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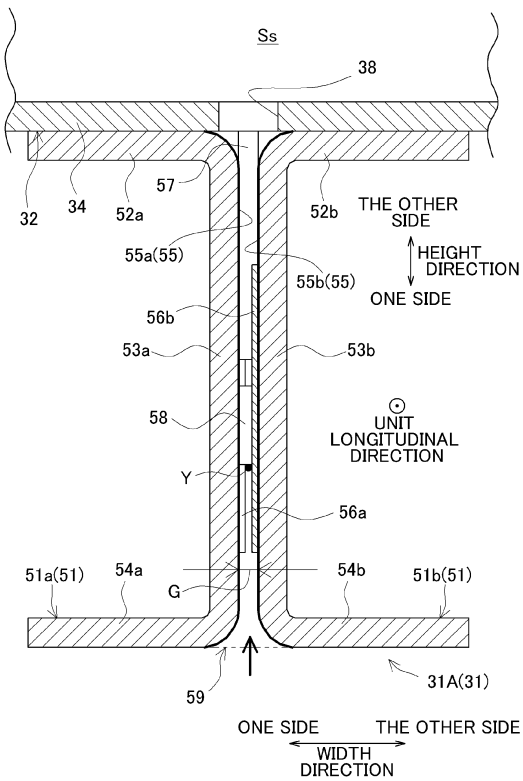
(54) COOLER AND YARN PROCESSOR

(57) Efficiency in cooling of a yarn is improved in a cooler that is configured to cool the yarn by cooling wind. A cooler 14 includes a cooling unit 31 in which a yarn running space S in which a yarn Y runs is formed and an intake duct 32 in which an intake space Ss connected to the yarn running space S is formed. The intake duct 32 includes a duct wall portion 34 in which one or more intake slit 38 is provided to extend in a unit longitudinal direction between the yarn running space S and the intake space Ss in a flow direction in which cooling wind flows. The cooling unit 31 includes paired unit wall plates 51 that are provided on one side of the duct wall portion 34 in the height direction. The paired unit wall plates 51 includes paired unit wall surfaces 55 which oppose each other in the width direction over the yarn running space S. The height in the height direction of each of the paired unit wall surfaces 55 is 30 mm or less.

FIG.5



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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a cooler configured to cool a yarn and a yarn processor including the cooler.

[0002] Patent Literature 1 (Japanese Laid-Open Patent Publication No. 2011-047074) discloses a cooler that is provided in a false-twist texturing machine (yarn processor) configured to perform false-twist texturing for a running yarn. To be more specific, the cooler includes a duct for supplying cooling wind to the yarn and a pair of guides provided below the duct. Between the paired guides, a yarn running space is formed to allow the yarn to run inside the same. The yarn running space is connected to an internal space (in-duct space) of the duct through a slit that is formed in a lower part of the duct. As an exhaust fan (negative pressure generator) provided at an end portion of the duct rotates, negative pressure is generated in the in-duct space. As a result, gas flows into the yarn running space connected to the in-duct space. Such gas cools the yarn as cooling wind.

SUMMARY OF THE INVENTION

[0003] There have recently been demands for further improvement in efficiency of cooling of yarns in order to, for example, cool yarns that are thicker than before. In order to improve the efficiency in cooling the yarn in the above-described cooler, the speed of cooling wind (air speed) is required to be increased. In this regard, the inventors of the subject application have found that the air speed is not easily increased even though the number of rotations of the exhaust fan (i.e., the output of the negative pressure generator) is simply increased to increase the negative pressure in the in-duct space.

[0004] An object of the present invention is to improve efficiency in cooling of a yarn in a cooler that is configured to cool the yarn by cooling wind.

[0005] According to a first aspect of the invention, a cooler which is configured to cool a running yarn by cooling wind comprises: a cooling unit which is formed so that a yarn running space in which the yarn runs extends in a predetermined lengthwise direction; and a duct in which an in-duct space connected to the yarn running space is formed, the duct including a duct wall portion in which one or more slit is provided to extend in the lengthwise direction between the yarn running space and the in-duct space in a flow direction in which the cooling wind flows, the cooling unit including paired unit wall portions provided on one side of the duct wall portion in a height direction orthogonal to the lengthwise direction, the paired unit wall portions including paired unit wall surfaces opposing each other over the yarn running space in a width direction that is orthogonal to both the lengthwise direction and the height direction, and length of each of the paired unit wall surfaces in the height direction being 30 mm or less.

[0006] In this aspect of the present invention, when negative pressure (or positive pressure) is generated in the in-duct space, cooling wind flows into the yarn running space (space formed between the paired unit wall surfaces) connected to the in-duct space. The cooling wind flows in the yarn running space mainly in the height direction. When the paired unit wall surfaces forming the passage of the cooling wind is long in the height direction, the passage resistance (frictional resistance) when the cooling wind flows in the height direction is large, with the result that large pressure loss is caused and the speed (air speed) of the cooling wind is significantly decreased. In this regard, according to the aspect of the present invention, the length in the height direction of each of the paired unit wall surfaces (hereinafter, this length may be simply referred to as wall surface height) is 30 mm or less. This arrangement shortens the passage of the cooling wind. Because the passage resistance is lowered and pressure loss is decreased, high air speed is achieved. Efficiency in cooling of the yarn is therefore improved in the cooler that is configured to cool the yarn by the cooling wind.

[0007] According to a second aspect of the invention, a cooler which is configured to cool a running yarn by cooling wind comprises: a cooling unit which is formed so that a yarn running space in which the yarn runs extends in a predetermined lengthwise direction; and a duct in which an in-duct space connected to the yarn running space is formed, the duct including a duct wall portion in which one or more slit is provided to extend in the lengthwise direction between the yarn running space and the in-duct space in a flow direction in which the cooling wind flows, the cooling unit including paired unit wall portions provided on one side of the duct wall portion in a height direction orthogonal to the lengthwise direction, the paired unit wall portions including paired unit wall surfaces opposing each other over the yarn running space in a width direction that is orthogonal to both the lengthwise direction and the height direction, and in the lengthwise direction, in a wall surface installation region in which the paired unit wall surfaces are provided, sum total of length of one or more formation region in which the one or more slit is formed in the duct wall portion being longer than sum total of length of a region excluding the one or more formation region.

[0008] According to this aspect of the present invention, in the lengthwise direction, the sum total of the length of the one or more formation region is longer than the sum total of the length of the remaining region. It is therefore possible to increase the total cross-sectional area (i.e., aperture area) of the one or more slit. Because the passage resistance is lowered and pressure loss is decreased, high air speed is achieved. The efficiency in cooling the yarn is therefore improved. It is noted that an arrangement in which a single slit is formed across the entirety of the wall surface installation region in the lengthwise direction is encompassed in the present invention.

[0009] According to a third aspect of the invention, the cooler of the first aspect is arranged so that, in the lengthwise direction, in a wall surface installation region in which the paired unit wall surfaces are provided, sum total of length of one or more formation region in which the one or more slit is formed in the duct wall portion is longer than sum total of length of a region excluding the one or more formation region.

[0010] According to this aspect of the present invention, being similar to the second aspect, the total length of the one or more formation region is long. On this account, the passage resistance is further reduced and the pressure loss is further reduced. Due to this, higher air speed is achieved. The efficiency in cooling the yarn is therefore further improved.

[0011] According to a fourth aspect of the invention, the cooler of the first or third aspect is arranged so that distance in the width direction between parts of the paired unit wall surfaces opposing each other in the width direction is 1 mm or less.

[0012] In this aspect of the present invention, the parts of the paired unit wall surfaces opposing each other in the width direction are parts of the paired unit wall surfaces, which are substantially in parallel to each other, and are parts where another member is not provided between the paired unit wall surfaces in the width direction. Typically, provided that the flow amount of fluid is the same, the flow rate of the fluid is high when the cross-sectional area of the passage is small. When the passage is too narrow in width, the pressure loss due to the wall surfaces forming the passage is large, and the flow amount of the fluid is disadvantageously decreased. According to the aspect of the present invention, the pressure loss due to the paired unit wall surfaces is suppressed by decreasing the wall surface height. It is therefore possible to suppress the increase in the pressure loss even if the distance in the width direction between the paired unit wall surfaces is decreased. The cross-sectional area in the direction orthogonal to the height direction of the yarn running space is decreased, and hence the air speed is further increased.

[0013] According to a fifth aspect of the invention, the cooler of any one of the first to fourth aspects is arranged so that the cooling unit includes one or more yarn guide which is provided in the yarn running space to restrict movement of the yarn toward the other side in the height direction.

[0014] According to this aspect of the present invention, because the yarn guide restricts the movement of the yarn to the other side in the height direction, unwanted entrance of the yarn into the in-duct space is suppressed.

[0015] According to a sixth aspect of the present invention, the cooler of the fifth aspect is arranged so that, in the height direction, an end on the one side of the one or more yarn guide is on the one side of the center of the paired unit wall surfaces.

[0016] According to this aspect of the present invention, because the yarn guide is provided to be far from the duct in the height direction, the yarn is entirely far from the duct in the height direction. This ensures the prevention of the entrance of the yarn into the in-duct space.

[0017] According to a seventh aspect of the invention, the cooler of any one of the first to sixth aspects is arranged so that the cooling unit includes: a first contact portion which is provided at part of one of the paired unit wall surfaces to be made contact with the yarn; and a second contact portion which is provided at part of the other of the paired unit wall surfaces to be made contact with the yarn, the second contact portion being positionally different from the first contact portion in the lengthwise direction.

[0018] This aspect of the present invention allows the yarn to run while making contact with the first contact portion or the second contact portion. This arrangement suppresses the yarn from moving in the width direction. In addition to the above, as the yarn makes contact with the first contact portion or the second contact portion cooled by the cooling wind, the yarn is further effectively cooled.

[0019] According to an eighth aspect of the invention, the cooler of any one of the first to seventh aspects further comprises a negative pressure generator which is configured to generate negative pressure in the in-duct space.

[0020] Oil is typically applied to the yarn in order facilitate smooth running of the yarn. On this account, when cooling wind is supplied from, for example, the in-duct space to the yarn running space, oil may scatter to the external space. In this regard, according to the aspect of the present invention, the problem of the scattering of the oil is avoided because the cooling wind is sucked into the in-duct space.

[0021] According to a ninth aspect of the invention, the cooler of the eighth aspect is arranged so that the negative pressure generator includes: an impeller which is configured to rotate; a motor which is configured to rotationally drive the impeller; and a rotation number changer which is capable of changing the number of rotations of a rotational shaft of the motor.

[0022] In the cooler of this aspect of the present invention, high air speed is achieved even if the negative pressure generated by the negative pressure generator is small as compared to known cases. It has been known that, when the negative pressure generator is arranged so that the negative pressure is changeable in accordance with the number of rotations of the rotational shaft of the motor, the power consumption of the motor is in proportion to the cube of the number of rotations. On this account, the power consumption of the negative pressure generator is significantly reduced while desired air speed is obtained, by arranging the number of rotations to be small as compared to the known cases.

[0023] According to a tenth aspect of the invention, a yarn processor comprises: the cooler of any one of the first to ninth aspects; a yarn deforming device which is configured to deform the yarn; and a yarn supplying device which is configured to supply the yarn to the cooler and the yarn deforming device and is provided to cause the yarn to run, the yarn processor being configured to process the yarn while causing the yarn to run.

[0024] According to this aspect of the present invention, the cooler is downsized and/or the power consumption thereof is reduced, while the yarn is efficiently cooled. On this account, the entire yarn processor is downsized and/or the power consumption thereof is reduced, while the good quality of the yarn processed by the yarn processor is maintained.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025]

FIG. 1 is a profile of a false-twist texturing machine related to an embodiment.
FIG. 2 is a schematic diagram of the false-twist texturing machine, expanded along paths of yarns.
FIG. 3 is a view of a winding unit, viewed along an arrow III in FIG. 1.
FIG. 4(a) is an enlarged view of a part of FIG. 3. FIG. 4(b) shows a cooling unit indicated by dotted lines in the enlarged view of the part of FIG. 3.
FIG. 5 is a cross section taken along a line V-V in FIG. 4(a).
FIG. 6 further schematizes the cooling unit.
FIG. 7 is an enlarged view of a part of FIG. 4(b).
FIG. 8 is a table showing evaluation results of air speed of cooling wind and power consumption of a cooler.
FIG. 9 is a graph showing the relationship between the air speed and the negative pressure of the cooling wind.
FIG. 10 is a graph showing the relationship between the air speed of the cooling wind and the power consumption of the cooler.
FIG. 11 is a graph showing the relationship between differences in structure of the cooler and the air speeds of the cooling wind.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0026] The following will describe an embodiment of the present invention. Hereinafter, the direction perpendicular to the sheet of FIG. 1 will be referred to as a base longitudinal direction. For the sake of convenience, each of the near side in the sheet of FIG. 1 and the left side in the sheet of FIG. 2 will be referred to as one side in the base longitudinal direction, whereas each of the far side in the sheet of FIG. 1 and the right side in the sheet of FIG. 2 will be referred to as the other side in the base longitudinal direction. Hereinafter, the left-right direction in the sheet of FIG. 1 will be referred to as a base width direction. The direction orthogonal to the base longitudinal direction and the base width direction is defined as the up-down direction (vertical direction) in which the gravity acts. A direction in which yarns Y (described later) run side by side will be referred to as a yarn running direction.

