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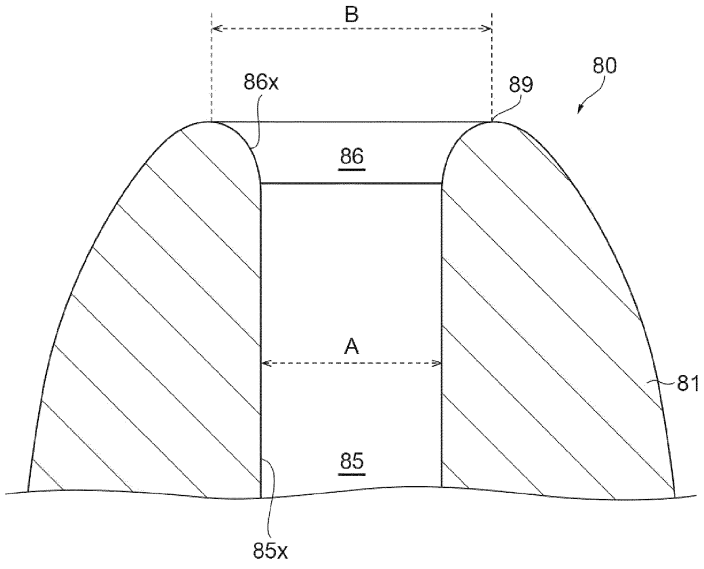
(54) **HOLLOW GUIDE SHAFT, PNEUMATIC SPINNING DEVICE, AND SPINNING MACHINE**

(57) The hollow guide shaft has a shaft portion having a fiber introduction hole into which fibers are introduced and a fiber passage that is continuous with the fiber introduction hole and extends along an axial direction. Where A is an inner diameter of the fiber passage and B is a diameter of an introduction opening serving as an opening end of the fiber introduction hole, $1.5 \leq B/A \leq 1.8$ is established.

Fig.6



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Description

TECHNICAL FIELD

[0001] One aspect of the present invention relates to a hollow guide shaft, a pneumatic spinning device, and a spinning machine.

BACKGROUND

[0002] A pneumatic spinning device is known that generates yarn by twisting fibers with a swirling air flow. Such a pneumatic spinning device includes a hollow guide shaft including a shaft portion having a fiber introduction hole into which fibers are introduced and a fiber passage that is continuous with the fiber introduction hole and extends along an axial direction (for example, refer to Japanese Unexamined Utility Model Publication No. H4-13063). A downstream end of fibers introduced into the fiber introduction hole is wound into preceding fibers sequentially to become a core (core fibers) of yarn to be generated, and an upstream end of the fibers is swung by the swirling air flow to be sequentially wound around the core fibers (wound fibers). Part of a single fiber becomes the core fiber and a different part becomes the wound fiber.

SUMMARY

[0003] Regarding the hollow guide shaft described above, while various types of yarn are required to be generated, for example, in order to make the texture of yarn softer, yarn with hairiness (specifically, a total length of the hairiness) increased above a specified value is desired to be generated in some cases.

[0004] An aspect of the present invention is to provide a hollow guide shaft, a pneumatic spinning device and a spinning machine capable of generating yarn with hairiness increased above a specified value.

[0005] As a result of diligent study by the present inventor, the following findings were obtained concerning behavior between core fibers and wound fibers that are wound around the core fibers when fibers are introduced into the fiber introduction hole in the hollow guide shaft. Specifically, it was found that where A is an inner diameter of the fiber passage and B is a diameter of an introduction opening serving as an opening end of the fiber introduction hole, as B/A becomes larger, a winding start position, where the wound fibers that are to be introduced into the fiber introduction hole start winding around the core fibers (hereinafter simply referred to as "winding start position"), can be separated from the core fibers, winding force with which the wound fibers are wound around the core fibers can be reduced, and tightness of the yarn to be generated can be reduced while increasing the hairiness. In this case, findings were obtained that, especially when B/A is 1.5 or higher, the hairiness can be increased above a required specified value. One aspect of the present invention is made based on the findings described above.

(1) A hollow guide shaft according to an aspect of the present invention is a hollow guide shaft including a shaft portion having a fiber introduction hole into which fibers are introduced and a fiber passage that is continuous with the fiber introduction hole and extends along an axial direction, in which, where A is an inner diameter of the fiber passage and B is a diameter of an introduction opening serving as an opening end of the fiber introduction hole, $1.5 \leq B/A \leq 1.8$ is established.
With such a hollow guide shaft, since B/A is 1.5 or more, it is possible to generate yarn with hairiness increased above a specified value (for example, a value corresponding to a threshold determined from required quality, etc., in a case where the yarn is generated at a general spinning speed). If B/A is too large, it is difficult for wound fibers to be wound around the core fibers, and the possibility of difficulty in generating yarn increases, and thus, the B/A is set to 1.8 or less, to reliably generate yarn. Thus, it is possible to reliably generate the yarn with hairiness increased above a specified value.
(2) In the hollow guide shaft described in (1), $1.6 \leq B/A \leq 1.75$ may be established. In this case, the winding force can be further reduced, the hairiness of the yarn to be generated can be further increased, and the wound fibers can be gently and securely wound around the core fibers to generate yarn more reliably.
(3) In the hollow guide shaft described in (1) or (2) above, an inner surface of the fiber introduction hole may have a curved surface that widens toward an opening side, and where R is a radius of curvature of the curved surface, $0.25\ \text{mm} \leq R \leq 0.35\ \text{mm}$ may be established. In this case, as the fibers are introduced into the fiber introduction hole, the fibers easily float from the inner surface of the fiber introduction hole, and thus resistance applied to the fibers can be reduced and the winding force can be decreased. In this manner, it is possible to further increase the hairiness of the yarn to be generated.
(4) In the hollow guide shaft described in any one of (1) to (3) above, an inner surface of the fiber introduction hole may have a flat surface that widens toward the opening side. In this case, the inner surface of the fiber introduction hole can be easily machined and the fiber introduction hole can be formed with high precision.
(5) In the hollow guide shaft described in any one of (1) through (4) above, where D is an outer diameter of the shaft portion, $2.8\ \text{mm} \leq D \leq 4.0\ \text{mm}$ and $0.8\ \text{mm} \leq A < 1.25\ \text{mm}$ may be established. In this case, it is possible to form a shaft portion having durability while keeping the B/A in the above-described range. Specifically, since D and A are within the above-described ranges, a thickness of the shaft portion can

be secured. If the outer diameter D is smaller than 2.8 mm, it is difficult to stably form the hollow guide shaft of any of the above (1) to (4). When the outer diameter D of the shaft portion is 4.0 mm or less, a swirling diameter of the fibers swirled near the fiber introduction hole does not become too large, and thus the fibers can be swirled stably at a desired speed without the fiber rotation speed being excessively decreased. If A is within the above-described range, the inner diameter of the fiber passage is large enough for a general diameter of the fibers (yarn) introduced through the fiber introduction hole, so that the fibers can move smoothly through the fiber passage even if the yarn has much hairiness.

(6) In the hollow guide shaft described in any one of (1) to (5) above, 0.8 mm $\leq$ A $\leq$ 1.1 mm may be established. In this case, the hairiness can be increased more efficiently, especially in a case where the inner diameter A is 1.1 mm or less. A distance between the fibers (core fibers) passing through the fiber passage and the wound fibers can be brought closer together. In other words, the downstream end of the wound fibers is closer to the center of the shaft portion (fiber passage), so that the fibers can be more easily controlled and the hairiness can be increased efficiently.

(7) In the hollow guide shaft described in any one of (1) to (6) above, the shaft portion may be formed of metal. In this case, a shape of the hollow guide shaft can be achieved with high precision.

(8) The pneumatic spinning device according to an aspect of the present invention includes a fiber guide configured to guide fibers, a nozzle block having a plurality of nozzles through which air to be injected passes, and the hollow guide shaft described above. Since this pneumatic spinning device includes the hollow guide shaft described above, the above-described action effect is exerted, that is, yarn with hairiness increased above a specified value can be generated.

(9) The spinning machine according to an aspect of the present invention includes: a drafting device configured to draft fibers; the pneumatic spinning device described above configured to twist the fibers supplied from the drafting device to generate yarn; and a winding device configured to wind the yarn generated by the pneumatic spinning device. Since this spinning machine includes the above-described pneumatic spinning device, the above-described action effect is exerted, that is, the yarn with hairiness increased above a specified value can be generated.

