion 151 and extends from the downstream end 151a of the plane portion 151 to the downstream end 111b of the first passage 111. The length L1 of the plane portion 151 in the first direction is half or more of the length L2 of the first passage 111 in the first direction.

[0133] Accordingly, the fiber bundle 34 can be guided well by the first passage 111 into the spinning chamber 113.

[0134] In the pneumatic spinning device 23 of the present embodiment, the cross-sectional area (passage area) of the first passage 111 when the fiber guide 101 is cut with a plane perpendicular to the first direction is equal to or greater than 4 mm^2 and equal to or less than 7 mm^2.

[0135] Accordingly, the fiber bundle 34 can pass through the first passage 111 well.

[0136] In the pneumatic spinning device 23 of the present embodiment, the interval S2 in the direction of the shaft center 108 of the spindle 102 between the downstream end 111b of the first passage 111 and the upstream end 122a of the second passage 122 is equal to or greater than 0.3 mm and equal to or less than 7 mm.

[0137] Accordingly, the fiber bundle 34 can be guided well to the second passage 122. When the fiber bundle 34 is guided to the second passage 122, to the fibers can be reliably reversed and swirled by the whirling airflow in the spinning chamber 113.

[0138] In the pneumatic spinning device 23 of the present embodiment, the interval S2 can be equal to or greater than 1.1 mm and equal to or less than 2.5 mm.

[0139] Accordingly, the fibers can be reliably reversed and swirled in the spinning chamber 113 even if the spinning speed is high.

[0140] In the pneumatic spinning device 23 of the present embodiment, the interval S2 can be equal to or greater than 4.2 mm and equal to or less than 7 mm.

[0141] In this case, spinning can be performed while the fibers are reversed well.

[0142] The pneumatic spinning device 23 of the present embodiment includes the nozzle block 103. The nozzle block 103 has the spinning nozzle 131 through which air can pass and arranged so as to form the spinning chamber 113 together with the fiber guide 101 and the spindle 102. The nozzle block 103 has an inner surface facing the spinning chamber 113. The inner surface of the nozzle block 103 is circular when viewed in a direction along the shaft center 108 of the spindle 102. The inner diameter D1 of the nozzle block 103 in this inner surface portion is equal to or greater than 3 mm and equal to or less than 9 mm.

[0143] Accordingly, spinning can be performed well.

[0144] In the pneumatic spinning device 23 of the present embodiment, the spindle 102 is provided with the auxiliary nozzle (passage hole) 135 through which air can pass. The auxiliary nozzle 135 opens into the second passage 122.

[0145] Accordingly, air can be supplied from the auxiliary nozzle 135 to the second passage 122 such that the fiber bundle 34 can travel through the second passage 122. Therefore, it is possible to reliably perform the yarn discharge spinning.

[0146] In the pneumatic spinning device 23 of the present embodiment, the plurality of auxiliary nozzles 135 are provided around the second passage 122.

[0147] Accordingly, airflow can be acted upon the fiber bundle 34 in the second passage 122 in a well-balanced manner, and the fiber bundle 34 can be delivered downstream.

[0148] The pneumatic spinning machine 1 of the present embodiment includes the pneumatic spinning device 23. The pneumatic spinning machine 1 further includes the suction pipe 87, the winding device 27, the suction mouth 89, and the yarn joining device 85. The suction pipe 87 catches the spun yarn 30 formed by the pneumatic spinning device 23 at the time of yarn discharge spinning. The winding device 27 winds, around the package 73, the spun yarn 30 formed by the pneumatic spinning device 23. The suction mouth 89 catches the spun yarn 30 wound around the package 73. The yarn joining device 85 joins the spun yarns 30 caught by the suction pipe 87 and the suction mouth 89.

[0149] Thus, in the pneumatic spinning machine 1, which performs yarn discharge spinning, even when the fibers are twisted by the whirling airflow, it is possible to effectively reduce propagation of the twist to the fibers located upstream of the twisted fibers in the travelling direction.

[0150] While the preferred embodiment of the present invention has been described above, the structure described above can be modified as below. The above embodiment and the following modifications may be combined as appropriate.

[0151] The pneumatic spinning device (pneumatic spinning machine) may be configured to bring the spun yarn into a continuous state by piecing after the spun yarn becomes in a divided state. The piecing is a method of bringing the spun yarn into a continuous state by sending back, to the pneumatic spinning device, the spun yarn from the package, and then restarting the draft by the draft device and the spinning by the pneumatic spinning device. The nozzle (passage hole) through which air is jetted for piecing may be formed in the hollow guide shaft body. That is, the auxiliary nozzle 135 described above may be configured as such a nozzle by forming the direction of the nozzle to be different from that of the above embodiment. When piecing is performed, the yarn joining device can be omitted.

[0152] The size, shape, and the like of the first passage 111 can be changed as appropriate. For example, the cross-sectional shape of the first passage 111 may be an asymmetrical shape in place of the line symmetrical shape illustrated in FIGS. 6A, 6B, 7A and 7B.

[0153] As long as the angle of the linear portion corresponding to the plane portion 151 with respect to the first direction is constant, the cross-sectional shape obtained by cutting the first passage 111 with any plane perpendicular to the first direction may not be uniform.

[0154] The auxiliary nozzle 135 may be omitted in the spindle 102.

[0155] Although the inner surface 103a of the nozzle block 103 is configured to have a cylindrical shape, it may include a taper shape widening towards downstream and/or a step formed on the inner surface 103a.

[0156] Although the fiber guide 101 and the nozzle block 103 are illustrated as separate members in the drawings, they may be formed by one member.

[0157] The configuration to draw the spun yarn 30 from the pneumatic spinning device 23 is not limited to the yarn accumulating device 25, and may be a delivery roller pair. In this case, at least any of the yarn accumulating device 25, a slack tube using suction airflow, and a mechanical compensator may be provided downstream of the delivery roller pair.

[0158] The configuration related to yarn joining may be provided in each spinning unit 7 instead of the yarn joining cart 9.

[0159] The "yarn" includes at least the spun yarn 30 and a roving yarn.