(Overall Structure of False-Twist Texturing Machine)

[0027] To begin with, the overall structure of a false-twist texturing machine 1 (a yarn processor of the present invention) of an embodiment will be described with reference to FIG. 1 and FIG. 3. FIG. 1 is a profile of the false-twist texturing machine 1. FIG. 2 is a schematic diagram of the false-twist texturing machine 1, expanded along paths of yarns Y (yarn paths) . FIG. 3 is a view of a winding unit, viewed along an arrow III in FIG. 1.

[0028] The false-twist texturing machine 1 is capable of performing false-twist texturing for yarns Y made of synthetic fibers (e.g., polyester). Each yarn Y is, for example, a multi-filament yarn formed of filaments. Alternatively, the yarn Y may be formed of a single filament. The false-twist texturing machine 1 includes a yarn supplying unit 2, a processing unit 3, and a winding unit 4. The yarn supplying unit 2 is arranged to be able to supply each yarn Y. The processing unit 3 is configured to take the yarn Y out from the yarn supplying unit 2 and perform false-twist texturing for the yarn Y. The winding unit 4 is configured to wind the yarn Y processed by the processing unit 3 onto a winding bobbin Bw. Components of the yarn supplying unit 2, the processing unit 3, and the winding unit 4 are aligned to form plural lines (as shown in FIG. 2) in the base longitudinal direction. The base longitudinal direction is a direction orthogonal to a running plane (plane of FIG. 1) of the yarn Y, and formed by a yarn path extending from the yarn supplying unit 2 to the winding unit 4 through the processing unit 3.

[0029] The yarn supplying unit 2 includes a creel stand 7 retaining yarn supply packages Ps, and supplies the yarns Y to the processing unit 3. The processing unit 3 is configured to take the yarns Y out from the yarn supplying unit 2 and process the yarns Y. In the processing unit 3, for example, the following members are provided in this order from the upstream in a yarn running direction: first feed rollers 11 (yarn supplying devices of the present invention); a twist-stopping guide 12; a first heater 13; a cooler 14; a false-twisting device 15 (a yarn deforming device of the present invention); second feed rollers 16; interlacing devices 17; third feed rollers 18; a second heater 19; and fourth feed rollers 20. The winding unit 4 includes a plurality of winding devices 21. Each winding device 21 winds the yarn Y for which the false winding has been performed at the processing unit 3 onto the winding bobbin Bw, and forms a wound package Pw.

[0030] The false-twist texturing machine 1 includes a main base 8 and a winding base 9 which are placed to be spaced apart from each other in the base width direction. The main base 8 and the winding base 9 are substantially identical in length in the base longitudinal direction. The main base 8 and the winding base 9 are arranged to face each other in the base width direction. Between the main frame 8 and the winding base 9, a working space Sw is formed to allow an operator to perform operations such as yarn threading (see FIG. 1). The false-twist texturing machine 1 includes units which are termed spans each of which includes a pair of the main base 8 and the winding base 9. In one span, each device is placed so that the yarns Y running while being aligned in the base longitudinal direction can be subjected to false-twist texturing at the same time. In the false-twist texturing machine 1, the spans are placed in a left-right symmetrical manner to the sheet, with a center line C of the base width direction of the main base 8 as a symmetry axis (main base 8 is shared between the left span and the right span). The spans are aligned in the base longitudinal direction.

(Structure of Processing Unit)

[0031] The structure of the processing unit 3 will be described with reference to FIG. 1 and FIG. 2. The first feed rollers 11 are arranged to unwind a yarn Y from a yarn supply package Ps attached to the yarn supplying unit 2 and feed the yarn Y to the first heater 13. For example, as shown in FIG. 2, each first feed roller 11 is arranged to send one yarn Y to the first heater 13. Alternatively, the first feed roller 11 is arranged to be able to send plural neighboring yarns Y to the downstream side in a yarn running direction. The twist-stopping guide 12 is provided to prevent twist of the yarn Y formed by the false-twisting device 15 from being propagated to the upstream in the yarn running direction of the twist-stopping guide 12.

[0032] The first heater 13 heats the yarn Y sent from the first feed rollers 11. For example, as shown in FIG. 2, the first heater 13 can heat two yarns Y. However, the disclosure is not limited to this. The first heater 13 may be arranged to be able to heat one yarn Y, for example. Alternatively, the first heater 13 may be arranged to be able to heat three or more yarns Y.

[0033] The cooler 14 is a contactless device configured to cool yarns Y by means of cooling wind. As shown in FIG. 3, the cooler 14 includes cooling units 31, an intake duct 32 (a duct of the present invention) to which the cooling units 31 are attached, and a negative pressure generator 33. The cooler 14 is configured to supply cooling wind to yarn running spaces S formed in the respective cooling units 31, by generating negative pressure in the internal space (intake space Ss that is equivalent to the in-duct space of the present invention) of the intake duct 32 by using the negative pressure generator 33. The negative pressure indicates pressure lower than the atmospheric pressure (to be more specific, air pressure in a space outside the cooler 14 in the present embodiment).

[0034] As shown in FIG. 3, the cooling units 31 are aligned in the base longitudinal direction. The cooling units 31 are attached to the intake duct 32. Each of the cooling units 31 extends in a direction intersecting with (more or less orthogonal to) the base longitudinal direction. Each cooling unit 31 extends substantially linearly in the present embodiment. The disclosure, however, is not limited to this arrangement. (For example, each cooling unit 31 may be curved.) Each cooling unit 31 includes a yarn running space S where a single yarn Y runs. The yarn Y running in the yarn running space S is cooled by cooling wind. The cooling units 31 include two cooling units 31A and 31B that are provided side by side in the base longitudinal direction. For example, the interval in the base longitudinal direction between the cooling unit 31A and the cooling unit 31B increases toward the downstream side in the yarn running direction. The two cooling units 31A and 31B are arranged to be line symmetric about a predetermined straight line L.

[0035] The intake duct 32 is configured to supply cooling wind to the cooling units 31. As shown in FIG. 3, the intake duct 32 extends in the base longitudinal direction. In the intake duct 32, an intake space Ss is formed to extend in the base longitudinal direction. The intake space Ss is connected to the yarn running spaces S. To the intake duct 32, the cooling units 31 are attached. To be more specific, the intake duct 32 has a duct wall portion 34 extending in the base longitudinal direction. The cooling units 31 are, for example, screwed to the duct wall portion 34. In the duct wall portion 34, intake slits 38 (see FIG. 4(b); these slits are equivalent to slits of the present invention and will be detailed later) are formed.

[0036] The negative pressure generator 33 is a known blower, for example. The negative pressure generator 33 is, for example, provided at an end portion on one side or the other side (one side in FIG. 3, for example) in the base longitudinal direction of the intake duct 32. The negative pressure generator 33 includes, for example, a rotatable impeller 35, a motor 36 rotationally driving the impeller 35, and an inverter device 37 (a rotation number changer of the present invention) capable of changing the number of rotations of the rotational shaft (not illustrated) of the motor 36. The motor 36 is, for example, a known AC motor. The negative pressure generator 33 is configured to generate negative pressure in the intake space Ss by rotationally driving the impeller 35 by using the motor 36. The cooler 14 will be further detailed below.

[0037] The false-twisting device 15 is provided on the downstream side in the yarn running direction of the cooler 14 and is configured to twist the yarn Y. The false-twisting device 15 is a known disc-friction-type false-twisting device or a known belt-type false-twisting device, for example. The disclosure, however, is not limited to this arrangement. The second feed roller 16 is configured to send the yarns Y processed by the false-twisting device 15 to the interlacing device 17. The conveyance speed of conveying the yarn Y by the second feed roller 16 is higher than the conveyance speed of conveying the yarn Y by the first feed rollers 11. The yarn Y is therefore drawn and false-twisted between the first feed roller 11 and the second feed roller 16.

[0038] The interlacing device 17 is configured to interlace the yarn Y. The interlacing device 17 includes, for example, a known interlace nozzle configured to interlace the yarn Y by an air flow.

[0039] The third feed roller 18 is configured to feed the yarn Y running on the downstream side of the interlacing device 17 in the yarn running direction to the second heater 19. For example, as shown in FIG. 2, the third feed roller 18 can send one yarn Y to the second heater 19. Alternatively, the third feed roller 18 may be arranged to be able to send neighboring yarns Y to the downstream side in the yarn running direction. The conveyance speed of conveying the yarn Y by the third feed roller 18 is lower than the conveyance speed of conveying the yarn Y by the second feed roller 16. The yarn Y is therefore relaxed between the second feed roller 16 and the third feed roller 18. The second heater 19 heats the yarns Y sent from the third feed rollers 18. The second heater 19 extends along the vertical direction, and one second heater 19 is provided in one span. The fourth feed roller 20 sends the yarns Y heated by the second heater 19 to the winding device 21. For example, as shown in FIG. 2, the fourth feed roller 20 can send one yarn Y to the winding device 21. Alternatively, the fourth feed roller 20 may be arranged to be able to send neighboring yarns Y to the downstream side in the yarn running direction. The conveyance speed of conveying the yarn Y by the fourth feed roller 20 is lower than the conveyance speed of conveying the yarn Y by the third feed roller 18. The yarn Y is therefore relaxed between the third feed roller 18 and the fourth feed roller 20.

[0040] In the processing unit 3 arranged as described above, the yarn Y drawn between the first feed roller 11 and the second feed roller 16 is twisted by the false-twisting device 15. The twist formed by the false-twisting devices 15 propagates to the twist-stopping guide 12 but does not propagate to the upstream of the twist-stopping guide 12 in the yarn running direction. The yarn Y which is twisted and drawn is heated at the first heater 13 and thermally set. After that, the yarn Y is cooled at each cooler 14. The yarn Y is untwisted at the downstream of the false-twisting device 15 in the yarn running direction. However, the yarn Y is maintained to be wavy in shape on account of the thermal setting described above (i.e., crimp of the yarn Y is maintained).

[0041] After being false-twisted, the yarn Y is interlaced by the interlacing device 17 while being relaxed between the second feed rollers 16 and the third feed rollers 18, and then the yarn Y is guided to the downstream side in the yarn running direction. Furthermore, the yarn Y is thermally processed at the second heater 19 while being relaxed between the third feed roller 18 and the fourth feed roller 20. Finally, the yarn Y sent from the fourth feed roller 20 is wound by the winding device 21.

(Structure of Winding Unit)

[0042] The following will describe the structure of the winding unit 4 with reference to FIG. 2. The winding unit 4 includes a plurality of winding devices 21. Each winding device 21 can wind the yarn Y onto one winding bobbin Bw. The winding device 21 includes fulcrum guides 41, a traverse unit 42, and a cradle 43. Each of the fulcrum guides 41 is a guide about which the yarn Y is traversed. The traverse unit 42 is capable of traversing the yarn Y by the traverse guide 45. The cradle 43 is arranged to support the winding bobbin Bw to be freely rotatable. A contact roller 46 is provided in the vicinity of the cradle 43. The contact roller 46 makes contact with the surface of the wound package Pw and applies contact pressure thereto. In the winding unit 4 structured as above, the yarn Y which is sent from the fourth feed roller 20 described above is wound onto the winding bobbin Bw by each winding device 21, and forms each wound package Pw.