[0006] According to an aspect of the present invention, it is possible to provide a hollow guide shaft, a pneumatic spinning device and a spinning machine capable of generating yarn with hairiness increased above a specified value.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007]

FIG. 1 is a front view illustrating a spinning machine according to an embodiment.

FIG. 2 is a side view illustrating a spinning unit in FIG. 1.

FIG. 3 is a sectional view illustrating a pneumatic spinning device in FIG. 2.

FIG. 4 is a front view illustrating a hollow guide shaft in FIG. 3.

FIG. 5 is a sectional view illustrating the hollow guide shaft in FIG. 3.

FIG. 6 is an enlarged view of part of FIG. 5.

FIG. 7A is a sectional view illustrating an example of wound fibers to be wound around core fibers. FIG. 7B is a sectional view illustrating another example of wound fibers to be wound around core fibers.

FIG. 8 is a graph indicating a relationship between a fiber passage and an introduction opening, and hairiness.

DETAILED DESCRIPTION

[0008] An embodiment will be explained hereinafter with reference to the drawings. In each of the drawings, the same or corresponding elements are denoted with the same reference numerals, and an overlapping explanation thereof is omitted.

[0009] As illustrated in FIG. 1, a spinning machine 1 includes a plurality of spinning units 2, a yarn joining cart 3, a doffing cart (not illustrated), a first end frame 4, and a second end frame 5. The plurality of spinning units 2 are arranged in a row. Each spinning unit 2 generates yarn Y and winds the yarn Y into a package P. When the yarn Y is cut or the yarn Y is broken for some reason in one spinning unit 2, the yarn joining cart 3 performs a yarn joining operation in the spinning unit 2. When a package P is fully wound in one spinning unit 2, the doffing cart doffs the package P and supplies a new bobbin B to the spinning unit 2.

[0010] The first end frame 4 accommodates a collecting device configured to collect fiber wastes, yarn wastes, and the like generated in the spinning units 2, and other components. The second end frame 5 accommodates, for example, an air supplier that adjusts the air pressure of compressed air (air) to be supplied to the spinning machine 1 and supplies the air to each part of the spinning machine 1, and a drive motor for supplying power to each part of the spinning units 2. The second end frame 5 is provided with a machine control device 41, a display screen 42, and input keys 43. The machine control device 41 centrally manages and controls each part of the spinning machine 1. The display screen 42 can display, for example, information on the settings and the state of the spinning units 2. The setting work for the spinning units 2 is performed by an operator's proper operation using

the input keys 43.

[0011] As illustrated in FIGs. 1 and 2, each of the spinning units 2 includes a drafting device 6, a pneumatic spinning device 7, a yarn monitoring device 8, a tension sensor 9, a yarn storage device 11, a waxing device 12, and a winding device 13, in this order from the upstream side in the traveling direction of the yarn Y. A unit controller 10 is provided for a predetermined number of spinning units 2, and controls operations of the spinning units 2.

[0012] The drafting device 6 drafts sliver (fiber bundle) S. The drafting device 6 has a pair of back rollers 14, a pair of third rollers 15, a pair of middle rollers 16, and a pair of front rollers 17, in order from the upstream side in the traveling direction of the sliver S. Each pair of rollers 14, 15, 16, and 17 has a bottom roller and a top roller. The bottom roller is driven in rotation by the drive motor provided in the second end frame 5 or the drive motor provided in each of the spinning units 2. The bottom roller of the pair of middle rollers 16 is provided with an apron belt 18a. The top roller of the pair of middle rollers 16 is provided with an apron belt 18b.

[0013] The pneumatic spinning device 7 twists the fiber bundle (fibers) F drafted by the drafting device 6 with a swirling flow of air to generate the yarn Y. The yarn monitoring device 8 monitors information about the traveling yarn Y between the pneumatic spinning device 7 and the yarn storage device 11, and detects the presence of yarn defect on the basis of the monitored information. When any yarn defect is detected, the yarn monitoring device 8 transmits a yarn defect detection signal to the unit controller 10. The yarn monitoring device 8 detects, for example, thickness abnormality of the yarn Y and a foreign matter or the like contained in the yarn Y as a yarn defect.

[0014] The tension sensor 9 measures tension of the traveling yarn Y between the pneumatic spinning device 7 and the yarn storage device 11 in the path between the pneumatic spinning device 7 and the winding device 13, and transmits a tension measurement signal to the unit controller 10. When the unit controller 10 detects that there is an abnormality on the basis of the detection result of the yarn monitoring device 8 and the tension sensor 9, the yarn Y is cut in the spinning unit 2. Specifically, the air supply to the pneumatic spinning device 7 is stopped and generation of the yarn Y is suspended, whereby the yarn Y is cut. Alternatively, the yarn Y may be cut by a cutter separately provided.

[0015] The waxing device 12 applies wax to the yarn Y between the yarn storage device 11 and the winding device 13. The yarn storage device 11 removes slack of the yarn Y between the pneumatic spinning device 7 and the winding device 13. The yarn storage device 11 has the function of stably drawing out the yarn Y from the pneumatic spinning device 7, the function of storing the yarn Y delivered from the pneumatic spinning device 7 in the yarn joining operation by the yarn joining cart 3 to prevent slacking of the yarn Y, and the function of preventing variation in tension of the yarn Y downstream from the yarn storage device 11 from propagating to the pneumatic spinning device 7.

[0016] The winding device 13 winds the generated yarn Y around a bobbin B to form the package P. The winding device 13 has a cradle arm 21, a winding drum 22, and a traverse guide 23. The cradle arm 21 rotatably supports the bobbin B. The cradle arm 21 is swingably supported with a support shaft 24 to bring the surface of the bobbin B or the surface of the package P into contact with the surface of the winding drum 22 with proper pressure. A drive motor (not illustrated) in the second end frame 5 drives the winding drums 22 of the plurality of spinning units 2 simultaneously. In this manner, in each of the spinning units 2, the bobbin B or the package P is rotated in a winding direction. The traverse guide 23 of each of the spinning units 2 is provided on a shaft 25 shared by the plurality of spinning units 2. When the drive motor of the second end frame 5 drives the shaft 25 in a rotating shaft direction of the winding drum 22 in a reciprocating manner, the traverse guide 23 traverses the yarn Y in a predetermined width relative to the bobbin B or the package P that is rotating.

[0017] When the yarn Y is cut or the yarn Y is broken for some reason in one spinning unit 2, the yarn joining cart 3 travels to the spinning unit 2 to perform a yarn joining operation. The yarn joining cart 3 includes a yarn joining device 26, a suction pipe 27, and a suction mouth 28. The suction pipe 27 is rotatably supported by a support shaft 31, and catches the yarn Y from the pneumatic spinning device 7 and guides the yarn Y to the yarn joining device 26. The suction mouth 28 is rotatably supported by a support shaft 32, and catches the yarn Y from the winding device 13 and guides the yarn Y to the yarn joining device 26. The yarn joining device 26 joins the guided yarns Y. The yarn joining device 26 is a splicer using compressed air, a piecer using seed yarn, or a knotter mechanically joining the yarn Y, or other devices.

[0018] Referring to FIGs. 3 and 4, a configuration of the pneumatic spinning device 7 will be described in detail. Hereinafter the upstream side in the traveling direction of the fiber bundle F and the yarn Y is simply referred to as "upstream side", and the downstream side in the traveling direction of the fiber bundle F and the yarn Y is simply referred to as "downstream side". The axial direction of the hollow guide shaft 80 is simply referred to as "axial direction".

[0019] As illustrated in FIG. 3, the pneumatic spinning device 7 includes a fiber guide 50, a nozzle block 60, and a hollow guide shaft unit 70. The fiber guide 50, the nozzle block 60, and the hollow guide shaft unit 70 are aligned on a line L along the axial direction from the upstream side toward the downstream side in a direction along the line L.

[0020] The fiber guide 50 guides the fiber bundle F supplied from the drafting device 6. The fiber guide 50 has a guide hole 51 that guides the fiber bundle F. The fiber guide 50 is provided with a needle 52 disposed along the line L. A tip 52a of the needle 52 is located down-

stream of the fiber guide 50. The pneumatic spinning device 7 twists the fiber bundle F, guided from the fiber guide 50, by the swirling air flow in a space 64 formed between the nozzle block 60 and the hollow guide shaft unit 70. The fiber guide 50 is disposed at an upstream side end of the nozzle block 60.

[0021] The nozzle block 60 has the space 64 into which the fiber bundle F is introduced and a plurality of nozzles 65 through which air to be injected into the space 64 passes through to generate the swirling air flow. In the space 64, fibers of the introduced fiber bundle F are swirled by the swirling air flow. The plurality of nozzles 65 are arranged at equal angular intervals around the space 64.