[0160] The downstream end surface 115b of the body 115 may not be a flat surface. For example, at least one protrusion projecting towards the spindle 102 may be formed on the downstream end surface 115b. This protrusion may have any shape and size. When the surface of the projection end of the protrusion is substantially connected to the downstream end 111b of the first passage 111, the height of the surface of the projection end can be used as a reference (one end) of the interval S2 described above.

[0161] A concave and/or a recess may be formed on a part or entirety of the downstream end surface 115b. The concave and/or the recess can be realized by forming elongated linear grooves and/or curved grooves, for example. When the concave and/or the recess are connected to the downstream end 111b of the first passage 111, the average height of the concave and/or the recess at the connection portion may be used as a reference of the interval S2 described above.

[0162] In consideration of the above teachings, it is obvious that the present invention can have many modifications and variations. Therefore, it should be understood that within the scope of the appended claims, the present invention can be carried out by the method other than as described herein.

Claims

1. A pneumatic spinning device (23) that forms a yarn (30) by twisting, by whirling airflow, fibers passing through a spinning chamber (113), the pneumatic spinning device (23) comprising:

    a fiber guiding section (101) having a first passage (111) through which a fiber bundle (34) passes; and
    a hollow guide shaft body (102) that has a second passage (122) through which the fiber bundle (34) having passed through the first passage (111) is guided, and that is provided so as to face the fiber guiding section (101) across the spinning chamber (113), wherein
    the first passage (111) is provided so as to extend linearly,
    the second passage (122) is provided so as to extend along a shaft center (108) of the hollow guide shaft body (102) with the shaft center (108) as a center,
    a downstream end (111b) where the first passage (111) opens into the spinning chamber (113) and an upstream end (122a) where the second passage (122) opens into the spinning chamber (113) are arranged with an interval (S1) in a direction of the shaft center (108) of the hollow guide shaft body (102),
    an inner surface of the first passage (111) has a flat plane portion (151) on a side close to the shaft center (108) of the hollow guide shaft body (102),
    an angle of a linear portion obtained by cutting the plane portion (151) with any plane perpendicular to a first direction in which the first passage (111) extends with respect to the first direction is constant between an upstream end (111a) and the downstream end (111b) of the first passage (111),
    the plane portion (151) is arranged to deviate with respect to the shaft center (108) of the hollow guide shaft body (102) in a second direction perpendicular to a direction of the shaft center (108) of the hollow guide shaft body (102), and

an interval (S1) in the second direction between a downstream end (151a) of the plane portion (151) and the shaft center (108) of the hollow guide shaft body (102) is equal to or greater than 0.8 mm and equal to or less than 3.4 mm.

2. The pneumatic spinning device (23) as claimed in claim 1, wherein the interval (S1) in the second direction between the downstream end (151a) of the plane portion (151) and the shaft center (108) of the hollow guide shaft body (102) is equal to or greater than 0.9 mm and equal to or less than 1.5 mm.

3. The pneumatic spinning device (23) as claimed in claim 1 or 2, wherein the plane portion (151) is arranged at a position where the plane portion (151) and an opening formed by the second passage (122) in the spinning chamber (113) do not appear to overlap each other when viewed in the first direction.

4. The pneumatic spinning device (23) as claimed in any one of claims 1 to 3, wherein in a cross-sectional shape of the first passage (111) when the fiber guiding section (101) is cut with a plane perpendicular to the first direction, provided that a distance in a direction orthogonal to a linear portion corresponding to the plane portion (151) between the linear portion and a contour on an opposite side of the linear portion across the first passage (111) is called a gap length (G), a gap length (G) is constant over an entire longitudinal direction of the linear portion, or a gap length (G1) at a longitudinal center of the linear portion is larger than a gap length (G2; G3) at a longitudinal end.

5. The pneumatic spinning device (23) as claimed in claim 4, wherein a cross-sectional shape of the first passage (111) is a quadrangle shape or a D shape.

6. The pneumatic spinning device (23) as claimed in any one of claims 1 to 5, wherein a length of the plane portion (151) in the first direction is equal to or greater than 3 mm and equal to or less than 12 mm.

7. The pneumatic spinning device (23) as claimed in any one of claims 1 to 6, wherein the plane portion (151) is arranged so as to be in parallel to the direction of the shaft center (108) of the hollow guide shaft body (102) or to be inclined at an angle (θ1) equal to or less than 10° with respect to the direction of the shaft center (108) of the hollow guide shaft body (102).

8. The pneumatic spinning device (23) as claimed in claim 6, wherein
the downstream end (151a) of the plane portion (151) is positioned in the first passage (111) and upstream of the downstream end (111b) of the first passage (111),
an inner surface of the first passage (111) has the plane portion (151), and
a downstream portion (161) inclined or curved with respect to the plane portion (151) and extending from the downstream end (151a) of the plane portion (151) to the downstream end (111b) of the first passage (111), and
a length (L1) of the plane portion (151) in the first direction is equal to or greater than half a length (L2) of the first passage (111) in a first direction.

9. The pneumatic spinning device (23) as claimed in any one of claims 1 to 8, wherein a passage area of the first passage (111) when the fiber guiding section (101) is cut with a plane perpendicular to the first direction is equal to or greater than 4 mm^2 and equal to or less than 7 mm^2.

10. The pneumatic spinning device (23) as claimed in any one of claims 1 to 9, wherein an interval (S2) in the first direction between a downstream end (111b) of the first passage (111) and an upstream end (122a) of the second passage (122) is equal to or greater than 0.3 mm and equal to or less than 7 mm.

11. The pneumatic spinning device (23) as claimed in claim 10, wherein the interval (S2) in the first direction between the downstream end (111b) of the first passage (111) and the upstream end (122a) of the second passage (122) is equal to or greater than 1.1 mm and equal to or less than 2.5 mm.

12. The pneumatic spinning device (23) as claimed in claim 10, wherein the interval (S2) in the first direction between the downstream end (111b) of the first passage (111) and the upstream end (122a) of the second passage (122) is equal to or greater than 4.2 mm and equal to or less than 7 mm.