[0043] There have recently been demands for further improvement in efficiency of cooling of yarns Y in order to, for example, cool yarns Y that are thicker than before. This improvement in efficiency of cooling may indicate various meanings. For example, "making it possible to rapidly cool the yarn Y in a short time", "obtaining high air speed with small negative pressure", and "reducing power consumption of the negative pressure generator 33 while obtaining desired air speed" are equivalent to the improvement in efficiency of cooling. Among them, in order to achieve "making it possible to rapidly cool the yarn Y in a short time", it is desired to make it possible to improve the speed (air speed) of the cooling wind. In this regard, the inventors of the subject application have found that the air speed is not easily increased even though the number of rotations of the impeller 35 (i.e., the output of the negative pressure generator 33) is simply increased to increase the negative pressure in the intake duct 32. On this account, in the present embodiment, the cooler 14 further has the arrangement described below, in order to improve the efficiency in cooling the yarn Y.

(Specific Details of Cooler)

[0044] The cooler 14 will be further detailed with reference to FIG. 4(a) to FIG. 7. FIG. 4(a) is an enlarged view of a part of FIG. 3. FIG. 4(b) shows the cooling unit 31A indicated by dotted lines in the enlarged view of the part of FIG. 3. FIG. 5 is a cross section taken along a line V-V in FIG. 4. FIG. 6 further schematizes the cooling unit 31A in order to make it easy to see the yarn running space S. FIG. 7 is an enlarged view of a part of FIG. 4(b). The up-down direction in the sheet of each of FIG. 6 and FIG. 7 is in parallel to the later-described unit longitudinal direction.

[0045] As described above, the cooling unit 31A and a cooling unit 31B are arranged to be line-symmetrical (see FIG. 3). On this account, in the descriptions below, the cooling unit 31A will be mainly detailed among the cooling units 31, and the cooling unit 31B will be only briefly described.

[0046] Hereinafter, the direction perpendicular to the sheet of each of FIG. 4(a) and FIG. 4(b) will be referred to as a height direction. The height direction is in parallel to the up-down direction in the sheet of FIG. 5. The height direction is orthogonal to the base longitudinal direction. In the present embodiment, furthermore, the height direction has at least a component in the up-down direction. In the present embodiment, one side in the height direction is roughly equivalent to a lower side. Meanwhile, the other side in the height direction is roughly equivalent to an upper side. It is, however, noted that the relationship between the height direction and the up-down direction may be changed in accordance with the orientation of the cooler 14.

[0047] In addition to the above, a direction orthogonal to both the base longitudinal direction and the height direction will be referred to as an orthogonal direction for the sake of convenience (see FIG. 4(a)). The cooling unit 31A and the cooling unit 31B extend at least in the orthogonal direction. In the present embodiment, each of the cooling unit 31A and the cooling unit 31B extend in a direction slightly tilted relative to the orthogonal direction. Furthermore, a direction in which the cooling unit 31A extends is referred to as a unit longitudinal direction (lengthwise direction of the present invention). A direction orthogonal to both the unit longitudinal direction and the height direction is referred to as a width direction for the sake of convenience (see FIG. 5). The left side of the sheet of FIG. 5 is one side in the width direction. The right side of the sheet of FIG. 5 is the other side in the width direction.

[0048] In the present embodiment, the unit longitudinal direction is a predetermined direction having a component in the orthogonal direction (see FIG. 4(a) and FIG. 4(b)). To put it differently, in the present embodiment, the unit longitudinal direction remains the same irrespective of the position of the cooling unit 31 in the orthogonal direction. In an arrangement in which, for example, the cooling unit 31 viewed in the height direction is curved, the unit longitudinal direction varies depending on a position in the orthogonal direction of the cooling unit 31.

(Structure of Cooling Unit)

[0049] As shown in FIG. 4 to FIG. 7, the cooling unit 31A includes a pair of unit wall plates 51 (a pair of unit wall portions of the present invention) . The pair of unit wall plates 51 are provided on one side in the height direction of the intake duct 32 (to be more specific, on one side in the height direction of the duct wall portion 34). Each of the paired unit wall plates 51 (unit wall plates 51a and 51b) is a long member by which the yarn running space S is formed. In the width direction, the yarn running space S is formed between paired wall surfaces 55 (described later) of the paired unit wall plates 51. The unit wall plates 51a and 51b are long members extending along the unit longitudinal direction. The unit wall plate 51a is provided on one side in the width direction of the yarn running space S. The unit wall plate 51b is provided on the other side in the width direction of the yarn running space S.

[0050] The unit wall plate 51a is, for example, substantially C-shaped in cross section (see FIG. 5) and formed by bending a metal flat plate member. The unit wall plate 51a may be fixed to the duct wall portion 34, for example. Alternatively, the unit wall plate 51a may be movable relative to the unit wall plate 51b at least in the width direction. When the unit wall plate 51a is movable, for example, cleaning of members such as a later-described yarn guide 58 can be easily done in the maintenance of the cooling unit 31A. The unit wall plate 51a includes a base end portion 52a, an intermediate portion 53a, and a leading end portion 54a (see FIG. 5).

[0051] The base end portion 52a is provided at an end portion on the other side in the height direction of the unit wall plate 51a and extends in the width direction. The intermediate portion 53a extends from an end portion on the other side in the width direction of the base end portion 52a toward one side in the height direction. At an end on the other side in the width direction of the intermediate portion 53a, a unit wall surface 55a is formed to extend at least in the height direction. The unit wall surface 55a is one of the paired unit wall surfaces 55. The unit wall surface 55a is a surface including curved surfaces which are formed at both end portions in the height direction of the intermediate portion 53a in the bending process (see the bold lines in FIG. 5). The unit wall surface 55a is a surface for forming the yarn running space S in the cooling unit 31A. On the unit wall surface 55a, for example, contact bodies 56a (first contact portions of the present invention; see FIG. 5 and FIG. 6) are provided to be separated from one another in the unit longitudinal direction. Each contact body 56a is arranged so that the running yarn Y is intentionally made contact with the contact body 56a. This prevents the yarn Y from unintentionally making contact with a part of the unit wall surface 55a, where no contact body 56a is provided. The thickness of the contact body 56a (i.e., the length in the width direction) is, for example, 0.35 mm. The leading end portion 54a extends from an end portion on one side in the height direction of the intermediate portion 53a toward one side in the width direction.

[0052] The unit wall plate 51b is, for example, substantially reverse C-shaped in cross section (see FIG. 5) and formed by bending a metal flat plate member. The unit wall plate 51b is fixed to the duct wall portion 34 by, for example, an unillustrated screw. In a cross section shown in FIG. 5, the unit wall plate 51b has a base end portion 52b, an intermediate portion 53b, and a leading end portion 54b.

[0053] The base end portion 52b is provided at an end portion on the other side in the height direction of the unit wall plate 51b and extends in the width direction. The intermediate portion 53b extends from an end portion on one side in the base longitudinal direction of the base end portion 52b toward one side in the height direction. At an end on one side in the width direction of the intermediate portion 53b, a unit wall surface 55b is formed to extend at least in the height direction. The unit wall surface 55b is the other one of the paired unit wall surfaces 55. The unit wall surface 55b is provided to oppose the unit wall surface 55a over the yarn running space S in the width direction. To put it differently, the paired unit wall surfaces 55 are on the opposite sides of the yarn running space S in the width direction. Being similar to the unit wall surface 55a, the unit wall surface 55b is a surface including curved surfaces which are formed at both end portions in the height direction of the intermediate portion 53b (see the bold lines in FIG. 5). The unit wall surface 55b is a surface for forming the yarn running space S together with the unit wall surface 55a. On the unit wall surface 55b, for example, contact bodies 56b (second contact portions of the present invention; see FIG. 5 and FIG. 6) are provided to be separated from one another in the unit longitudinal direction. This prevents the yarn Y from unintentionally making contact with a part of the unit wall surface 55b, where no contact body 56b is provided. The thickness of the contact body 56b (i.e., the length in the width direction) is, for example, 0.35 mm. The contact bodies 56b are provided to be positionally different from the contact bodies 56a in the unit longitudinal direction (see FIG. 6). The leading end portion 54b extends from an end portion on one side in the height direction of the intermediate portion 53b toward the other side in the width direction.

[0054] Between the unit wall surface 55a and the unit wall surface 55b in the width direction, for example, plate-shaped spacers 57 (only one of them is shown in FIG. 5) are provided. Although not illustrated, the spacers 57 are provided to be spaced apart from one another in the unit longitudinal direction. The spacers 57 are arranged to define the distance in the width direction (i.e., the interval in the width direction) between the unit wall surface 55a and the unit wall surface 55b. The thickness of the spacer 57 (i.e., the length in the width direction) is, for example, 1 mm or less. With this arrangement, the distance G (see FIG. 5) in the width direction between parts of the paired unit wall surfaces 55 opposing each other in the width direction is 1 mm or less. In the present embodiment, the parts of the paired unit wall surfaces 55 opposing each other in the width direction are parts of the paired unit wall surfaces 55, which are substantially in parallel to each other, and are parts where another member is not provided between the paired unit wall surfaces 55 in the width direction. To put it differently, at a part where both the unit wall surface 55a and the unit wall surface 55b extend along the height direction, the distance (G) in the width direction between the unit wall surface 55a and the unit wall surface 55b is 1 mm or less. In the present embodiment, the both end portions (which are bended and are not substantially in parallel to each other) in the height direction of the paired unit wall surfaces 55 are not encompassed in the parts of the paired unit wall surfaces 55 opposing each other in the width direction. Meanwhile, for example, the distance in the width direction between the unit wall surface 55a and the contact body 56b is 0.65 mm. This distance, however, is not encompassed in the distance in the width direction between the parts of the paired unit wall surfaces 55 opposing each other in the width direction. The same applies to the distance in the width direction between the unit wall surface 55b and the contact body 56a.

[0055] Between the unit wall surface 55a and the unit wall surface 55b in the width direction, for example, yarn guides 58 are provided (as shown in FIG. 5 and FIG. 6). Alternatively, only one yarn guide 58 may be provided. The one or more yarn guide 58 is a member which prevents the yarn Y from being sucked into the intake space Ss. Each yarn guide 58 is provided in the yarn running space S. In the present embodiment, for example, three yarn guides 58 are provided. Each yarn guide 58 is, for example, provided on one side of the spacer 57 in the height direction. Each yarn guide 58 is arranged so that the yarn Y makes contact with an end portion of each yarn guide 58, which is on one side in the height direction. With this arrangement, each yarn guide 58 restricts the movement of the yarn Y toward the other side in the height direction. It is therefore possible to prevent the yarn Y from being sucked into the intake space Ss. Each yarn guide 58 is preferably provided on one side in the height direction of the center of the paired unit wall surfaces 55. This further ensures the prevention of the yarn Y from being sucked into the intake space Ss.

[0056] The yarn running space S is connected to the intake space Ss formed in the intake duct 32 through the above-described intake slits 38 (see FIG. 4(b) and FIG. 5). For example, the intake slits 38 penetrate the duct wall portion 34 in the height direction (see FIG. 5) and extend in the unit longitudinal direction (see FIG. 4(b)). In a flow direction in which cooling wind flows, the intake slits 38 are provided on the downstream side of the yarn running space S and on the upstream side of the intake space Ss.

[0057] In the cooler 14 structured as described above, when negative pressure is generated in the intake space Ss by the negative pressure generator 33, cooling wind mainly flows in the yarn running space S from one side to the other side in the height direction (see the arrow in FIG. 5). The cooling wind is then sucked into the intake space Ss through the intake slit 38. In order to improve the efficiency in cooling the yarn Y in the cooler 14, the inventors of the subject application focused on the reduction of frictional resistance (passage resistance) of a passage through which the cooling wind flows.

(Structures for Improving Cooling Efficiency)

[0058] The following will describe two structures effective for improving the cooling efficiency will be described. In a first structure, the length in the height direction of each of the paired unit wall surfaces 55 (hereinafter, this length may be simply referred to as wall surface height) is 30 mm or less. To put it differently, in the height direction, the length from an entrance 59 of the yarn running space S to an end of the intake slit 38 on one side is 30 mm or less. The position of the entrance 59 in the height direction is identical with the position of the end of each of the paired unit wall surfaces 55, which is on one side in the height direction (see FIG. 5). A conventional wall surface height is, for example, 34 mm. The wall surface height of the cooler 14 is therefore lower than the conventional height. On this account, provided that the yarn running space S is a passage of cooling wind, the passage of the cooling wind mainly flowing in the height direction is short in the height direction. Because the passage resistance is lowered and pressure loss is decreased, it is possible to increase the air speed of the cooling wind as compared to the known arrangement, without increasing the output of the negative pressure generator 33. When the spacer 57 and the yarn guide 58 are provided in the yarn running space S as in the present embodiment, the wall surface height is preferably 10 mm or more in consideration of the installation regions of the spacer 57 and the yarn guide 58.