[0022] The hollow guide shaft unit 70 has the hollow guide shaft 80, a guide pipe 71, a support member 72, and a fixing member (holding member) 73. As illustrated in FIGs. 3, 4, and 5, the hollow guide shaft 80 has a first shaft portion (shaft portion) 81, a second shaft portion 82, and a third shaft portion 83. The first shaft portion 81, the second shaft portion 82, and the third shaft portion 83 are aligned from the upstream side toward the downstream side and are integrally formed. A downstream side end of the third shaft portion 83 is provided with a flange 83a. The hollow guide shaft 80 is formed of metal, such as stainless steel. The hollow guide shaft 80 may be formed of ceramic. The hollow guide shaft 80 is also referred to as spindle.

[0023] The first shaft portion 81 has a fiber introduction hole 86 into which the fiber bundle F from the fiber guide 50 is introduced, a fiber passage 85 that is continuous with the fiber introduction hole 86 and extends along the axial direction, and a fiber passage 87 that is continuous with the downstream end of the fiber passage 85 and extends along the axial direction. The fiber passage 87 leads to the inside of the second shaft portion 82 and the third shaft portion 83, which are hollow. The outer shape of the first shaft portion 81 is a truncated cone spreading from the upstream side toward the downstream side. The outer shape of the second shaft portion 82 is a truncated cone spreading from the upstream side toward the downstream side, and spreads at a greater angle than the first shaft portion 81 does. At least an end area of the upstream side of the first shaft portion 81 is disposed in the nozzle block 60.

[0024] As illustrated in FIG. 3, the guide pipe 71 is provided with a passage 74 configured to guide the fiber bundle F to the outside of the pneumatic spinning device 7. The passage 74 is open to the upstream side and the downstream side on the line L. An inner diameter of a downstream side portion of the passage 74 is larger than an inner diameter of an upstream side portion of the passage 74. The end area of the upstream side of the guide pipe 71 is provided with a plurality of nozzles 75 through which air to be injected into the passage 74 passes. The plurality of nozzles 75 are provided, for example, at equal angular intervals around line L.

[0025] The support member 72 is provided with a housing hole 76 opening to the upstream side and a yarn guiding channel 77 opening to the upstream side and the downstream side. The upstream side end of the yarn guiding channel 77 is connected to the downstream side end of the housing hole 76. An inner diameter of the yarn guiding channel 77 is substantially equal to the inner diameter of the downstream side portion of the passage 74 in the guide pipe 71 and smaller than the inner diameter of the housing hole 76. An air supply pipe 78 that is continuous to the housing hole 76 is attached to the support member 72. An upstream side end of the support member 72 has a male thread 72a.

[0026] A fixing member 73 is a cap-shaped nut provided with a flange 73a. In the hollow guide shaft unit 70, the guide pipe 71 is disposed in the housing hole 76 of the support member 72, and the hollow guide shaft 80 is disposed at the upstream side end of the support member 72 to cover the upstream side end of the guide pipe 71. Accordingly, the fiber passage 87 of the hollow guide shaft 80 is connected to the passage 74 of the guide pipe 71, and the passage 74 of the guide pipe 71 is connected to the yarn guiding channel 77 of the support member 72. In this state, the fixing member 73 is screwed onto the male thread 72a of the support member 72 while being engaged with the flange 83a of the hollow guide shaft 80.

[0027] In the pneumatic spinning device 7 configured as described above, at the start of spinning operation, air is injected into the nozzle block 60 from the plurality of nozzles 65 and air is injected into the passage 74 from the plurality of nozzles 75. In this manner, the fiber bundle F introduced from the drafting device 6 into the space 64 through the guide hole 51 is led to the downstream side through the passage 74 and the yarn guiding channel 77. Thereafter, injection of air from the plurality of nozzles 65 into the space 64 continues, and the injection of air from the plurality of nozzles 75 into the passage 74 is stopped, and the spinning operation proceeds to normal spinning operation. The swirling air flow generated in the space 64 allows fibers constituting the fiber bundle F to swirl. A downstream end of fibers of the fiber bundle F introduced into the fiber introduction hole 86 is wound into preceding fibers sequentially to become the core (core fibers) of the yarn Y to be generated, and the upstream end of the fibers is swung by the swirling air flow to be sequentially wound around the core fibers (wound fibers). Part of a single fiber becomes the core fiber and a different part becomes the wound fiber. The yarn Y generated by twisting the fiber bundle F is led to the downstream side through the passage 74 and the yarn guiding channel 77.

[0028] Next, key parts of the hollow guide shaft 80 of the present embodiment will be described.

[0029] As illustrated in FIGs. 5 and 6, in the hollow guide shaft 80, the first shaft portion 81 has the fiber introduction hole 86 and the fiber passage 85. The fiber introduction hole 86 is a space that penetrates from the outside of the hollow guide shaft 80 to the fiber passage

85. The fiber introduction hole 86 is a hole in which a shape of a cross-section perpendicular to the axial direction is circular. The circle may be an oval. The opening end (upstream side end or edge) of the fiber introduction hole 86 constitutes an introduction opening 89 of the fiber bundle F. The introduction opening 89 is a boundary between the inside and the outside of the hollow guide shaft 80. An inner surface 86x of the fiber introduction hole 86 is a curved surface that widens toward the opening side.

[0030] The fiber passage 85 is a space continuous from the fiber introduction hole 86 toward the downstream side. Level difference is not formed at the boundary between an inner surface 85x of the fiber passage 85 and the inner surface 86x of the fiber introduction hole 86. The fiber passage 85 is a hole in which a shape of a cross-section perpendicular to the axial direction is circular. The circle may be an oval. The inner surface 85x of the fiber passage 85 is a surface along the axial direction.

[0031] As illustrated in FIG. 6, where A is the inner diameter of the fiber passage 85 and B is a diameter of the introduction opening 89 of the fiber introduction hole 86, $1.5 \leq B/A \leq 1.8$ is established. More specifically, $1.6 \leq B/A \leq 1.75$ is established. In the present embodiment, B/A is 1.63. The diameter of the introduction opening 89 can also be said to be a distance between vertices of the hollow guide shaft 80 when the vertices are connected by a straight line in a side view of the hollow guide shaft 80. The inner diameter of the fiber passage 85 is the diameter of the fiber passage 85. The inner diameter of the fiber passage 85 may be an average value, a minimum value, or a maximum value of the inner diameters at a plurality of positions in the fiber passage 85. The diameter of the introduction opening 89 is a diameter of the introduction opening 89.

[0032] Where R is the radius of curvature of the inner surface 86x that is a curved surface, $0.25 \text{ mm} \leq R \leq 0.35$ mm is established. In the present embodiment, R is 0.3 mm $\pm$ 0.05 mm.

[0033] Where D is the outer diameter of the first shaft portion 81 (refer to FIG. 5), $2.8 \text{ mm} \leq D \leq 4.0$ mm and $0.8 \text{ mm} \leq A < 1.25$ mm are established. In the present embodiment, D is 2.8 mm. Also, $0.8 \text{ mm} \leq A \leq 1.1$ mm is established. The outer diameter of the first shaft portion 81 is a distance, viewed from the side of the hollow guide shaft 80 (direction perpendicular to the axial direction), between intersection points da and db of a straight line passing through the upstream side end of the first shaft portion 81 and perpendicular to the axial direction (dashed line extending in the right-left direction in FIG. 5) and extension lines of periphery of the first shaft portion 81 (dashed lines respectively extending in diagonally upward and downward directions in FIG. 5). The inner diameter of the fiber passage 85, the diameter of the introduction opening 89, the radius of curvature of the inner surface 86x, and the outer diameter of the first shaft portion 81 can be measured by non-destructive testing equipment or the like, and can be measured by, for example, a 3D shape measuring machine VR-5000 (Keyence Corporation).

[0034] The following findings are obtained regarding the behavior of the core fibers and the wound fibers that wrap around the core fibers when the fibers of the fiber bundle F are introduced into the fiber introduction hole 86 in the hollow guide shaft 80. FIG. 7A is an enlarged sectional view of the upstream side portion of the hollow guide shaft 80 according to the present embodiment. FIG. 7B is an enlarged sectional view of an upstream side portion of a hollow guide shaft 180 according to the comparative example. The hollow guide shaft 180 according to the comparative example differs from the hollow guide shaft 80 in that a fiber introduction hole 186 is formed in place of the fiber introduction hole 86. The radius of curvature of an inner surface 186x of the fiber introduction hole 186 is smaller than the radius of curvature of the inner surface 86x of the fiber introduction hole 86. The B/A of the hollow guide shaft 180 is smaller than the B/A of the hollow guide shaft 80, for example, 1.21.