13. The pneumatic spinning device (23) as claimed in any one of claims 1 to 12, comprising:

a casing (103) having a spinning nozzle (131) through which air can pass and arranged so as to form the spinning chamber (113) together with the fiber guiding section (101) and the hollow guide shaft body (102), wherein
the casing (103) has an inner surface facing the spinning chamber (113),
the inner surface of the casing (103) is circular when viewed in a direction along the shaft center (108) of the hollow guide shaft body (102), and
an inner diameter of the casing (103) in the inner surface portion is equal to or greater than 3 mm and equal to or less than 9 mm.

14. The pneumatic spinning device (23) as claimed in

any one of claims 1 to 13, wherein the hollow guide shaft body (102) is formed with a passage hole (135) through which air can pass, and the passage hole (135) opens into the second passage (122), wherein a plurality of the passage holes (135) are preferably provided around the second passage (122).

15. A pneumatic spinning machine (1) including the pneumatic spinning device (23) as claimed in any one of claims 1 to 14, comprising:

a first catching device (87) adapted to catch a yarn (30) formed by the pneumatic spinning device (23) at a time of yarn discharge spinning;
a winding device (27) adapted to wind a yarn (30) formed by the pneumatic spinning device (23);
a second catching device (89) adapted to catch a wound yarn (30); and
a yarn joining device (85) adapted to join the yarn (30) caught by the first catching device (87) and the yarn (30) caught by the second catching device (89).

FIG. 1

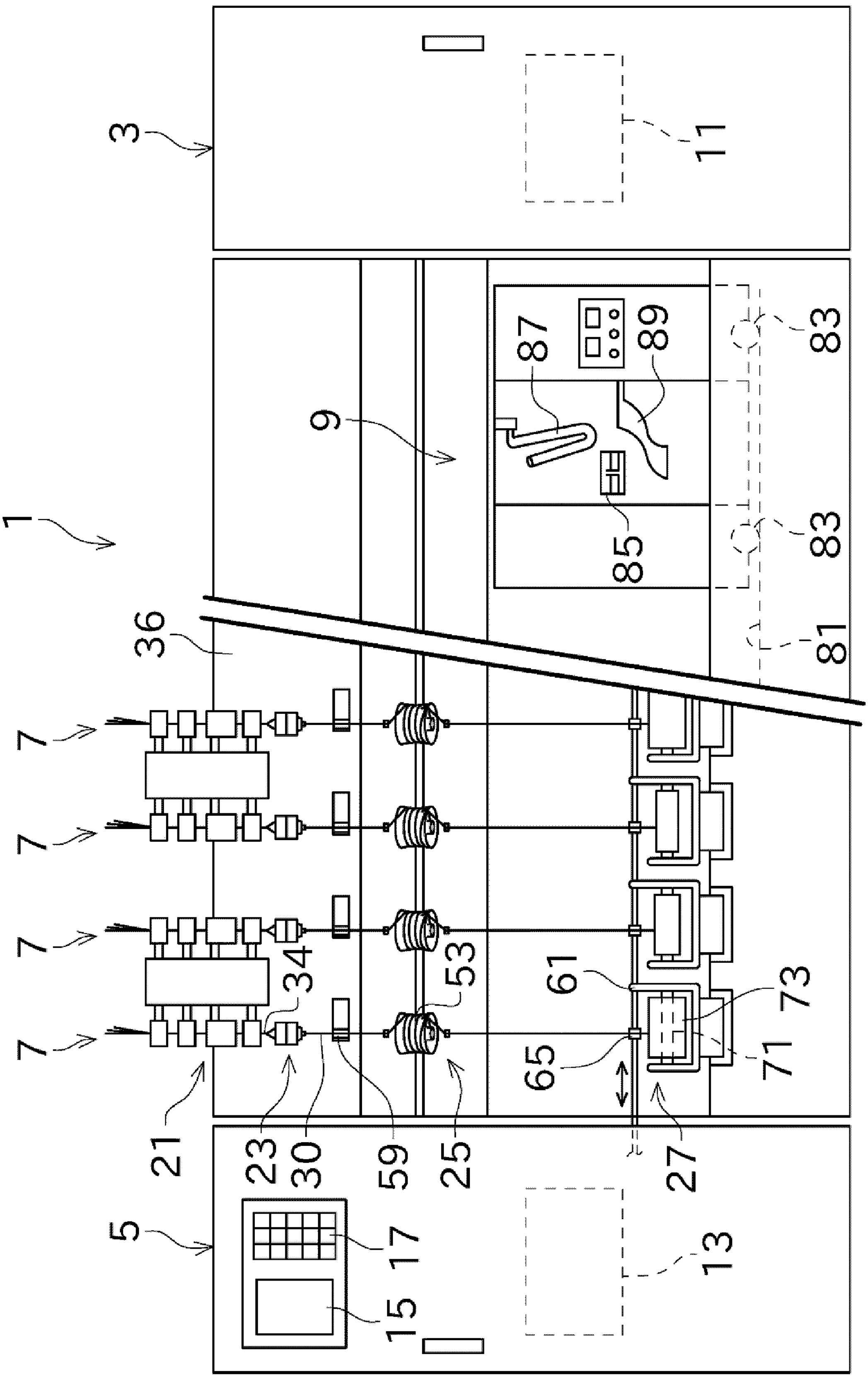
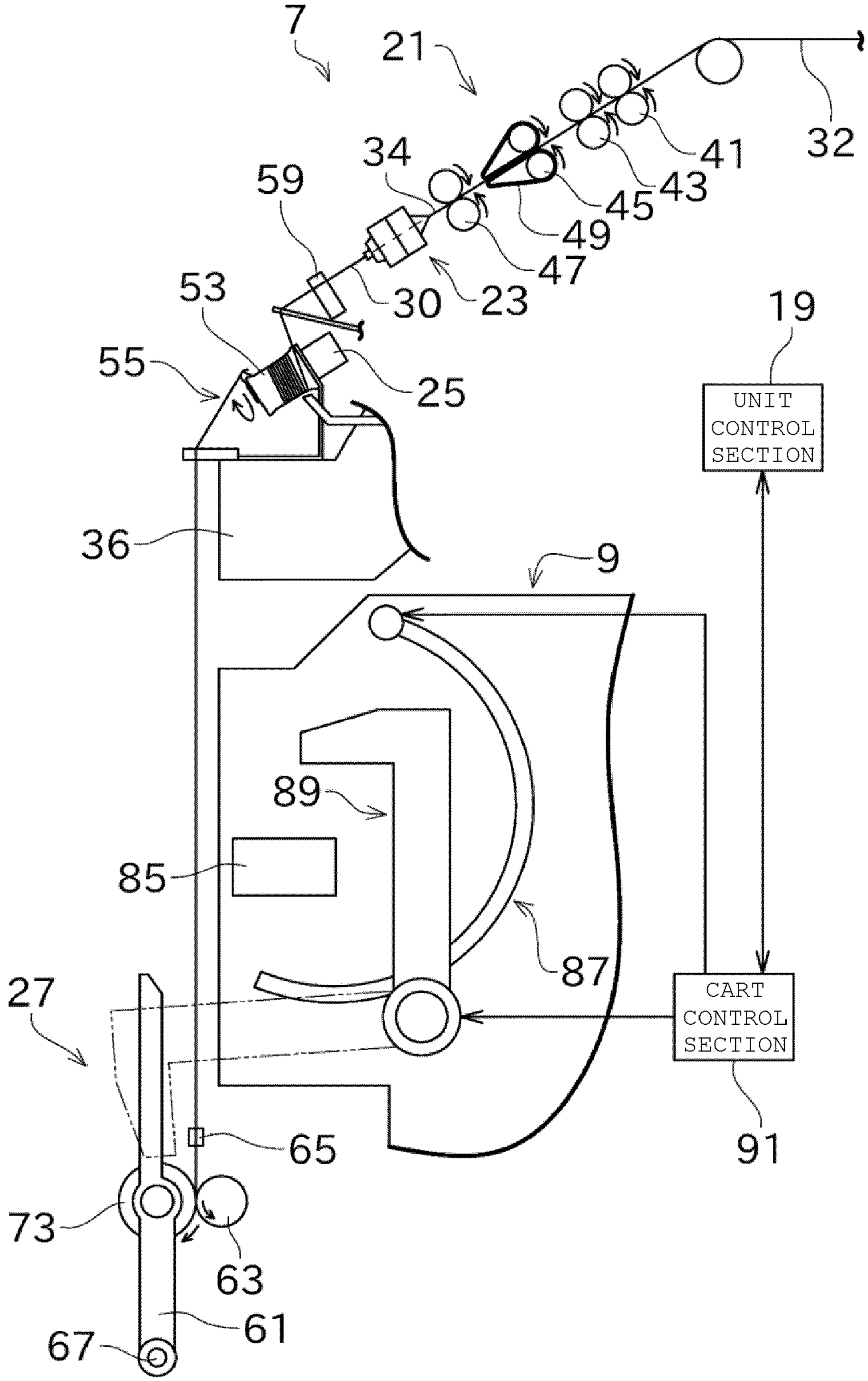