[0059] Now, the following will describe a second structure. In the unit longitudinal direction, a region where the paired unit wall surfaces 55 are provided is referred to as a wall surface installation region R (see FIG. 4) for the sake of convenience. In the unit longitudinal direction, in the wall surface installation region R, regions of the duct wall portion 34 where the intake slits 38 are formed are referred to as formation regions R1 (see FIG. 7) for the sake of convenience. In the unit longitudinal direction, in the wall surface installation region R, regions excluding the formation regions R1 are referred to as non-formation regions R2 (see FIG. 7) for the sake of convenience. In the unit longitudinal direction, the sum total of the lengths of the formation regions R1 is longer than the sum total of the lengths of the non-formation regions R2 (see FIG. 4(b)). To put it differently, in the unit longitudinal direction, the sum total of the lengths of the formation regions R1 is longer than a half of the length of the wall surface installation region R. It is therefore possible to increase the total cross-sectional area (i.e., aperture area) of the intake slits 38. Because the passage resistance of the intake slits 38 is lowered and pressure loss is decreased, it is possible to increase the air speed of the cooling wind.

[0060] The following will describe a specific example of the second structure. For example, the length in the unit longitudinal direction of the wall surface installation region R is 550 mm. As shown in FIG. 4(b), five intake slits 38 are formed to correspond to one cooling unit 31. In other words, five formation regions R1 exist in one wall surface installation region R. The length in the unit longitudinal direction of each formation region R1 is, for example, 90 mm. The sum total of the lengths in the unit longitudinal direction of the five formation regions R1 is 450 mm. The width (i.e., the length in the width direction) of each formation region R1 is, for example, 3 mm. In addition, for example, six non-formation regions R2 are formed in one wall surface installation region R, in addition to the five formation regions R1. The non-formation regions R2 are substantially identical in length in the unit longitudinal direction. The sum total of the lengths in the unit longitudinal direction of the six non-formation regions R2 is arranged to be 100 mm.

[0061] The inventors of the subject application considered that the pressure loss was reduced and the air speed of the cooling wind was increased with the first and second structures described above.

(Confirmation of Effects Regarding Improvement in Cooling Efficiency)

[0062] As described below, the inventors of the subject application conducted evaluations regarding the improvement in cooling efficiency of various types of coolers having the first structure and/or the second structure described above. The following will describe the contents and results of the evaluations with reference to FIG. 8 to FIG. 11. FIG. 8 is a table showing evaluation results of air speed of cooling wind and power consumption of a cooler of each type. FIG. 9 is a graph showing the relationship between the air speed and the negative pressure of the cooling wind. FIG. 10 is a graph showing the relationship between the air speed of the cooling wind and the power consumption of the cooler of each type. FIG. 11 is a graph showing the relationship between a difference in structure of the cooler of each type and the air speed of the cooling wind.

[0063] The inventors of the subject applicant mainly performed two evaluations. As a first evaluation, physical properties were compared between a cooler having the first and second structures in the same manner as the cooler 14 (Example shown in FIG. 8 to FIG. 10) and a cooler not having the first and second structures (Comparative Example shown in FIG. 8 to FIG. 10). As a second evaluation, whether the cooling effect was improved was checked for a cooler (not illustrated) having only one of the first and second structures (see FIG. 11).

[0064] The content and result of the first evaluation are described below. The inventors of the subject application prepared a cooler (not illustrated) of Example and a cooler (not illustrated) of Comparative Example. The cooler of Example was structured as described below. In regard to the first structure, the wall surface height (length of one pair of unit wall surfaces 55 in the height direction) was 27 mm. In regard to the second structure, five formation regions R1 were formed in the same manner as in the above-described embodiment. The sum total of the lengths in the unit longitudinal direction of the formation regions R1 was 450 mm. The sum total of the lengths in the unit longitudinal direction of the non-formation regions R2 was 100 mm.

[0065] Meanwhile, the cooler of Comparative Example was structured as described below. In regard to the first structure, the height of one pair of unit wall surfaces (not illustrated) was 34 mm. In regard to the second structure described above, nine formation regions (not illustrated) were formed. The length in the unit longitudinal direction of each formation region was 30 mm. The sum total of the lengths in the unit longitudinal direction of the formation regions was 270 mm. Furthermore, 10 non-formation regions (not illustrated) were provided. The sum total of the lengths in the unit longitudinal direction of the non-formation regions was 280 mm. In other words, in Comparative Example, the sum total of the lengths in the unit longitudinal direction of the formation regions was equal to or shorter than the sum total in the unit longitudinal direction of the non-formation regions.

[0066] In each of the cooler of Example and the cooler of Comparative Example, the inventors of the subject application activated a known blower (negative pressure generator 33) and set different conditions of the negative pressure (static pressure) generated in the intake space Ss. To be more specific, in order to acquire a predetermined negative pressure, the inventors of the subject application switched the frequency of a signal sent to a motor (motor 36) by using an inverter (inverter device 37). The frequency of the signal is in proportion to the number of rotations of the rotational shaft of the motor. In each condition, the inventors of the subject application acquired a time mean value of air speed (average air speed) in the vicinity of the entrance 59 of the yarn running space S and a power consumption value of the blower (see FIG. 8). The air speed of the cooling wind was measured by using Anemomaster (registered trademark) that is an air velocity meter manufactured by KANOMAX JAPAN INCORPORATED. To be more specific, a leading end portion of a prove of the air velocity meter was provided in the vicinity of a central portion in the unit longitudinal direction of the yarn running space S. The information of the power consumption of the blower was obtained by using the inverter. The magnitude of the negative pressure in the intake space Ss was measured by using a known pressure gauge. In regard to Example and Comparative Example, FIG. 8 shows absolute values of the negative pressure (in units of kPa), the frequencies (in units of Hz), the average air speeds (in units of m/s), and the power consumption (in units of kW). Hereinafter, a value of negative pressure is indicated by an absolute value. The larger the absolute value is, the larger the sucking force of the blower is.

[0067] The set value of the negative pressure was switched between three conditions, i.e., 0.3kPa, 0.6kPa, and 1.0kPa in each of Example and Comparative Example. The larger the set value of the negative pressure was, the larger the above-described frequency was (i.e., the larger the number of rotations of the rotational shaft of the motor was). As the negative pressure was increased, the difference in the frequency between Example and Comparative Example was gradually increased. To be more specific, when the set value of the negative pressure was 0.3kPa, the frequency in Example and the frequency in Comparative Example were both 22Hz. Meanwhile, when the set value of the negative pressure was 1.0kPa, the frequency in Example was 42Hz and the frequency in Comparative Example was 46Hz. In this way, the results show that, in Example, negative pressure identical in magnitude with that of Comparative Example was generated even though the number of rotations of the rotational shaft of the motor was small as compared to Comparative Example. According to the results, in the cooler of Example, the load on the motor was decreased presumably because the pressure loss was decreased by the first and second structures described above.

[0068] The graph of FIG. 9 shows the relationship between average air speed and negative pressure in Example and Comparative Example based on the table of FIG. 8. The transverse axis indicates negative pressure whereas the vertical axis indicate average air speed. When the set value of the negative pressure was 0.3kPa, the average air speed in Comparative Example was 0.96 m/s and the average air speed in Example was 1.77 m/s. When the set value of the negative pressure was 0.6kPa, the average air speed in Comparative Example was 1.19 m/s and the average air speed in Example was 2.57 m/s. When the set value of the negative pressure was 1.0kPa, the average air speed in Comparative Example was 1.35 m/s and the average air speed in Example was 3.07 m/s. In each condition of the negative pressure, the average air speed in Example was about twice as high as the average air speed in Comparative Example. In this way, in Example, high air speed was obtained (i.e., the cooling efficiency was improved).

[0069] As described above, in the cooler of Example, the average air speed was 1.77 m/s when the set value of the negative pressure was 0.3kPa. This value is larger than the average air speed (1.35 m/s) when the set value of the negative pressure was 1.0kPa in the cooler of Comparative Example. In this way, in Example, very high air speed was obtained even if the negative pressure was small (i.e., the cooling efficiency was significantly improved).

[0070] The graph of FIG. 10 shows the relationship between power consumption and average air speed in Example and Comparative Example based on the table of FIG. 8. The transverse axis indicates average air speed whereas the vertical axis indicates power consumption of the blower (particularly the motor). For example, in Comparative Example, the power consumption required for obtaining the air speed of 1.35 m/s was 3.05kW. The above-described frequency in this case was 46Hz. Meanwhile, in Comparative Example, the power consumption required for obtaining the air speed of 1.77 m/s was only 0.34kW. The above-described frequency in this case was 22Hz. As such, the power consumption in Example for obtaining more or less the same air speed as the known case is about 10% of the power consumption in the known case. It has been known that the power consumption of a motor in which the number of rotations of the rotational shaft is changeable is in proportion to the cube of the number of rotations. It is considered that such significant reduction in power consumption was achieved (i.e., the cooling efficiency was significantly improved) for this reason.

[0071] As described above, the air speed was increased and the power consumption was decreased without increasing the negative pressure in the cooler of Example. These effects both contribute to the improvement in cooling efficiency. While in Example the wall surface height was set at 27 mm, the cooling efficiency is considered to be significantly improved when the wall surface height is lower than 34 mm that is the height in the known case (e.g., the wall surface height is equal to or lower than 30 mm). The cooling efficiency is considered to be further improved when the height is lower than 27 mm.

[0072] Now, the content and result of the second evaluation are described below. The inventors of the subject application evaluated whether the cooling efficiency was improved when the cooler 14 had only one of the first structure (the wall surface height was 30 mm or less) and the second structure (the sum total of the above-described lengths of the formation regions R1 was longer than the sum total of the above-described lengths of the non-formation regions R2). The inventors prepared the following four types of coolers. A cooler of the first type was identical with the cooler of Example described above and had both the first and second structures. A cooler of the second type had only the first structure (the wall surface height was 27 mm in this case). That is to say, in the cooler of the second type, the sum total of the above-described lengths of the formation regions R1 was identical with that of the above-described Comparative Example. A cooler of the third type had only the second structure. That is to say, in the cooler of the third type, the wall surface height was identical with that of the above-described Comparative Example. A cooler of the fourth type was identical with the cooler of the above-described Comparative Example.

[0073] The inventors of the subject application set the negative pressure in the intake space Ss at a constant condition, and acquired information of the air speed of the cooling wind of each of the coolers of the first to fourth types. The results are indicated by bar graphs in FIG. 11. The vertical axis indicates the air speed. Roughly speaking, air speed higher than that of Comparative Example was acquired in all of the coolers of the first to third types (i.e., high cooling efficiency was achieved). In other words, it was found that the cooling efficiency could be improved when at least one of the above-described first or second structure was employed.

[0074] As described above, the length in the height direction of each of the paired unit wall surfaces 55 (i.e., the wall surface height) is 30 mm or less. This arrangement shortens the passage of the cooling wind. Because the passage resistance is lowered and pressure loss is decreased, high air speed is achieved. The efficiency in cooling the yarn Y is therefore improved.

[0075] In addition to the above, the sum total of the lengths in the unit longitudinal direction of the formation regions R1 is longer than the sum total of the lengths in the unit longitudinal direction of the non-formation regions R2. It is therefore possible to increase the cross-sectional area (i.e., aperture area) of the intake slits 38. Because the passage resistance is lowered and pressure loss is decreased, high air speed is achieved. The efficiency in cooling the yarn Y is therefore improved.

[0076] In addition to the above, the distance G in the width direction between parts of the paired unit wall surfaces 55 opposing each other in the width direction is 1 mm or less. Typically, provided that the flow amount of fluid is the same, the flow rate of the fluid is high when the cross-sectional area of the passage is small. When the passage is too narrow in width, the pressure loss due to the wall surfaces forming the passage is large, and the flow amount of the fluid is disadvantageously decreased. In this connection, in the present embodiment, the pressure loss due to the paired unit wall surfaces 55 is suppressed by decreasing the wall surface height. On this account, increase in the pressure loss due to the decrease in size of the distance G is suppressed. The cross-sectional area in the direction orthogonal to the height direction of the yarn running space S is decreased, and hence the air speed is further increased.

[0077] In addition to the above, the cooling unit 31 has one or more yarn guide 58. Because the yarn guide 58 restricts the movement of the yarn Y to the other side in the height direction, unwanted entrance of the yarn Y into the intake duct 32 is suppressed. Furthermore, because the yarn guide 58 is provided to be far from the intake duct 32 in the height direction, the yarn Y is entirely far from the intake duct 32 in the height direction. This ensures the prevention of the entrance of the yarn Y into the intake space Ss.