[0035] FIG. 8 is a graph indicating a relationship between a fiber passage and an introduction opening, and hairiness. In FIG. 8, the vertical axis is Hairiness, which corresponds to hairiness, and the horizontal axis is B/A. Hairiness is a total length of hairiness in the generated yarn Y for a length of 1 cm. Hairiness can be measured, for example, with a yarn evenness tester UT-6 (Uster Technologies K.K.). Data in FIG. 8 is data in a case where the yarn Y is generated at a typical spinning speed (for example, 540 m/min).

[0036] As illustrated in FIGs. 7A and 7B, as B/A becomes larger, a winding start position, where wound fibers Fb, out of the fiber bundle F that is to be introduced into the fiber introduction hole 86, start winding around core fibers Fa (hereinafter also simply referred to as "winding start position"), can be separated from the core fibers Fa. As a result, winding force with which the wound fibers Fb are wound around the core fibers Fa can be weakened, and tightness of the yarn Y to be generated can be reduced to increase the hairiness, as illustrated in FIG. 8.

[0037] As R that is the radius of curvature of the inner surface 86x becomes larger, a bent angle of the wound fibers Fb becomes larger, the wound fibers Fb are wound around the core fibers Fa with low tension applied to the wound fibers Fb, and tightening force of the yarn Y is reduced. As R that is the radius of curvature of the inner surface 86x becomes larger, an area where the wound fibers Fb make contact with the inner surface 86x becomes larger, frictional resistance of the first shaft portion 81 with respect to the wound fiber Fb increases, whirling force of the swirling air flow on the wound fibers Fb decreases, and the tightening force of the yarn Y becomes weak.

[0038] In particular, when B/A is 1.5 or higher, the hairiness can be increased above a required specified value α. The specified value α is, for example, a value corresponding to a lower threshold determined from required

quality of the yarn Y and other factors. In the present embodiment, the yarn Y having tightness smaller than a certain value, in other words, the yarn Y having a soft texture, is desired, and the specified value α corresponding to the desire is defined. In other words, the hollow guide shaft 80 has a structure for generating the yarn Y with much hairiness, that is, the yarn Y with a soft texture.

[0039] As in the foregoing, with the hollow guide shaft 80, since B/A is 1.5 or more, it is possible to generate the yarn Y with hairiness increased above the specified value α. If B/A is too large, it is difficult for the wound fibers Fb to be wound around the core fibers Fa, and the possibility of difficulty in generating the yarn Y increases, and thus, B/A is set to 1.8 or less, to reliably generate the yarn Y. Thus, it is possible to reliably generate the yarn Y with hairiness increased above the specified value α. It is possible to generate the yarn Y with a larger yarn diameter.

[0040] In the hollow guide shaft 80, $1.6 \leq B/A \leq 1.75$ is established. In this case, with the winding force further reduced, the hairiness of the yarn Y to be generated can be further increased, and with the wound fibers Fb gently and securely wound around the core fibers Fa, the yarn Y can be more reliably generated.

[0041] In the hollow guide shaft 80, the inner surface 86x of the fiber introduction hole 86 has a curved surface that widens toward the opening side. Where R is the radius of curvature of the inner surface 86x, $0.25 \text{ mm} \leq R \leq 0.35 \text{ mm}$ is established. In this case, as the fiber bundle F is introduced into the fiber introduction hole 86, the fibers (wound fibers Fb) of the fiber bundle F easily float from the inner surface 86x of the fiber introduction hole 86, and thus resistance applied to the fiber band Fb can be reduced and the winding force can be decreased. In this manner, it is possible to further increase the hairiness of the yarn Y to be generated.

[0042] In the hollow guide shaft 80, where D is the outer diameter of the first shaft portion 81, $2.8 \text{ mm} \leq D \leq 4.0 \text{ mm}$ and $0.8 \text{ mm} \leq A < 1.25 \text{ mm}$ are established. In this case, it is possible to form the first shaft portion 81 having durability while keeping B/A in the above-described range. In other words, since D and A are within the above-described ranges, the thickness of the first shaft portion 81 can be secured. If the outer diameter D is smaller than 2.8 mm, it is difficult to stably form the hollow guide shaft 80 according to the present embodiment. When the outer diameter D of the first shaft portion 81 is 4.0 mm or less, a swirling diameter of the fibers swirled near the fiber introduction hole 86 does not become too large, and thus the fibers can be swirled stably at a desired speed without the fiber rotation speed being excessively decreased. If A is within the above-described range, the inner diameter of the fiber passage 85 is large enough for the general diameter of the fibers (yarn Y) introduced through the fiber introduction hole 86, so that the fibers can move smoothly through the fiber passage 85 even if the yarn Y has much hairiness.

[0043] In the hollow guide shaft 80, $0.8 \text{ mm} \leq A \leq 1.1 \text{ mm}$ is established. In this case, the hairiness can be increased more efficiently, especially in a case where the inner diameter A is 1.1 mm or less. A distance between the fibers passing through the fiber passage 85 (core fibers Fa) and the wound fibers Fb can be brought closer together. In other words, the downstream end of the wound fibers Fb is closer to a center of the first shaft portion 81 (fiber passage 85), so that the fibers can be more easily controlled and the hairiness can be increased efficiently.

[0044] In the hollow guide shaft 80, the first shaft portion 81 is formed of metal. In this case, a shape of the hollow guide shaft 80 can be achieved with high precision.

[0045] The pneumatic spinning device 7 has the fiber guide 50, the nozzle block 60, and the hollow guide shaft 80. Since the pneumatic spinning device 7 includes the hollow guide shaft 80, the above-described action effect is exerted, that is, the yarn Y with hairiness increased above the specified value α can be generated.

[0046] The spinning machine 1 includes the drafting device 6, the pneumatic spinning device 7, and the winding device 13. Since the spinning machine 1 includes the pneumatic spinning device 7, the above-described action effect is exerted, that is, the yarn Y with hairiness increased above the specified value α can be generated.

[0047] Note that in the hollow guide shaft 80 according to the present embodiment, the surface shape of the inner surface 86x of the fiber introduction hole 86 is not particularly limited and may have a flat surface that widens toward the opening side (what is called a chamfered surface). In this case, the inner surface 86x of the fiber introduction hole 86 can be easily machined and the fiber introduction hole 86 can be formed with high precision. An inclining angle of the inner surface 86x as a flat surface is not particularly limited and may be any angle. For example, the inclining angle may be inclined by 45° or 60° with respect to the plane along the axial direction.

[0048] As in the foregoing, an aspect of the present invention is not limited to the above-described embodiment, and various changes can be made without departing from the gist of the invention.

[0049] In the above-described embodiment, the shape of the introduction opening 89 is not limited and may be a shape other than a circle. In this case, the diameter of the introduction opening 89 may be a diameter of an inscribed circle of the introduction opening 89, a diameter of a circumscribed circle thereof, or an average value of these diameters. The shape of fiber passage 85 is not limited and may be a shape other than a circle. In this case, the inner diameter of the fiber passage 85 may be a diameter of an inscribed circle of the fiber passage 85, a diameter of a circumscribed circle thereof, or an average value of these diameters.

[0050] In the above-described embodiment, the inner surface 85x does not have to be parallel to the axial direction, may be inclined, may be concave, and/or may convex. The radius of curvature of the inner surface 86x

does not have to be constant. In this case, R may be a maximum value, a minimum value, or an average value of the radius of curvature of the inner surface 86x. In the above-described embodiment, the outer shape of the first shaft portion 81 may be a shape other than a truncated cone.

[0051] In the above-described embodiment, the hollow guide shaft unit 70 does not have to have the nozzles 75. Of the hollow guide shaft unit 70, the first shaft portion 81 may be formed separately from the second shaft portion 82 and the third shaft portion 83. In this case, if the hollow guide shaft unit 70 has the nozzles 75, the first shaft portion 81 may be integrally formed with the upstream side end of the guide pipe 71 provided with the nozzles 75. The second shaft portion 82 and the third shaft portion 83 may be integrally formed with the fixing member 73.

[0052] In the above-described embodiment, the pneumatic spinning device 7 may have a configuration in which the needle 52 is not provided and the downstream end of the fiber guide 50 may prevent the twists of the fiber bundle F from being transmitted to the upstream side of the pneumatic spinning device 7.