FIG. 2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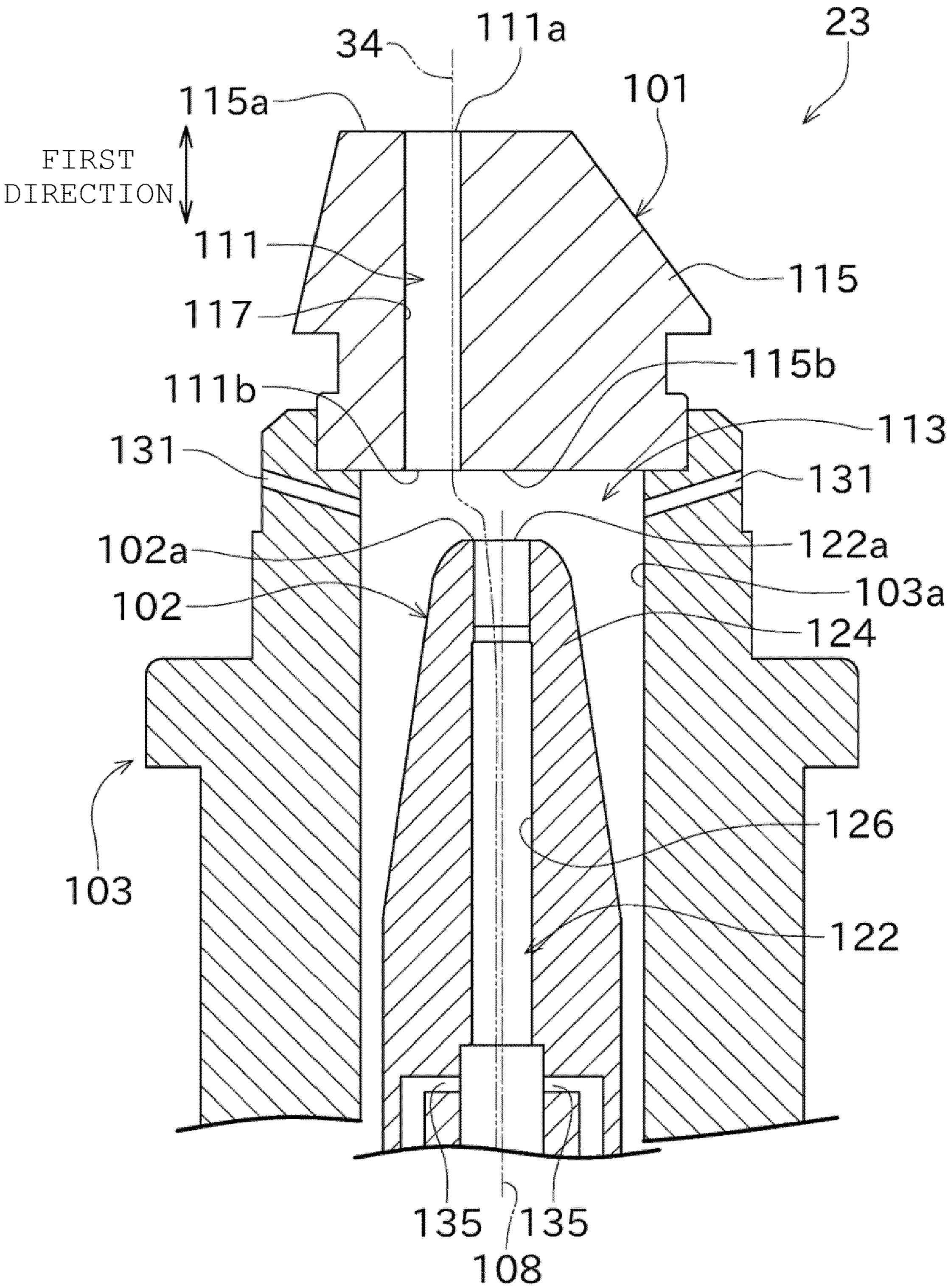
9
89
85
87
27
CART CONTROL SECTION
91
65
73
63
61
67