[0078] In addition to the above, the present embodiment allows the yarn Y to run while making contact with the contact bodies 56a and the contact bodies 56b in an alternate manner. This arrangement suppresses the yarn Y from moving in the width direction. In addition to the above, as the yarn Y makes contact with the contact body 56a or the contact body 56b cooled by the cooling wind, the yarn Y is further effectively cooled.

[0079] In addition to the above, the negative pressure generator 33 generates cooling wind heading from the yarn running space S toward the intake space Ss. Oil is typically applied to the yarn Y in order facilitate smooth running of the yarn Y. On this account, when cooling wind is supplied from, for example, the in-duct space to the yarn running space S, oil may scatter to the external space (to be more specific, to the working space Sw). In this regard, the problem of the scattering of the oil is avoided in the present embodiment because the cooling wind is sucked into the intake space Ss.

[0080] In addition to the above, the negative pressure generator 33 includes the impeller 35, the motor 36, and the inverter device 37. In the cooler 14 with improved cooling efficiency, the power consumption of the negative pressure generator 33 is significantly reduced while desired air speed is obtained, by arranging the number of rotations of the rotational shaft of the motor 36 to be small as compared to known cases by the inverter device 37.

[0081] In addition to the above, the cooler 14 is downsized and/or the power consumption thereof is reduced, while the yarn Y is efficiently cooled by the cooler 14. On this account, the entire false-twist texturing machine 1 is downsized and/or the power consumption thereof is reduced, while the good quality of the yarn Y processed by the false-twist texturing machine 1 is maintained.

[0082] The following will describe modifications of the above-described embodiment. The members identical with those in the embodiment above will be denoted by the same reference numerals and the explanations thereof are not repeated.

(1) In the embodiment above, the distance G in the width direction between parts of the paired unit wall surfaces 55 opposing each other in the width direction is 1 mm or less. However, the disclosure is not limited to this. The distance G may be longer than 1 mm.

(2) In the embodiment above, the cooling unit 31 includes contact bodies 56a and contact bodies 56b. However, the disclosure is not limited to this. The contact bodies 56a and the contact bodies 56b may not be provided.

(3) In the embodiment above, an end on one side in the height direction of one or more yarn guide 58 is provided on one side of the center of the pair of unit wall surfaces 55. However, the disclosure is not limited to this. The end on one side of the one or more yarn guide 58 may be provided on the other side of the center of the pair of unit wall surfaces 55.

(4) In the embodiment above, the cooling unit 31 includes one or more yarn guide 58. However, the disclosure is not limited to this. The yarn guide 58 may not be provided. In such an arrangement, it is unnecessary to secure an area where the yarn guide 58 is provided. On this account, the above-described wall surface height may be less than 10 mm. The wall surface height may be, for example, 5 mm. When this arrangement is employed, it is preferable to take a measure for preventing the yarn Y from being sucked into the intake space Ss.

(5) In the embodiment above, the cooling unit 31 includes the spacer 57. However, the disclosure is not limited to this. Instead of the spacer 57, the positional relationship in the width direction between the unit wall surface 55a and the unit wall surface 55b may be determined by a positioning member (not illustrated).

(6) In the embodiment above, the cooling unit 31 includes the paired unit wall plates 51 each of which is formed by bending a metal flat plate member. However, the disclosure is not limited to this. In place of the paired unit wall plates 51, for example, paired block members (not illustrated) formed by machining may be provided as features equivalent to the paired unit wall portions of the present invention. Paired wall surfaces equivalent to the paired unit wall surfaces 55 may be formed at paired block members. In this case, the paired wall surfaces may not have curved surfaces such as those of the paired unit wall surfaces 55, and may be formed to be substantially linear in a cross section cut along a direction orthogonal to the unit longitudinal direction.

[0083] Alternatively, for example, paired wall surfaces equivalent to the paired unit wall surfaces 55 may be formed by machining a single block-shaped member. In this case, the above-described spacers 57 or positioning member (not illustrated) may not be provided.

[0084] Alternatively, for example, paired wall surfaces equivalent to the paired unit wall surfaces 55 may be formed by machining part of the duct wall portion 34. In this case, the wall surface height may be further lower than the above. The wall surface height may be, for example, 1 mm. In this case, the spacers 57 or positioning member (not illustrated) may not be provided.

[0085] (7) In the embodiment above, plural intake slits 38 are formed in the duct wall portion 34 to correspond to one cooling unit 31. However, the disclosure is not limited to this. For example, one long and narrow intake slit (not illustrated) may be provided to correspond to one cooling unit 31. The one intake slit may be formed across the entirety of the wall surface installation region R in the unit longitudinal direction. Such an arrangement is encompassed in the arrangement "the sum total of the length of one or more formation region is longer than the sum total of the length of a region excluding the one or more formation region" of the present invention.

[0086] (8) In the embodiment above, the negative pressure generator 33 includes the motor 36 that is an AC motor and the inverter device 37. However, the disclosure is not limited to this. Instead of the motor 36, for example, an unillustrated DC motor may be provided. According to this arrangement, the number of rotations of the rotational shaft of the motor may be changed by changing the magnitude of voltage applied to the DC motor.

[0087] (9) In the embodiment above, the negative pressure generator 33 is arranged to be able to change the number of rotations of the rotational shaft of the motor 36 (or the unillustrated DC motor). However, the disclosure is not limited to this. The negative pressure generator 33 may include, for example, a power transmission mechanism (not illustrated) that is provided between the rotational shaft and the impeller 35 in a transmission direction in which power is transmitted to the impeller. For example, the power transmission mechanism may have unillustrated plural gears and may be arranged so that the gear ratio is changeable. With such an arrangement, the magnitude of the generated negative pressure may be changed by changing the number of rotations of the impeller 35.

[0088] (10) In the embodiment above, the negative pressure generator 33 is a blower. However, the disclosure is not limited to this. As the negative pressure generator of the present invention, an unillustrated fan or an unillustrated aspirator may be provided, for example.

[0089] (11) In the embodiment above, the negative pressure generator 33 generates negative pressure in the intake space Ss (in-duct space) so as to supply cooling wind to the yarn running space S. However, the disclosure is not limited to this. In place of the negative pressure generator 33, an apparatus configured to generate positive pressure (i.e., pressure higher than the air pressure of the space outside the cooler 14) in the in-duct space. In this case, cooling wind is supplied from the in-duct space toward the yarn running space S. Also in this case, the passage resistance is reduced and the pressure loss is reduced. In this arrangement, cooling wind blows toward the working space Sw. When the cooling wind blows toward the working space Sw, oil may scatter to the working space Sw as described above. On this account, in the arrangement above, it is preferable that a scattering prevention apparatus (not illustrated) is provided to prevent the scattering of oil to the working space Sw.

[0090] (12) The above-described cooler 14 can be used not only in the false-twist texturing machine 1 but also in a known false-twist texturing machine (not illustrated) that is differently structured. For example, the present invention may be applied to a false-twist texturing machine (not illustrated) recited in Japanese Laid-Open Patent Publication No. 2009-74219. This false-twist texturing machine is configured to form one yarn by combining two yarns. This false-twist texturing machine is configured to be able to wind, onto one cradle, one yarn formed by combination or non-combined two yarns. The present invention may be applied to such a false-twist texturing machine, for example. Apart from the false-twist texturing machines, the cooler 14 may be employed in a yarn processor which is configured to process a yarn (not illustrated) while the yarn is running, such as a known air texturing machine (not illustrated).

Claims

1. A cooler (14) which is configured to cool a running yarn (Y) by cooling wind, the cooler (14) comprising:

   a cooling unit (31, 31A) which is formed so that a yarn running space (S) in which the yarn (Y) runs extends in a predetermined lengthwise direction; and
   a duct (32) in which an in-duct space (Ss) connected to the yarn running space (S) is formed,
   the duct (32) including a duct wall portion (34) in which one or more slit (38) is provided to extend in the lengthwise direction between the yarn running space (S) and the in-duct space (Ss) in a flow direction in which the cooling wind flows,
   the cooling unit (31A) including paired unit wall portions (51, 51a, 51b) provided on one side of the duct wall portion (34) in a height direction orthogonal to the lengthwise direction,
   the paired unit wall portions (51, 51a, 51b) including paired unit wall surfaces (55, 55a, 55b) opposing each other over the yarn running space (S) in a width direction that is orthogonal to both the lengthwise direction and the height direction, and
   length of each of the paired unit wall surfaces (55, 55a, 55b) in the height direction being 30 mm or less.

2. A cooler (14) which is configured to cool a running yarn (Y) by cooling wind, the cooler (14) comprising:

   a cooling unit (31, 31A) which is formed so that a yarn running space (S) in which the yarn (Y) runs extends in a predetermined lengthwise direction; and
   a duct (32) in which an in-duct space (Ss) connected to the yarn running space (S) is formed,
   the duct (32) including a duct wall portion (34) in which one or more slit (38) is provided to extend in the lengthwise direction between the yarn running space (S) and the in-duct space (Ss) in a flow direction in which the cooling wind flows,
   the cooling unit (31A) including paired unit wall portions (51, 51a, 51b) provided on one side of the duct wall portion (34) in a height direction orthogonal to the lengthwise direction,
   the paired unit wall portions (51, 51a, 51b) including paired unit wall surfaces (55, 55a, 55b) opposing each other over the yarn running space (S) in a width direction that is orthogonal to both the lengthwise direction and the height direction, and
   in the lengthwise direction, in a wall surface installation region (R) in which the paired unit wall surfaces (55, 55a, 55b) are provided, sum total of length of one or more formation region (R1) in which the one or more slit (38) is formed in the duct wall portion (34) being longer than sum total of length of a region (R2) excluding the one or more formation region (R1).

3. The cooler (14) according to claim 1, wherein, in the lengthwise direction, in a wall surface installation region (R) in which the paired unit wall surfaces (55, 55a, 55b) are provided, sum total of length of one or

more formation region (R1) in which the one or more slit (38) is formed in the duct wall portion (34) is longer than sum total of length of a region (R2) excluding the one or more formation region (R1).

4. The cooler (14) according to claim 1 or 3, wherein, distance (G) in the width direction between parts of the paired unit wall surfaces (55, 55a, 55b) opposing each other in the width direction is 1 mm or less.

5. The cooler (14) according to any one of claims 1 to 4, wherein, the cooling unit (31A) includes one or more yarn guide (58) which is provided in the yarn running space (S) to restrict movement of the yarn (Y) toward the other side in the height direction.

6. The cooler (14) according to claim 5, wherein, in the height direction, an end on the one side of the one or more yarn guide (58) is on the one side of the center of the paired unit wall surfaces (55, 55a, 55b).

7. The cooler (14) according to any one of claims 1 to 6, wherein,
the cooling unit (31A) includes:

a first contact portion (56a) which is provided at part of one (55a) of the paired unit wall surfaces (55a, 55b) to be made contact with the yarn; and
a second contact portion (56b) which is provided at part of the other (55b) of the paired unit wall surfaces (55a, 55b) to be made contact with the yarn (Y), the second contact portion (56b) being positionally different from the first contact portion (56a) in the lengthwise direction.