[0053] In the above-described embodiment, the fiber guide 50 and the nozzle block 60 may be integrally configured.

[0054] In the spinning unit 2 according to the above-described embodiment, the yarn storage device 11 has a function of drawing the yarn Y from the pneumatic spinning device 7. However, the yarn Y may be drawn from the pneumatic spinning device 7 by a delivery roller and a nip roller. When the yarn Y is drawn from the pneumatic spinning device 7 by the delivery roller and the nip roller, a slack tube configured to absorb slack of the yarn Y with suction air flow and/or a mechanical compensator may be provided, instead of the yarn storage device 11, or in addition to the yarn storage device 11.

[0055] In the spinning machine 1 according to the above-described embodiment, in the height direction of the machine, the devices are disposed such that the yarn Y supplied from the upper side is wound up on the lower side. However, the devices may be disposed such that the yarn Y supplied from the lower side is wound up on the upper side.

[0056] In the spinning machine 1 according to the above-described embodiment, at least one of the bottom rollers of the drafting device 6 and the traverse guide 23 are driven by motive power from the second end frame 5 (that is, in common with a plurality of the spinning units 2). However, each part (such as the drafting device 6, the pneumatic spinning device 7, and the winding device 13) of the spinning unit 2 may be driven independently in each of the spinning units 2. At least one of the devices related to yarn joining (yarn joining device 26, suction pipe 27, suction mouth 28) may be provided in each of the spinning units 2 instead of in the yarn joining cart 3.

[0057] In the above-described embodiment, in the traveling direction of the yarn Y, the tension sensor 9 may be disposed upstream of the yarn monitoring device 8. The unit controller 10 may be provided for each of the spinning units 2. In the spinning units 2, the waxing device 12, the tension sensor 9, and the yarn monitoring device 8 may be omitted.

[0058] In the above-described embodiment, the spinning machine 1 is illustrated (refer to FIG. 1) such as to wind the package P in a cheese shape, but the spinning machine 1 can wind the package P in a cone shape. In a case of the package P in a cone shape, traversing the yarn Y causes slack of the yarn Y, but the slack can be absorbed by the yarn storage device 11. In the above-described embodiment, the specified value α does not have to be a fixed value, but may be a value that varies depending on, for example, the raw material of the sliver S and the conditions of the yarn Y to be generated.

[0059] The materials and shapes of the components are not limited to the materials and shapes described above, and various materials and shapes can be employed. Each of the above values may include at least some error in design, manufacturing, measurement, or the like.

Claims

1. A hollow guide shaft (80) comprising a shaft portion (81) having a fiber introduction hole (86) into which fibers are introduced and a fiber passage (85) that is continuous with the fiber introduction hole (86) and extends along an axial direction, wherein
   where A is an inner diameter of the fiber passage (85) and B is a diameter of an introduction opening (89) serving as an opening end of the fiber introduction hole (86), $1.5 \leq B/A \leq 1.8$ is established.

2. The hollow guide shaft (80) according to claim 1, wherein $1.6 \leq B/A \leq 1.75$ is established.

3. The hollow guide shaft (80) according to claim 1 or 2, wherein

   an inner surface (86x) of the fiber introduction hole (86) has a curved surface that widens toward an opening side, and
   where R is a radius of curvature of the curved surface, $0.25\ mm \leq R \leq 0.35\ mm$ is established.

4. The hollow guide shaft (80) according to claim 1 or 2, wherein an inner surface (86x) of the fiber introduction hole (86) has a flat surface that widens toward an opening side.

5. The hollow guide shaft (80) according to any one of claims 1 to 4, wherein, where D is an outer diameter of the shaft portion (81), $2.8\ mm \leq D \leq 4.0\ mm$ and $0.8\ mm \leq A < 1.25\ mm$ are established.

6. The hollow guide shaft (80) according to claim 5, wherein 0.8 mm $\leq$ A $\leq$ 1.1 mm is established.

7. The hollow guide shaft (80) according to any one of claims 1 to 6, wherein the shaft portion (81) is formed of metal.

8. A pneumatic spinning device (7) comprising:

a fiber guide (50) configured to guide fibers;
a nozzle block (60) having a plurality of nozzles (65) through which air to be injected passes; and
the hollow guide shaft (80) according to any one of claims 1 to 7.

9. A spinning machine (1) comprising:

a drafting device (6) configured to draft fibers;
the pneumatic spinning device (7) according to claim 8 configured to twist the fibers supplied from the drafting device (6) to generate yarn (Y); and
a winding device (13) configured to wind the yarn (Y) generated by the pneumatic spinning device (7).