FIG. 3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102
124
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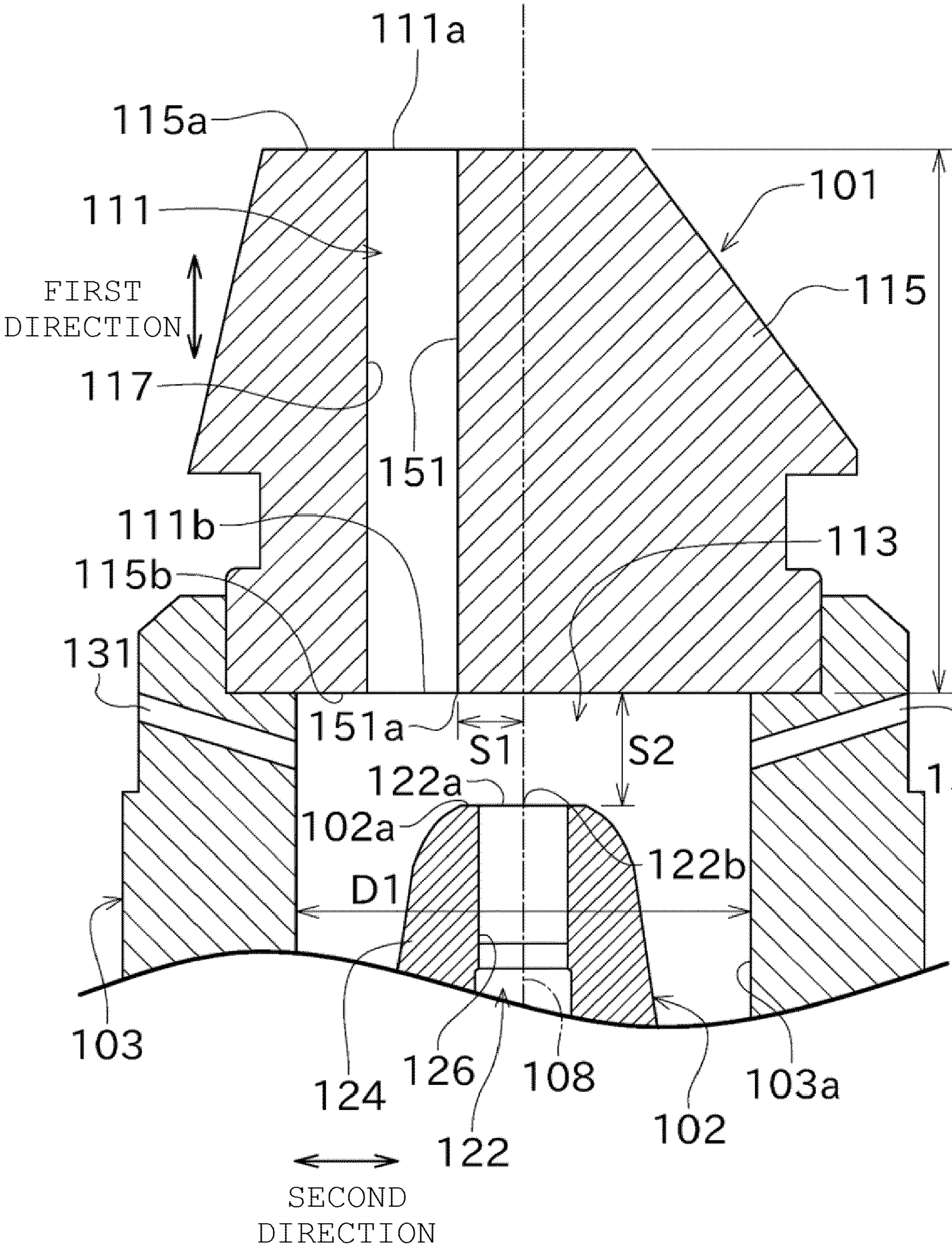
103
122
135
135
108