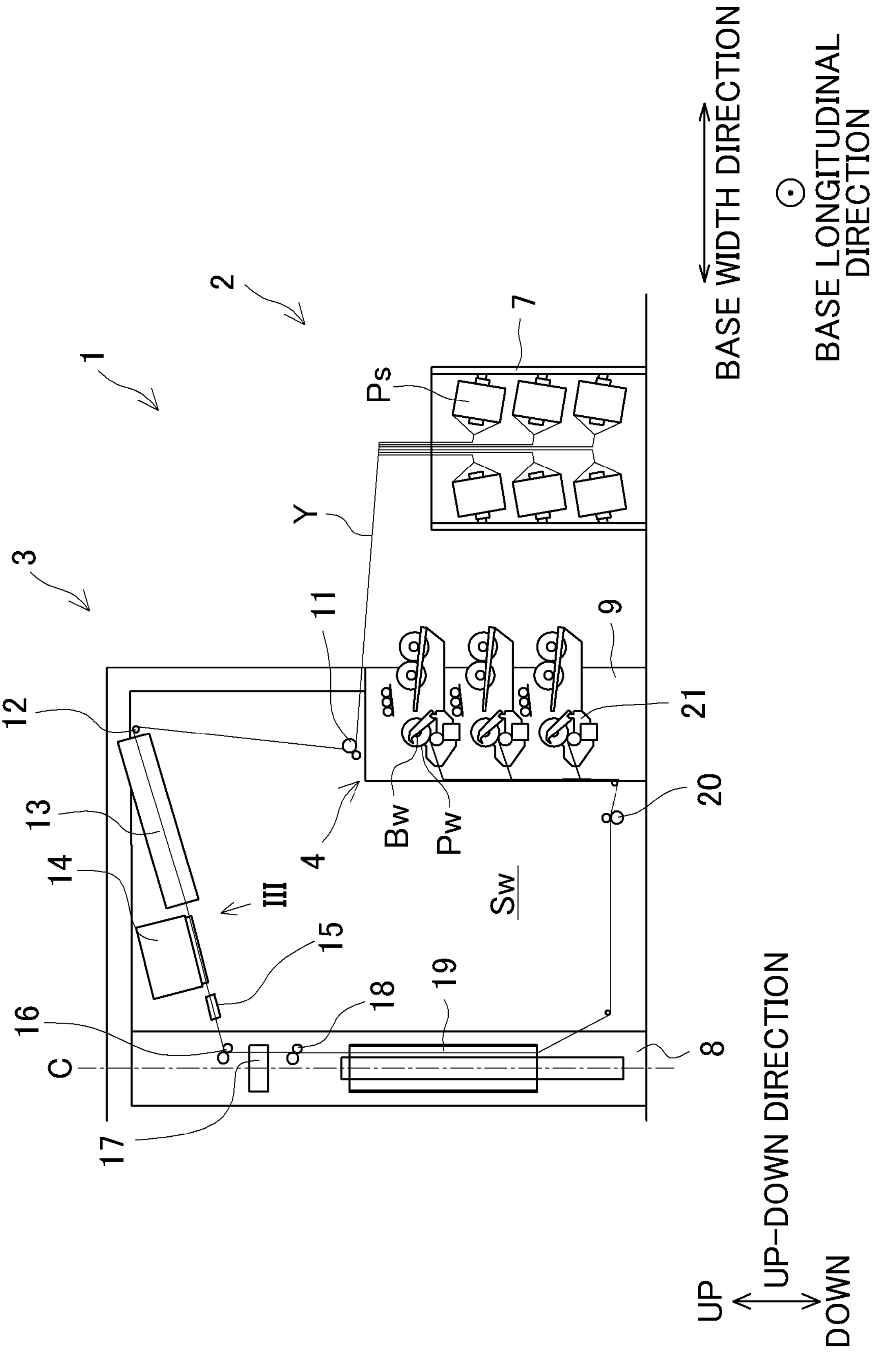
8. The cooler (14) according to any one of claims 1 to 7, further comprising a negative pressure generator (33) which is configured to generate negative pressure in the in-duct space (S).

9. The cooler (14) according to claim 8, wherein, the negative pressure generator (33) includes: an impeller (35) which is configured to rotate; a motor (36) which is configured to rotationally drive the impeller (35); and a rotation number changer (37) which is capable of changing the number of rotations of a rotational shaft of the motor (36) .

10. A yarn processer (1) comprising:

the cooler (14) of any one of claims 1 to 9;
a yarn deforming device (15) which is configured to deform the yarn (Y); and
a yarn supplying device (11) which is configured to supply the yarn (Y) to the cooler (14) and the yarn deforming device (15) and is provided to cause the yarn (Y) to run,
the yarn processor (1) being configured to process the yarn (Y) while causing the yarn (Y) to run.

FIG.1



1
2
3
4
7
8
9
11
12
13
14
15
16
17
18
19
20
21
III
C
Y
Ps
Bw
Pw
Sw
BASE WIDTH DIRECTION
BASE LONGITUDINAL DIRECTION
UP-DOWN DIRECTION
UP
DOWN

FIG.2

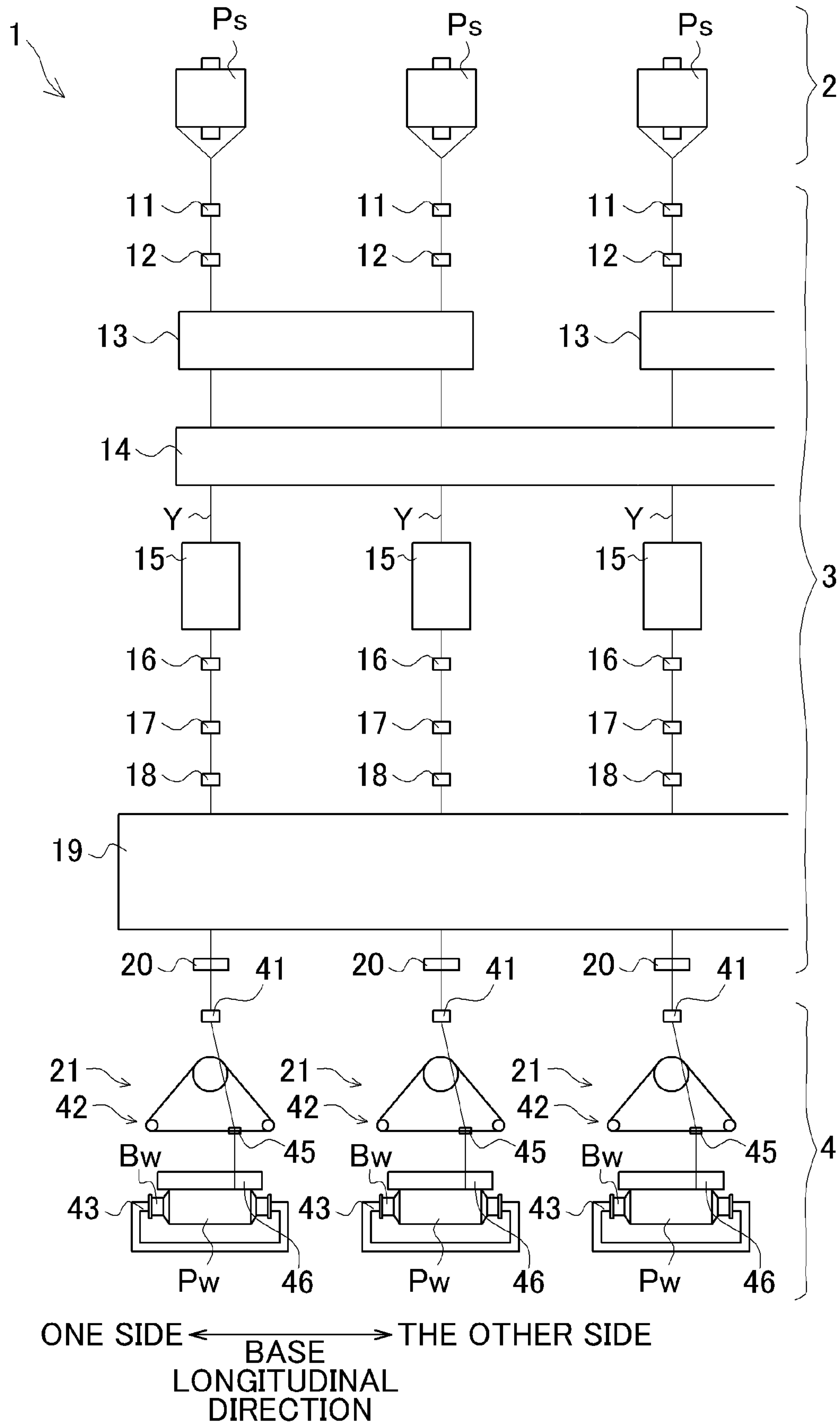

1
Ps
Ps
Ps
2
11
12
13
14
Y
15
16
17
18
19
20
41
3
21
42
45
Bw
43
Pw
46
4
ONE SIDE
THE OTHER SIDE
BASE
LONGITUDINAL
DIRECTION

FIG.3

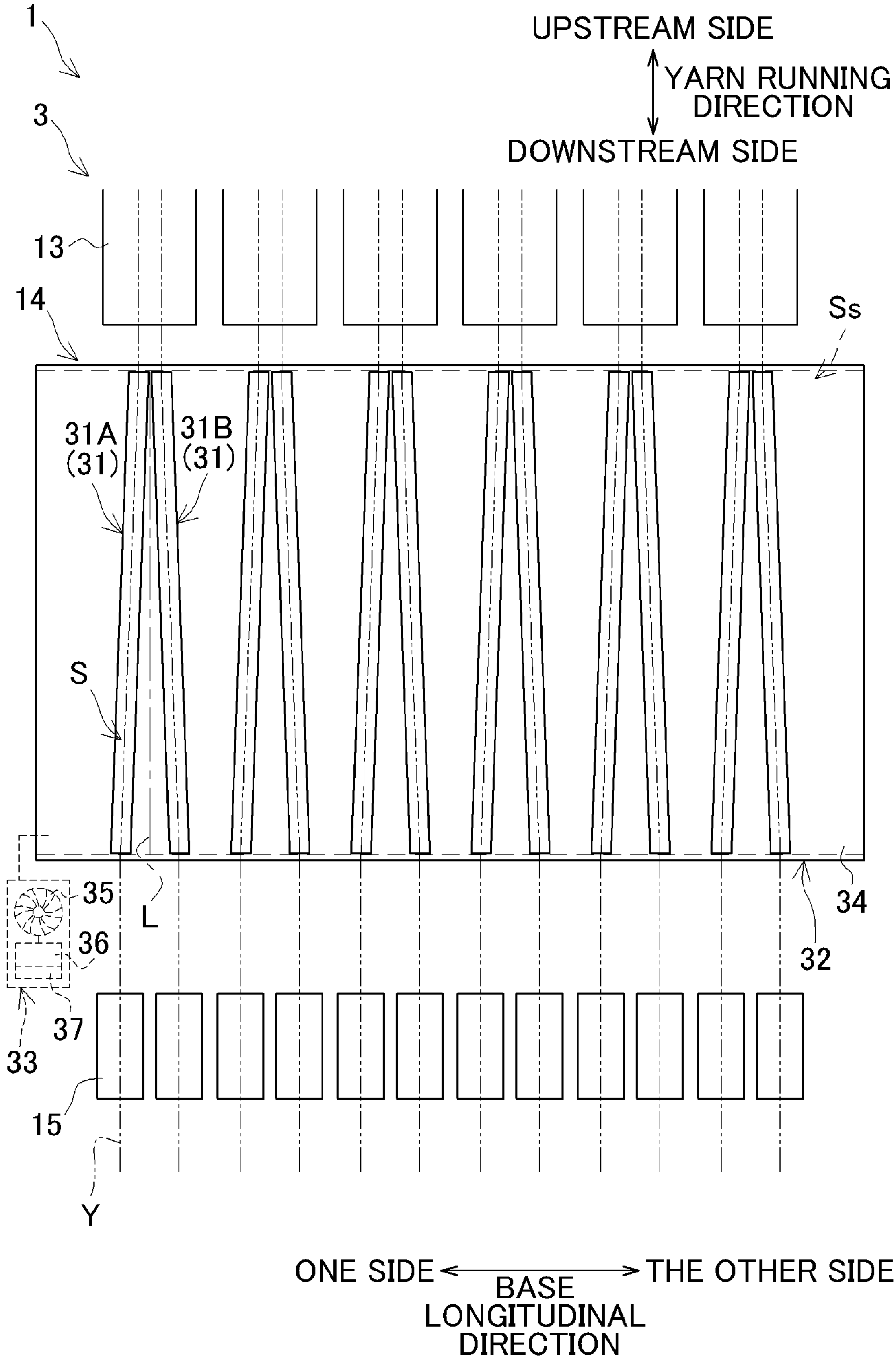

1
3
UPSTREAM SIDE
YARN RUNNING DIRECTION
DOWNSTREAM SIDE
13
14
Ss
31A (31)
31B (31)
S
35
36
L
34
32
37
33
15
Y
ONE SIDE
THE OTHER SIDE
BASE LONGITUDINAL DIRECTION