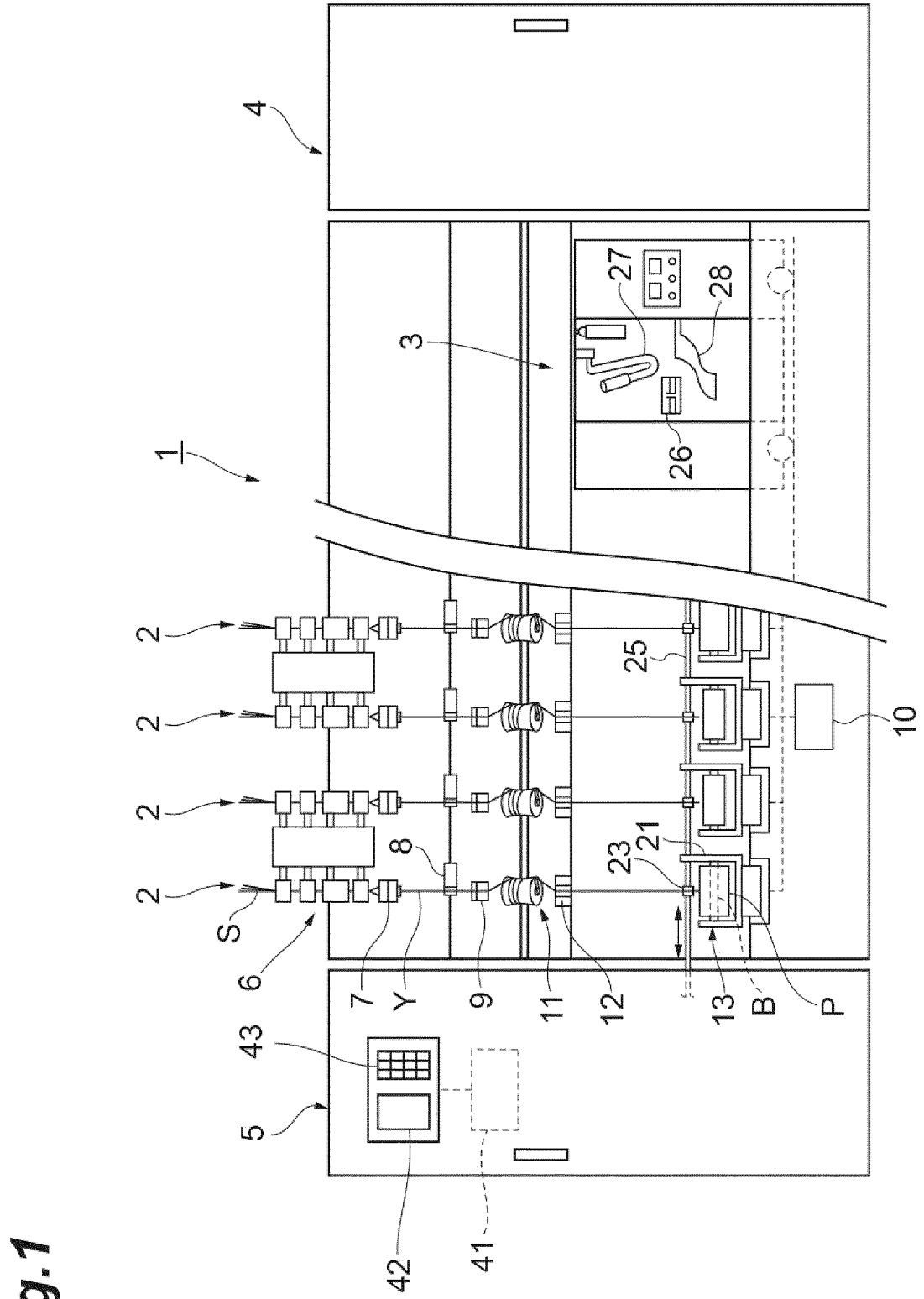


Fig.1

Fig.2

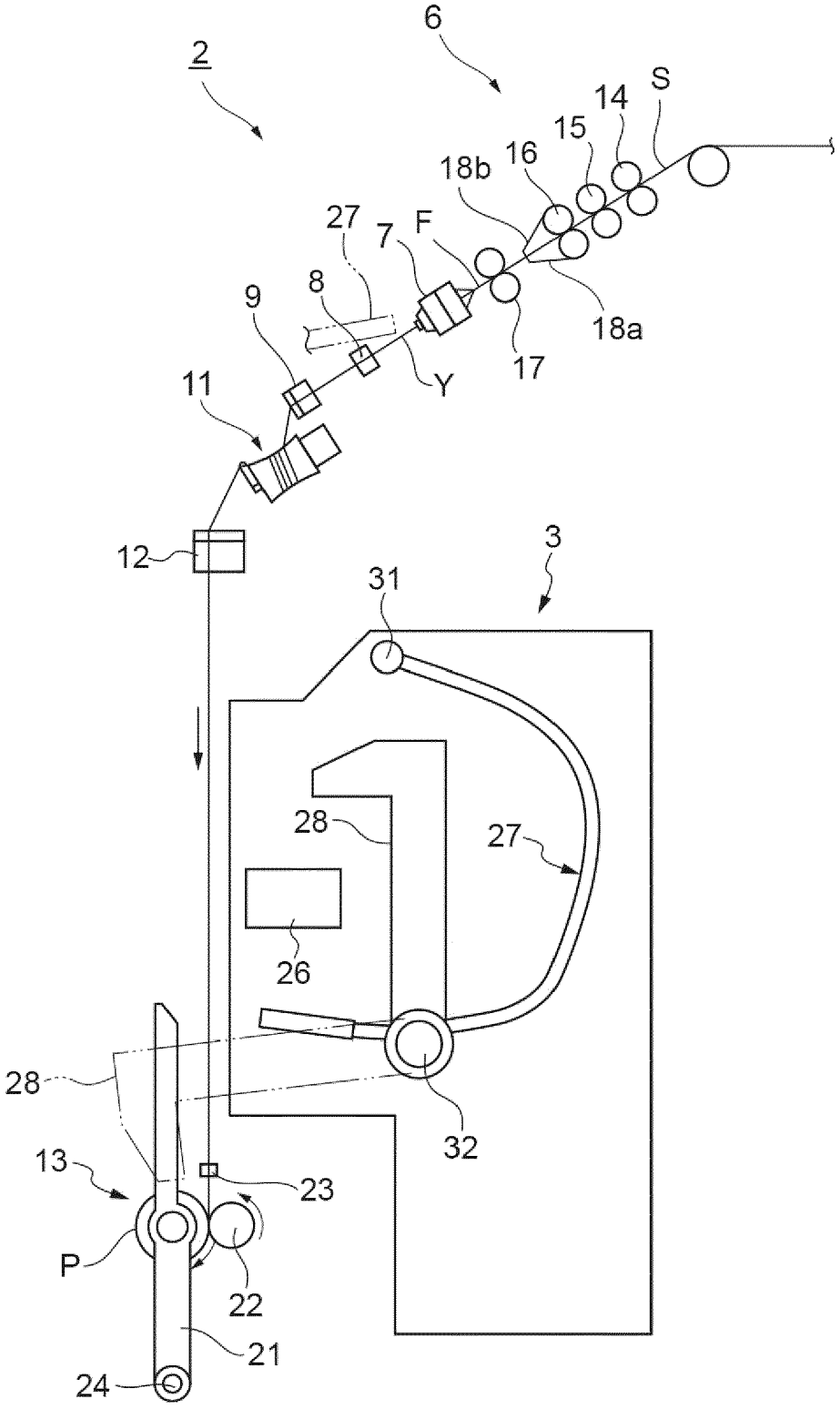
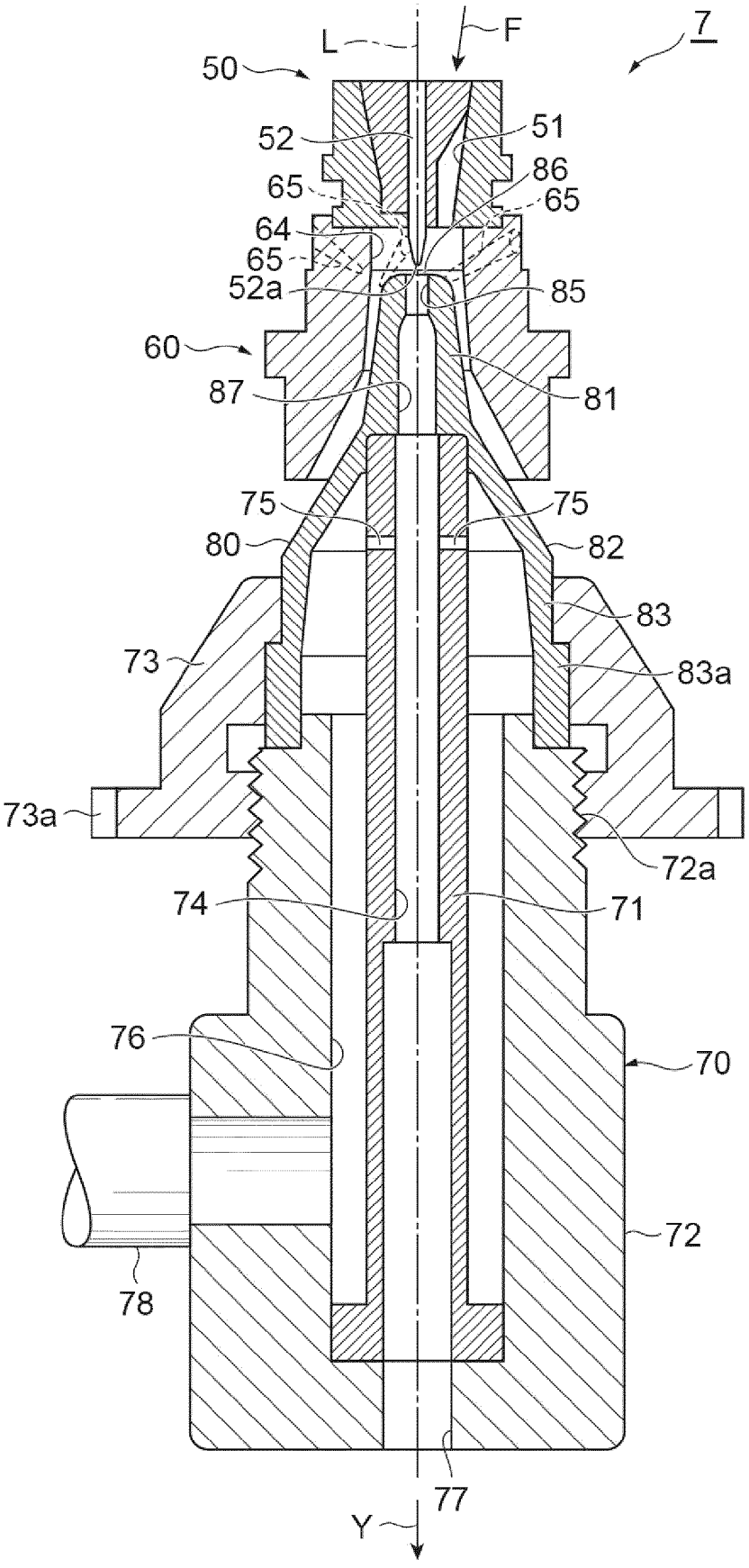

6
2
S
14
15
16
18b
27
7
F
8
9
18a
17
Y
11
12
3
31
28
27
26
28
32
13
23
P
22
21
24

Fig.3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F
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51
86
65
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60
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70
72
78
77
Y