FIG. 4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151a
S1
S2
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122b
D1
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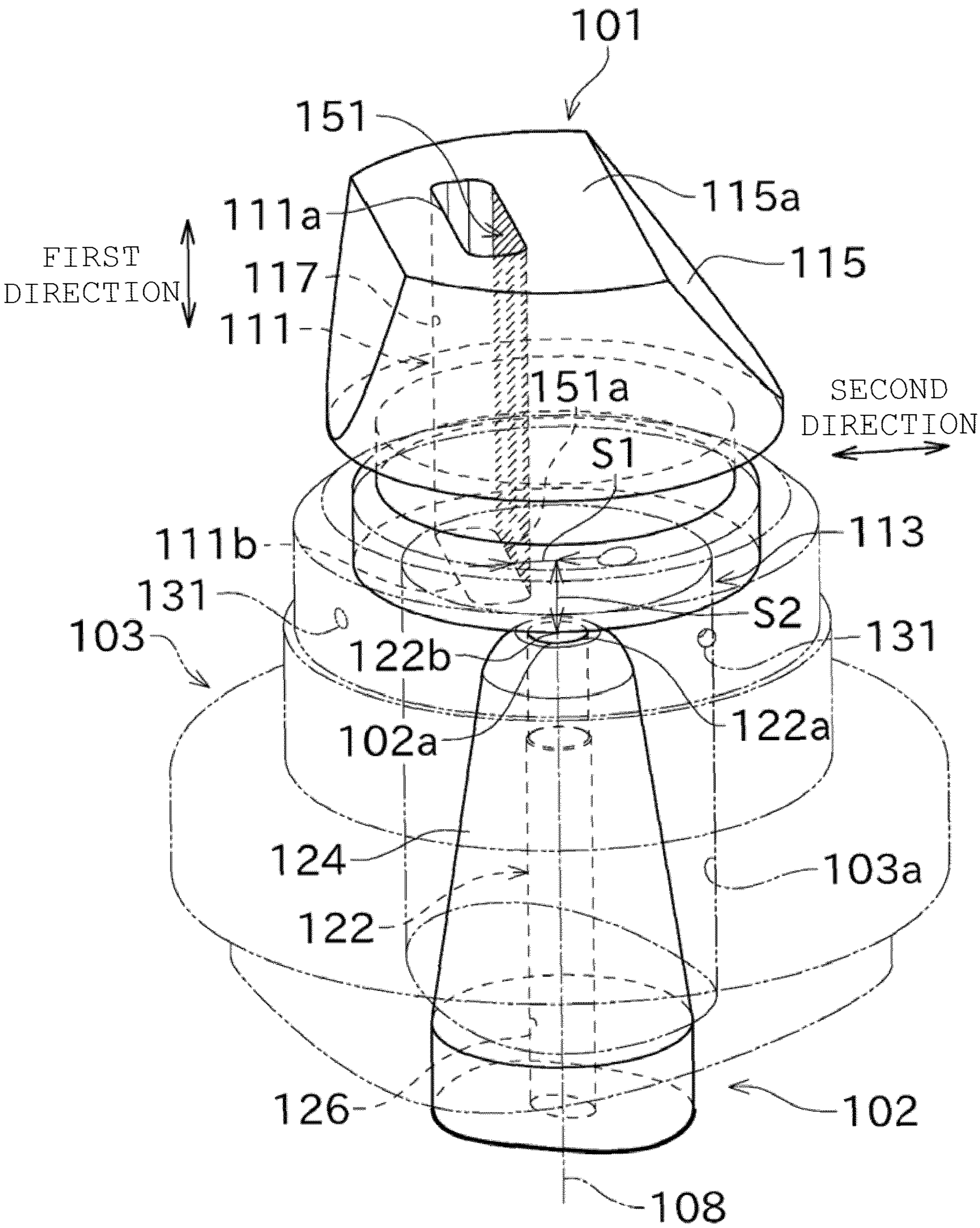
124
126
108
103a
102
122
SECOND
DIRECTION

FIG. 5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151a
SECOND DIRECTION
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S2
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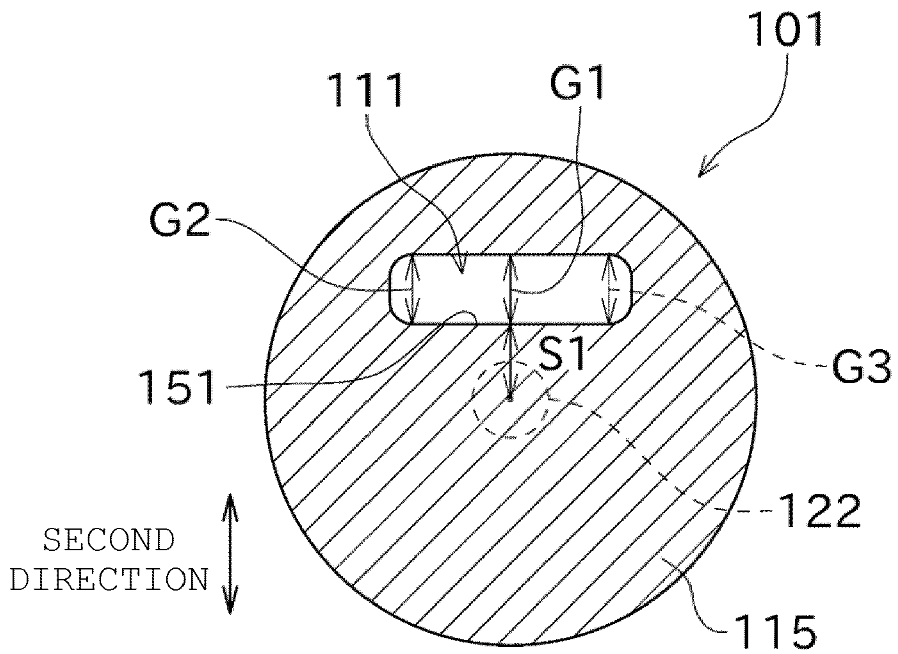
122b
122a
102a
124
103a
122
126
102
108