FIG.4

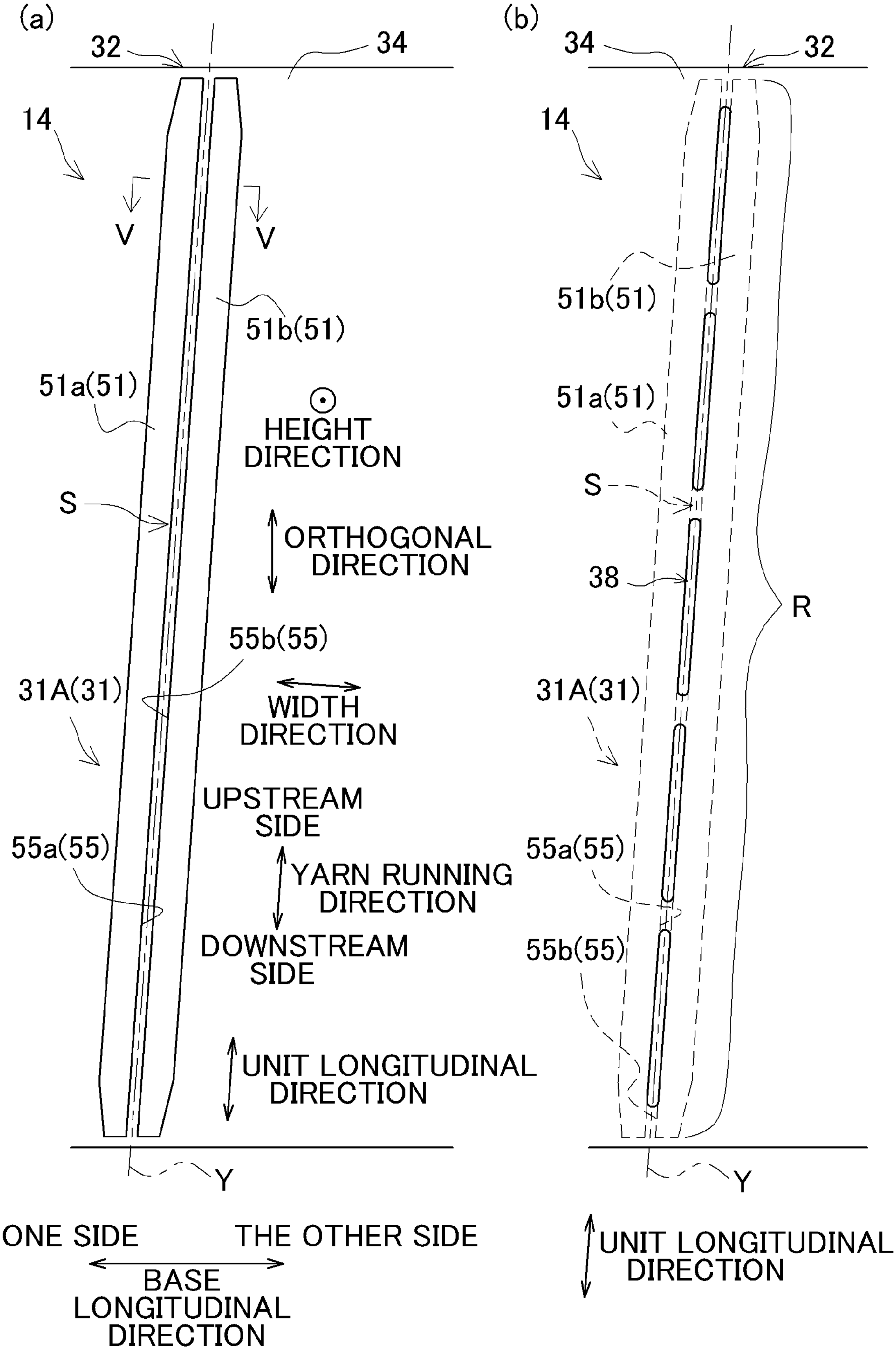

(a)
32
34
14
V
V
51b(51)
51a(51)
HEIGHT DIRECTION
S
ORTHOGONAL DIRECTION
55b(55)
31A(31)
WIDTH DIRECTION
UPSTREAM SIDE
55a(55)
YARN RUNNING DIRECTION
DOWNSTREAM SIDE
UNIT LONGITUDINAL DIRECTION
Y
ONE SIDE
THE OTHER SIDE
BASE LONGITUDINAL DIRECTION
(b)
34
32
14
51b(51)
51a(51)
S
38
R
31A(31)
55a(55)
55b(55)
Y
UNIT LONGITUDINAL DIRECTION

FIG.5

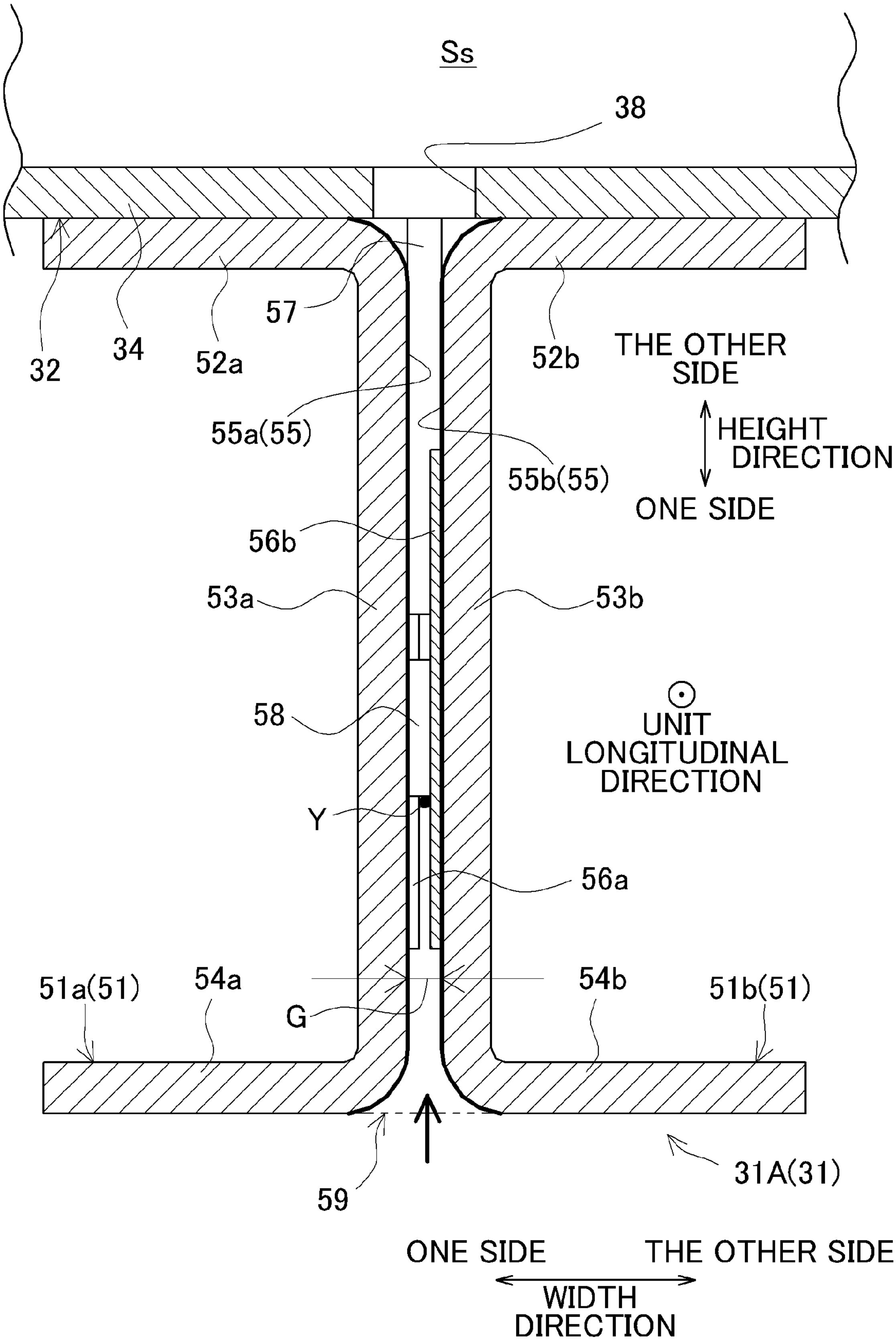

Ss
38
32
34
52a
57
52b
THE OTHER SIDE
HEIGHT DIRECTION
ONE SIDE
55a(55)
55b(55)
56b
53a
53b
58
UNIT LONGITUDINAL DIRECTION
Y
56a
51a(51)
54a
54b
51b(51)
G
59
31A(31)
ONE SIDE
THE OTHER SIDE
WIDTH DIRECTION

FIG.6

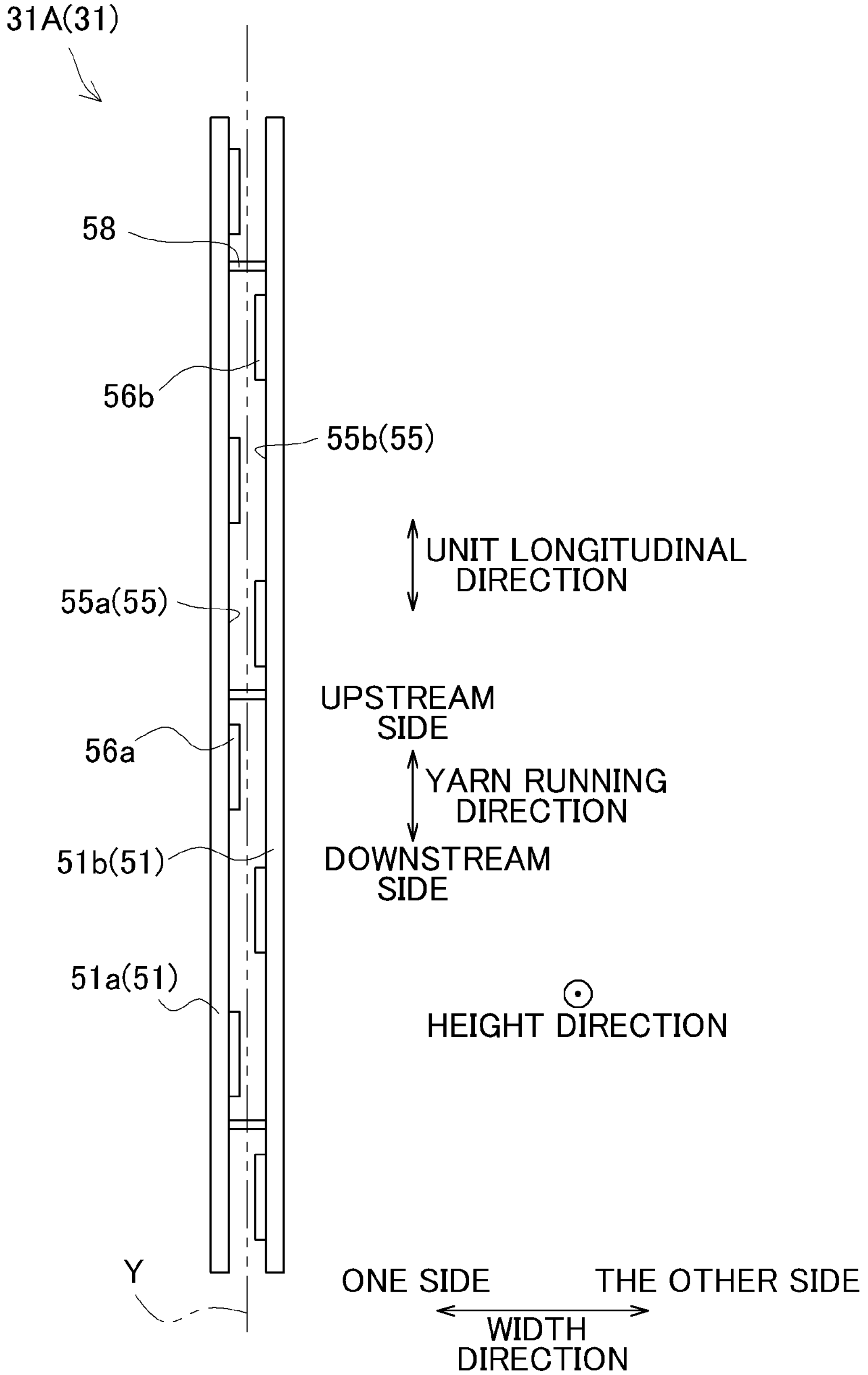

31A(31)
58
56b
55b(55)
UNIT LONGITUDINAL DIRECTION
55a(55)
UPSTREAM SIDE
56a
YARN RUNNING DIRECTION
51b(51)
DOWNSTREAM SIDE
51a(51)
HEIGHT DIRECTION
Y
ONE SIDE
THE OTHER SIDE
WIDTH DIRECTION