Fig.4

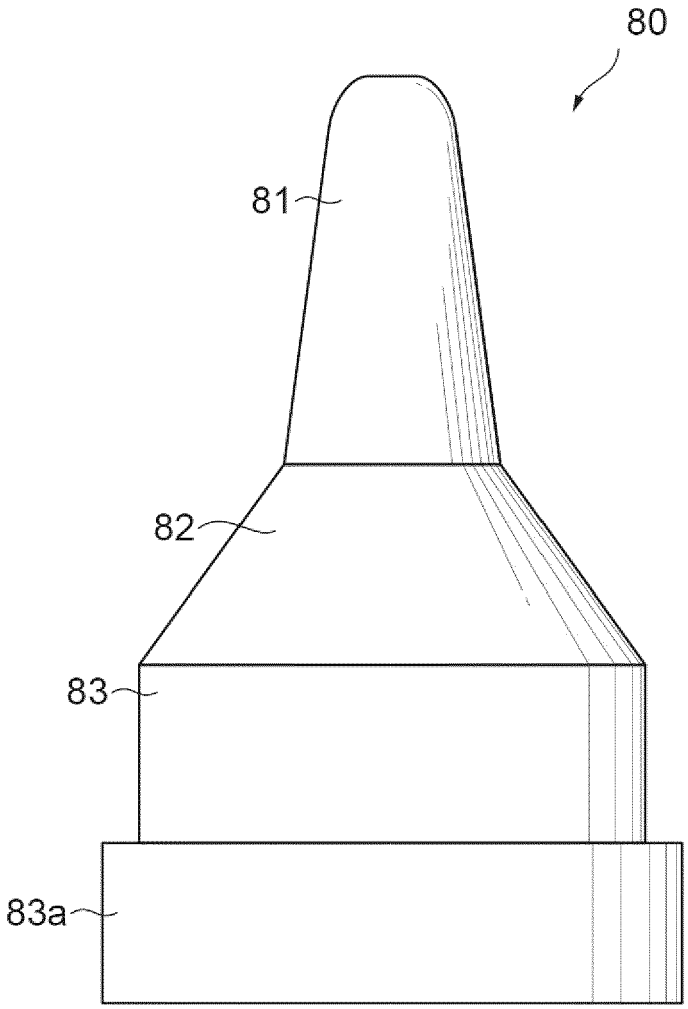


Fig.5

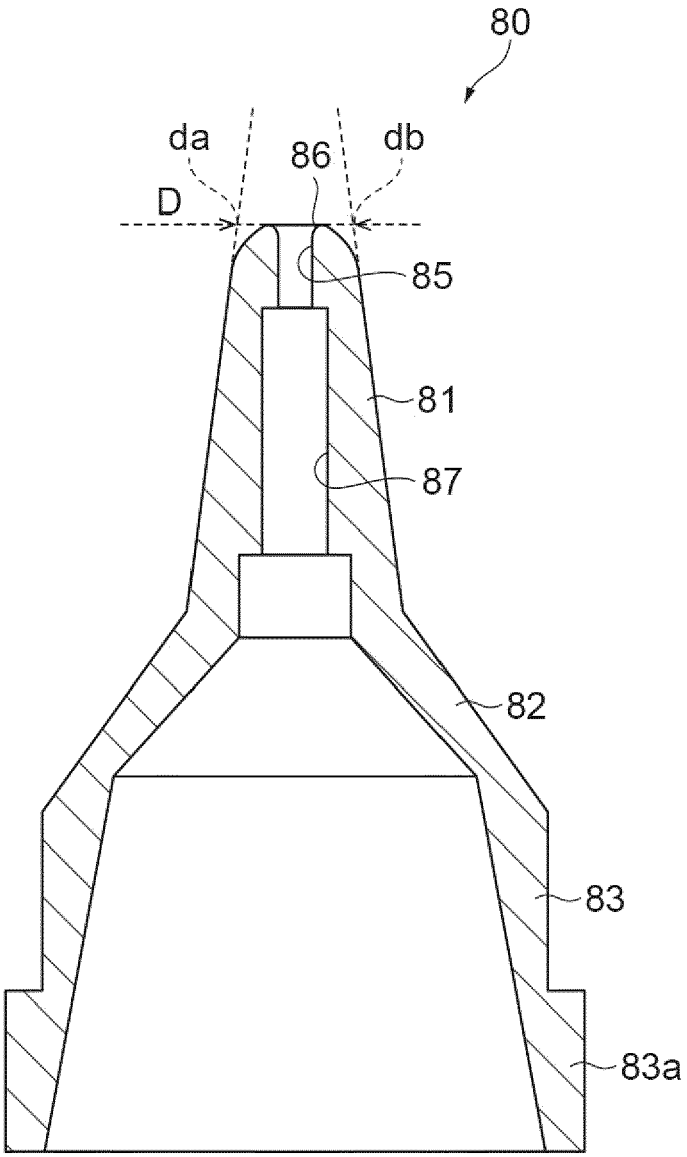


Fig.6

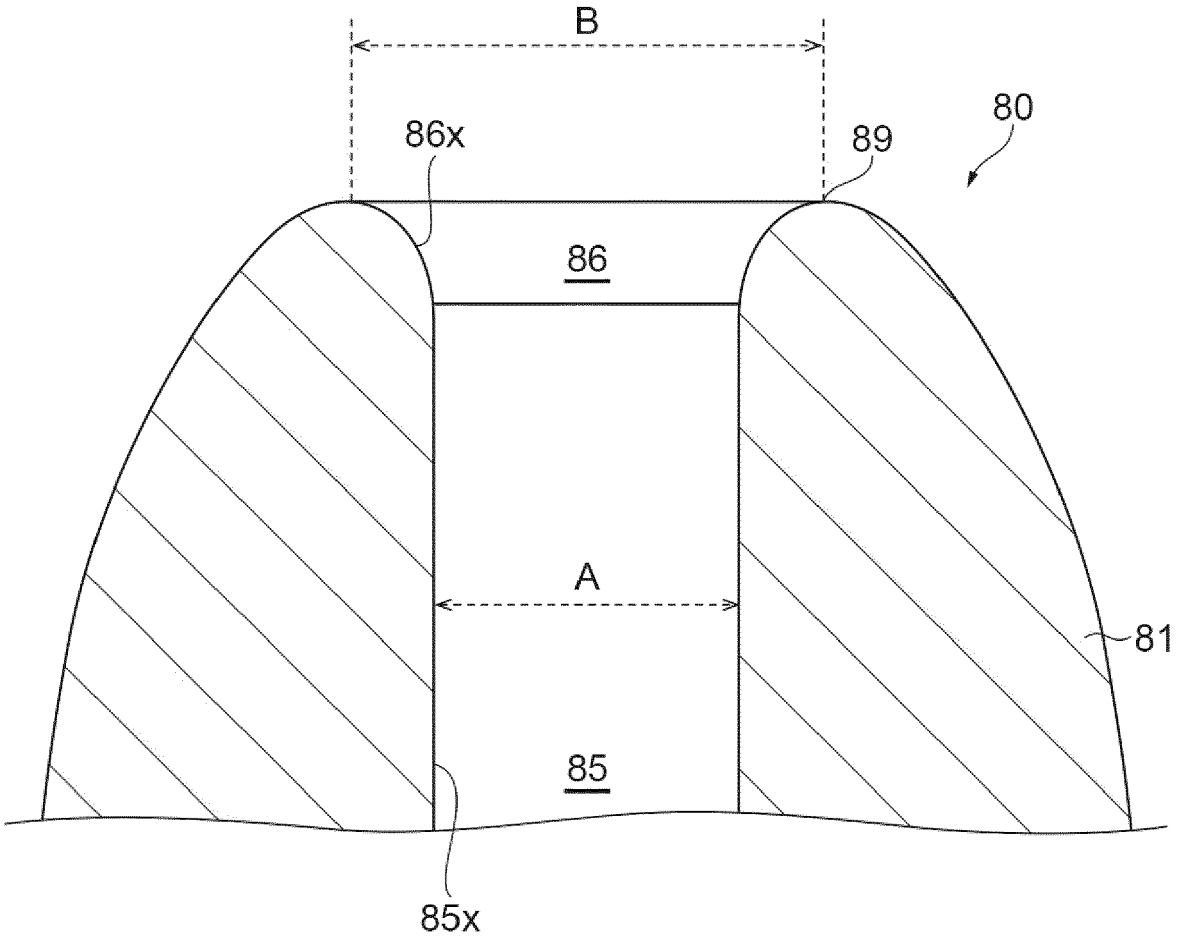


Fig.7A

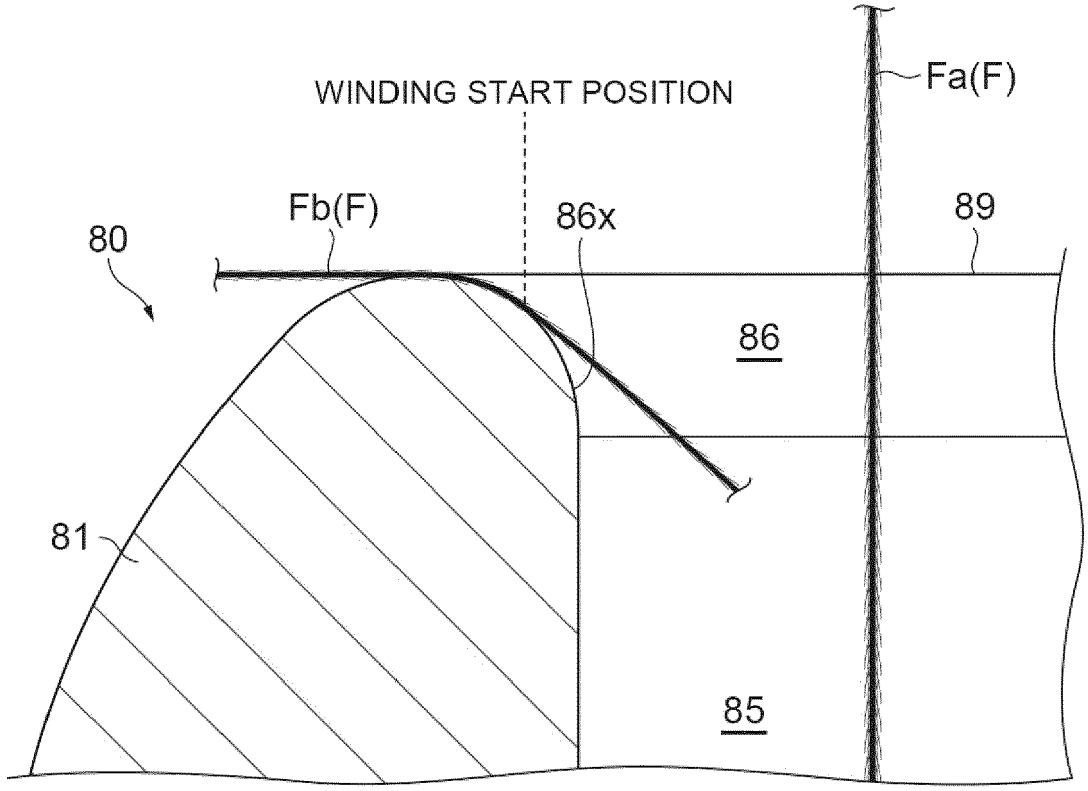

WINDING START POSITION
Fa(F)
Fb(F)
86x
89
80
86
81
85

Fig.7B

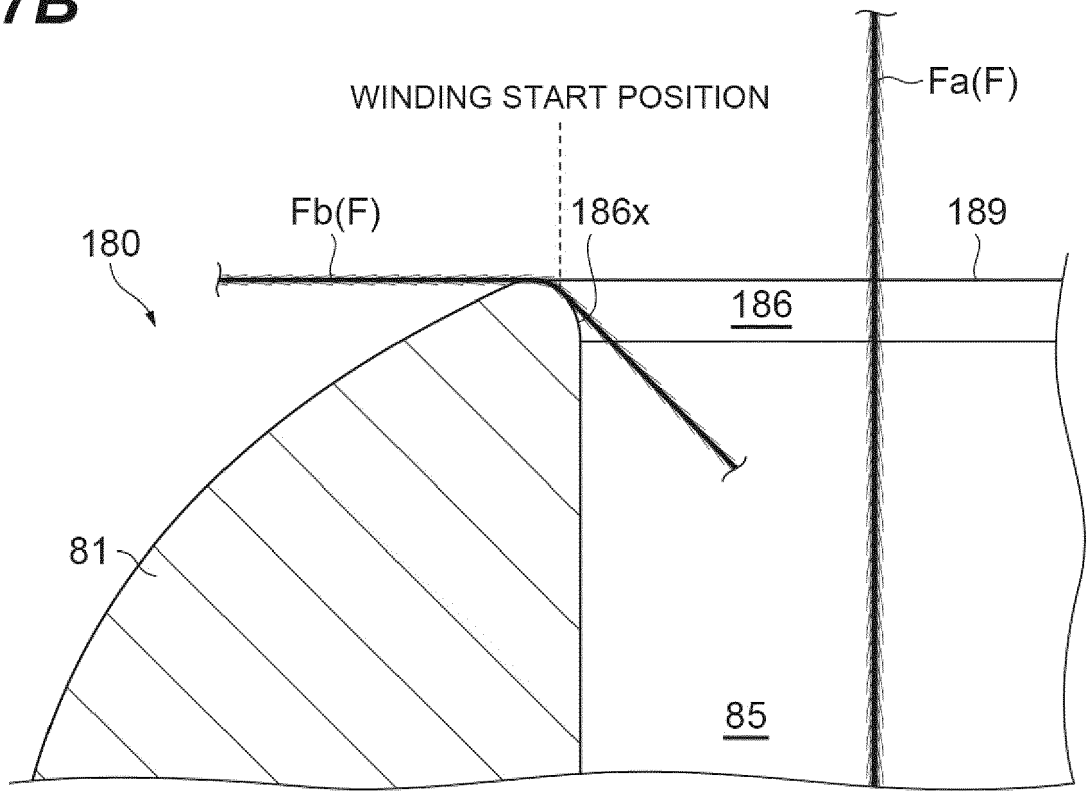
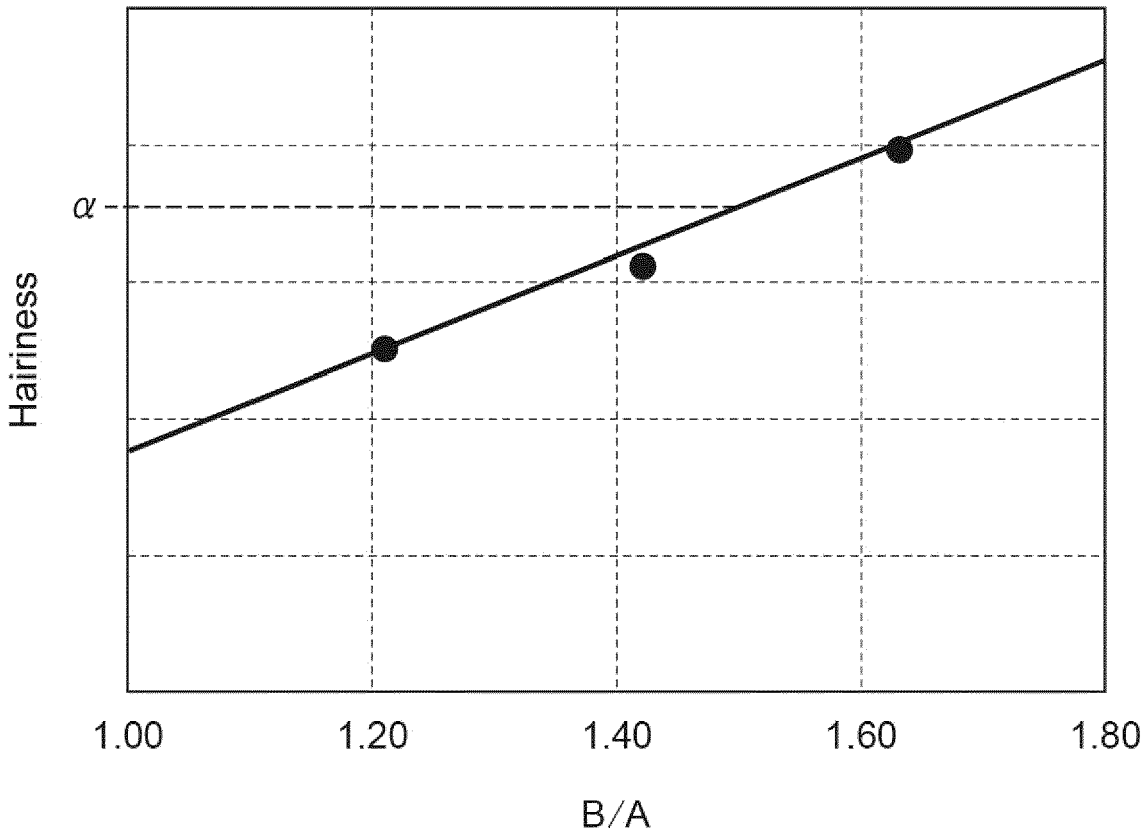

WINDING START POSITION
Fa(F)
Fb(F)
186x
189
180
186
81
85

Fig.8



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EUROPEAN SEARCH REPORT

Application Number
EP 23 20 0126

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	CN 103 305 979 A (UNIV DONGHUA) 18 September 2013 (2013-09-18) * paragraph [0026]; figure 1; example 1 *	1-9	INV. D01H1/115
X	CN 203 977 003 U (ZHEJIANG HUAFU TOP DYED YARN MELANGE CO LTD) 3 December 2014 (2014-12-03) * claims 1-4; figures 1-3 *	1	
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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	1 March 2024	Todarello, Giovanni

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01-03-2024

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