FIG. 6A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G2
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S1
G3
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SECOND
DIRECTION
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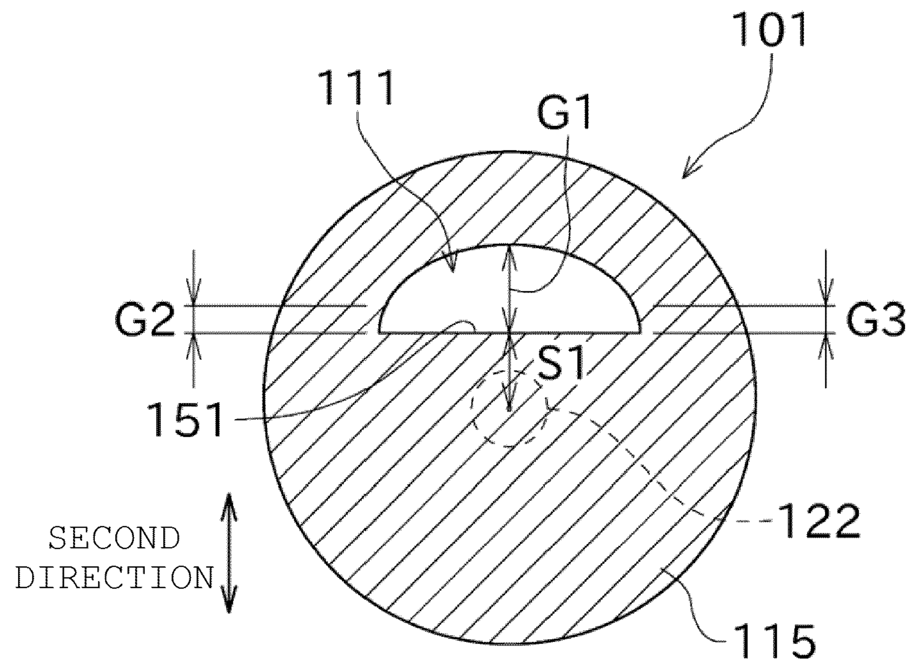
FIG. 6B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G2
G3
S1
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122
SECOND
DIRECTION
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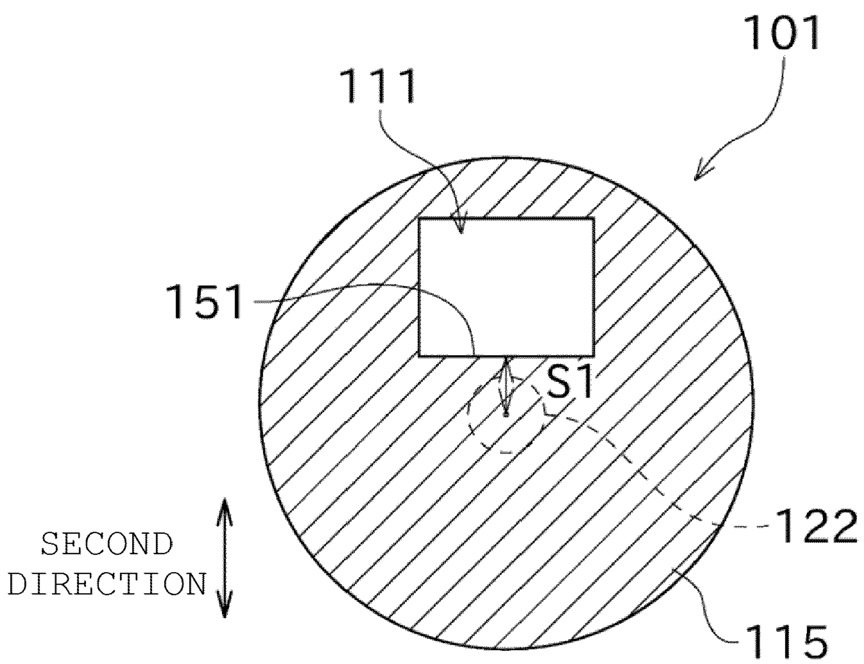
FIG. 7A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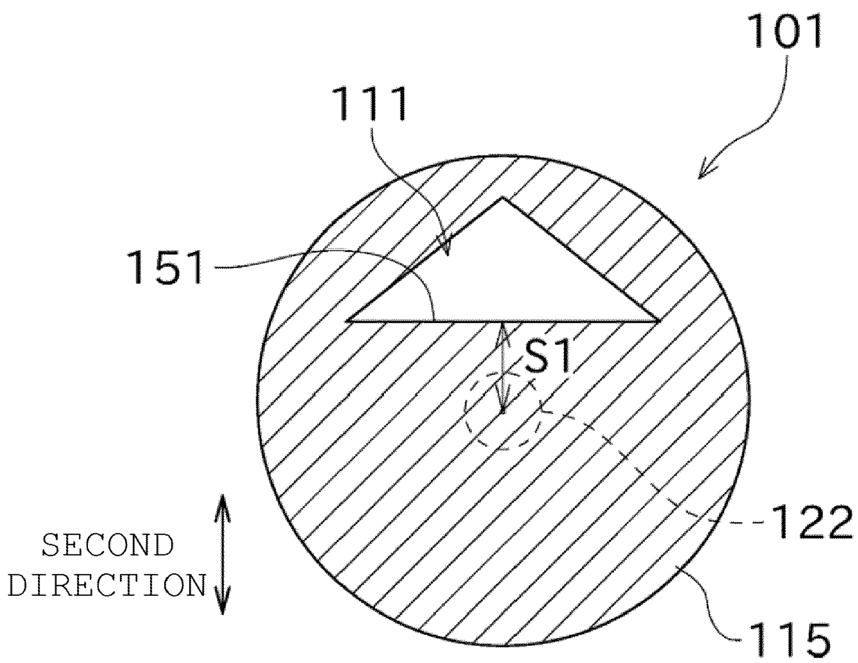
SECOND
DIRECTION

FIG. 7B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S1
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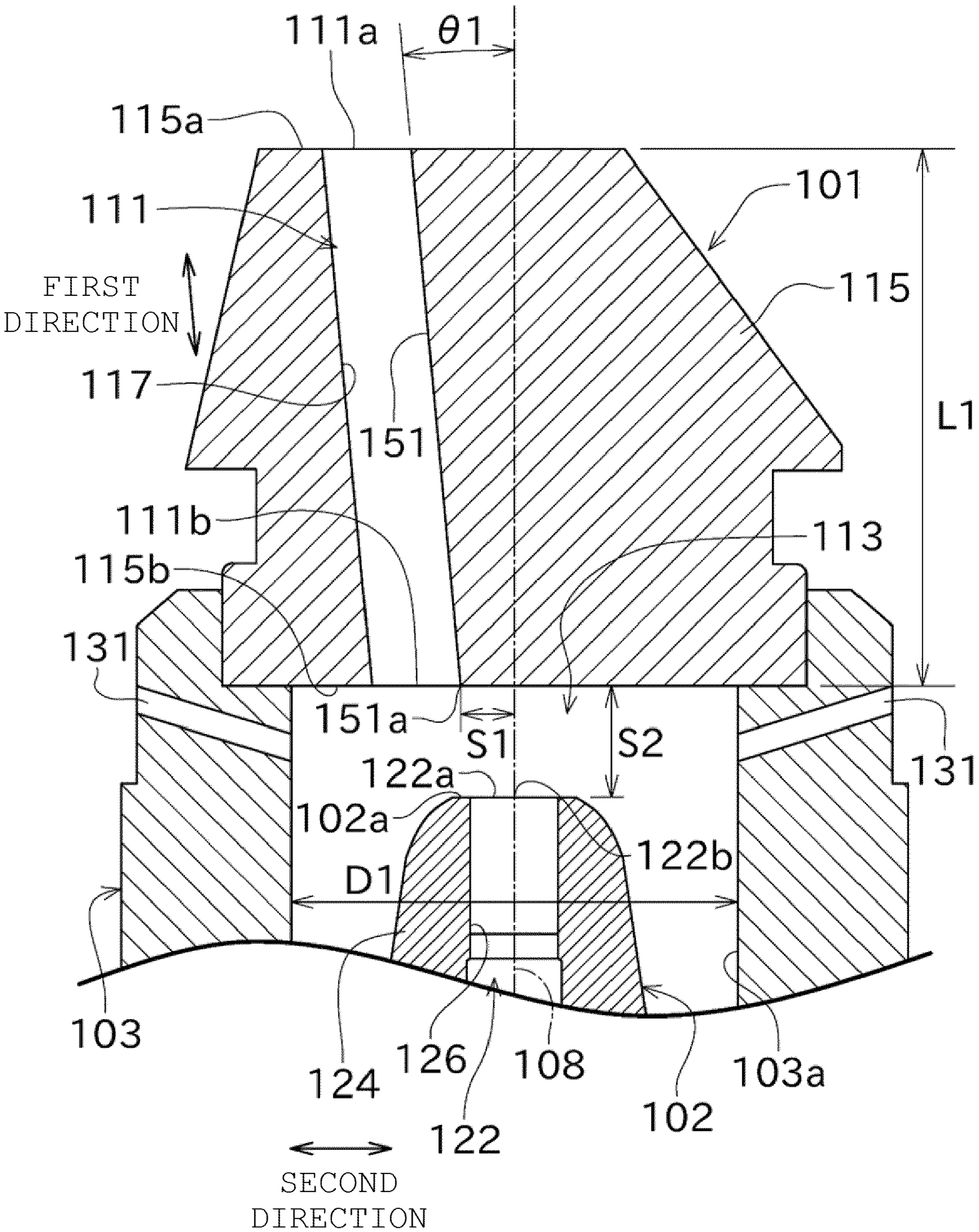
SECOND
DIRECTION

FIG. 8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115b
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S2
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122b
D1
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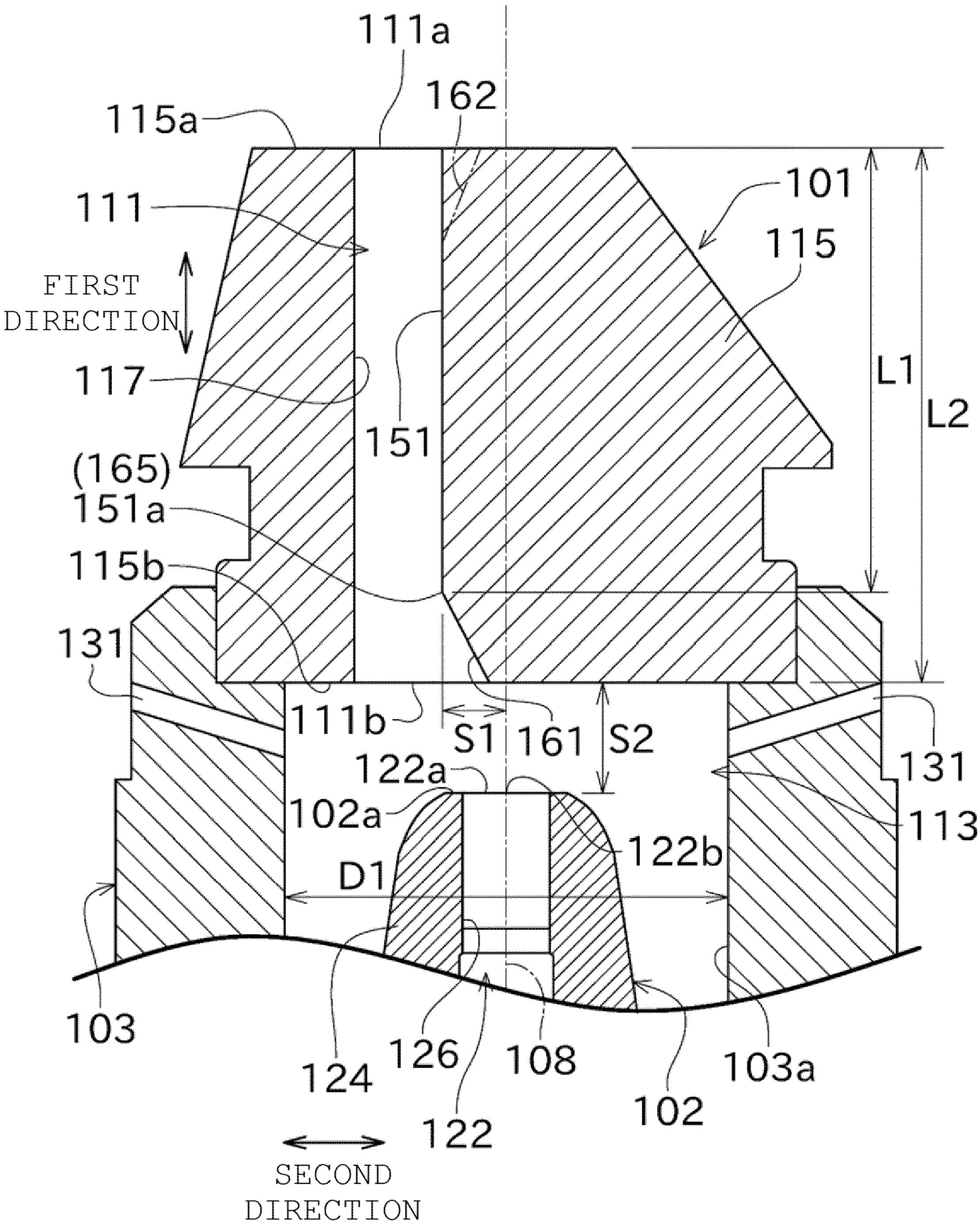
108
103a
122
102
SECOND DIRECTION

FIG. 9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115a
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S1
161
S2
131
122a
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102a
122b
D1
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108
103a
102
122
SECOND
DIRECTION

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EUROPEAN SEARCH REPORT

Application Number
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X	DE 10 2016 121331 A1 (RIETER AG MASCHF [CH]) 9 May 2018 (2018-05-09) * paragraph [0015]; claim 2; figures 2-3 * -----	1-3,15	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	28 January 2021	Todarello, Giovanni

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