FIG.7

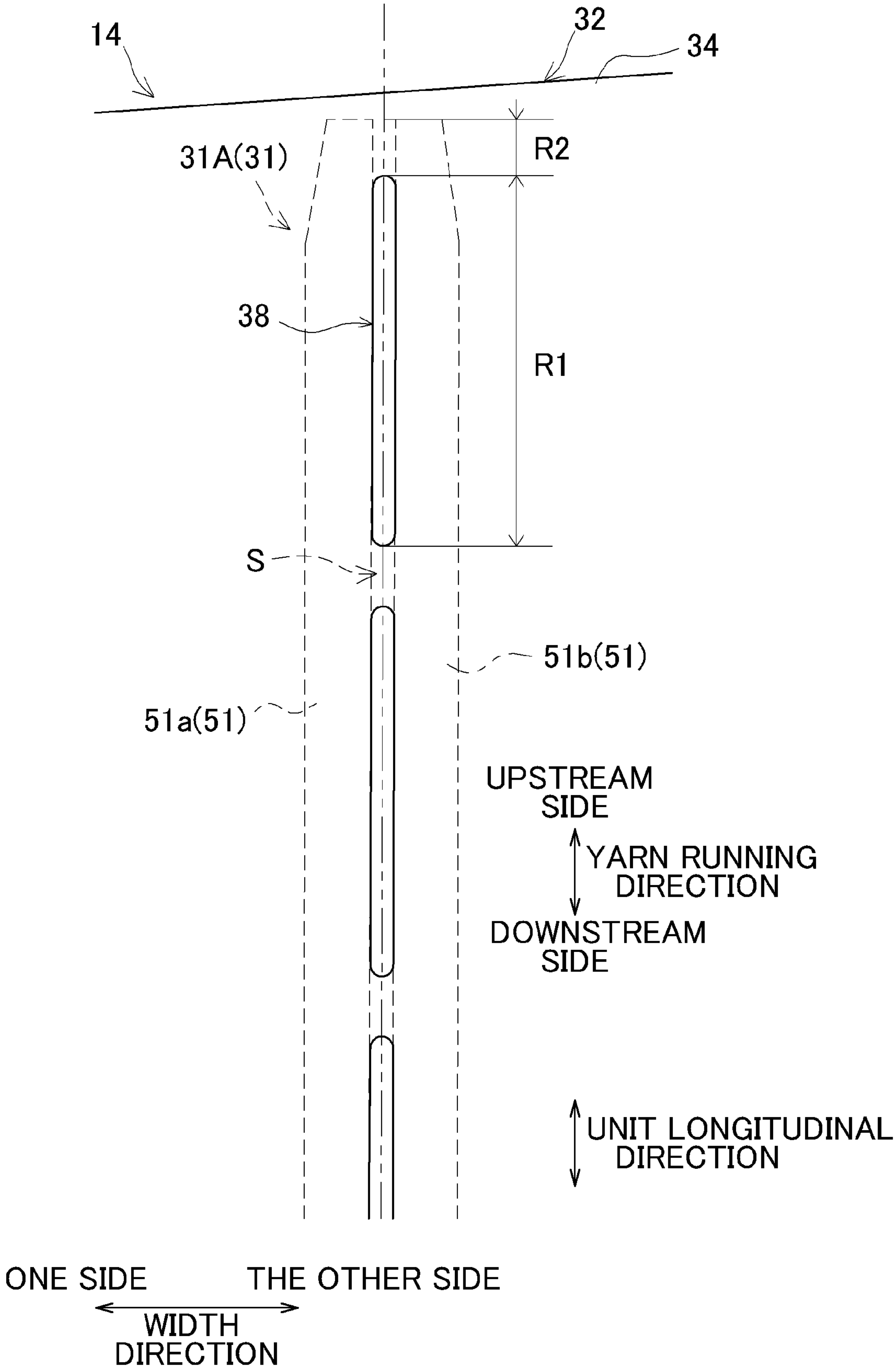

14
32
34
31A(31)
R2
38
R1
S
51b(51)
51a(51)
UPSTREAM SIDE
YARN RUNNING DIRECTION
DOWNSTREAM SIDE
UNIT LONGITUDINAL DIRECTION
ONE SIDE
THE OTHER SIDE
WIDTH DIRECTION

FIG.8

	NEGATIVE PRESSURE [kPa]	NUMBER OF ROTATIONS [Hz]	AVERAGE AIR SPEED [m/s]	POWER CONSUMPTION [kW]
EXAMPLE	0.3	22	1.77	0.34
	0.6	32	2.57	1.04
	1.0	42	3.07	2.28
COMPARATIVE EXAMPLE	0.3	22	0.96	0.34
	0.6	33	1.19	1.15
	1.0	46	1.35	3.05

FIG.9

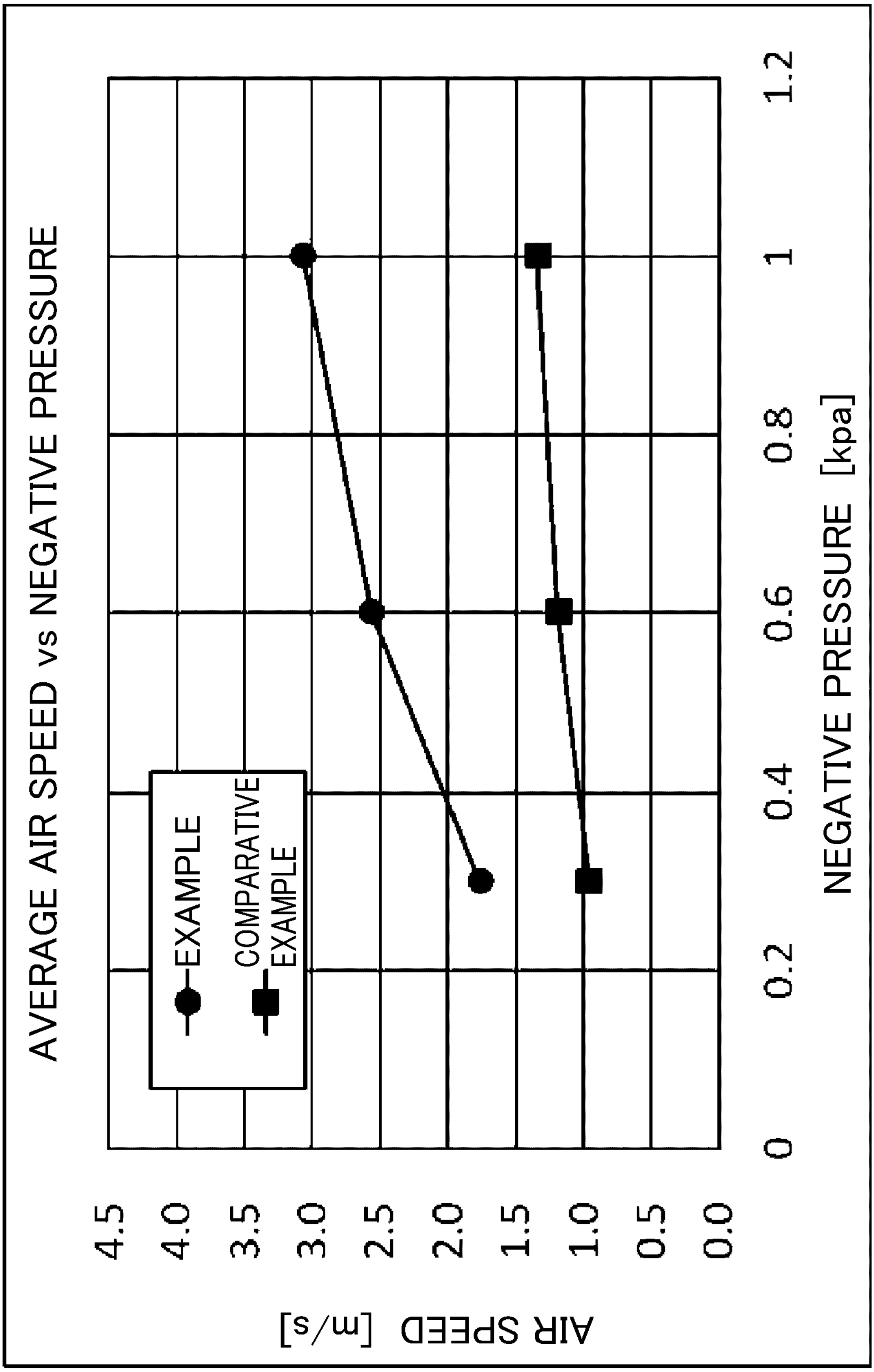

AVERAGE AIR SPEED vs NEGATIVE PRESSURE
AIR SPEED [m/s]
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
0.2
0.4
0.6
0.8
1
1.2
NEGATIVE PRESSURE [kpa]
EXAMPLE
COMPARATIVE EXAMPLE

FIG.10

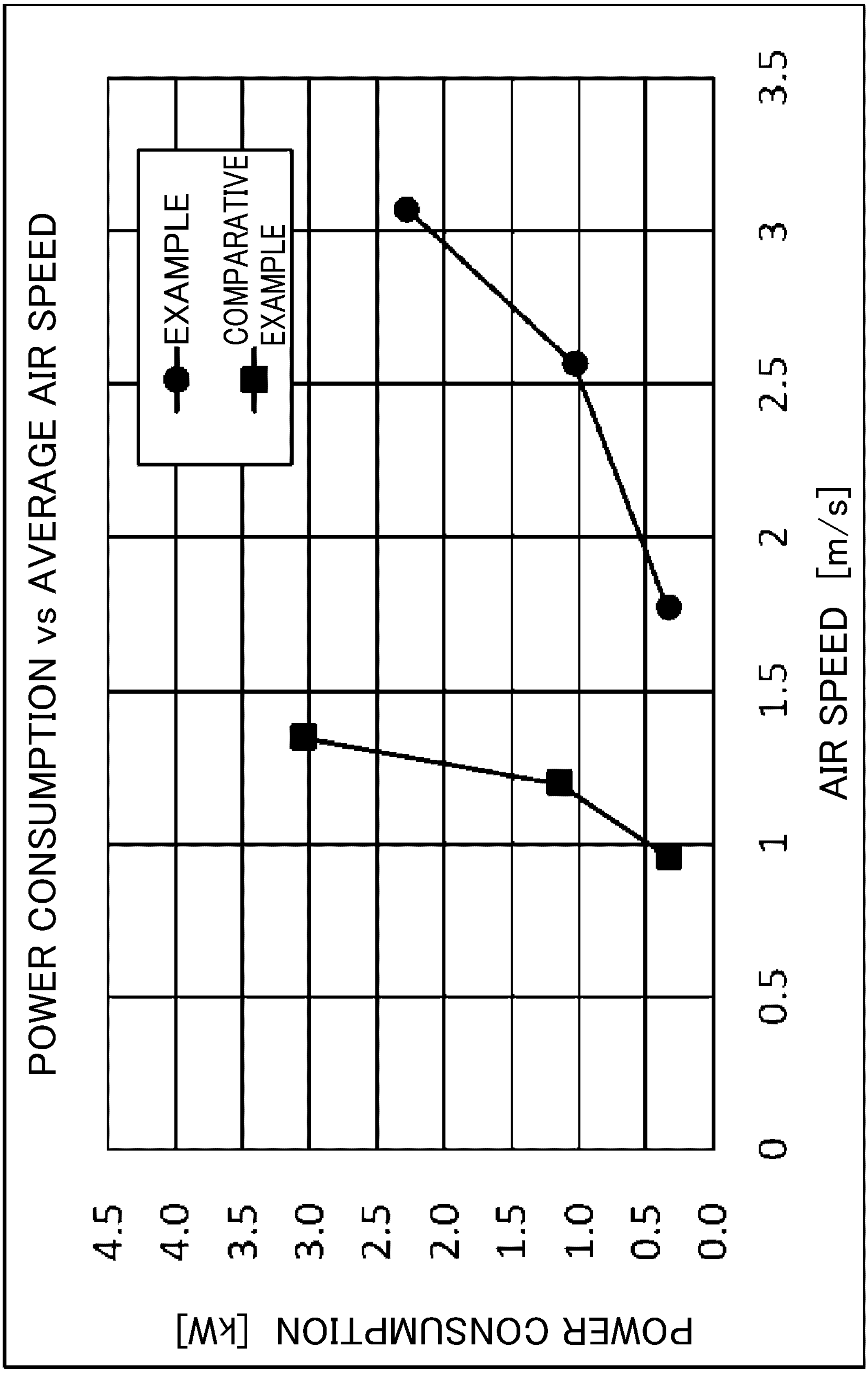
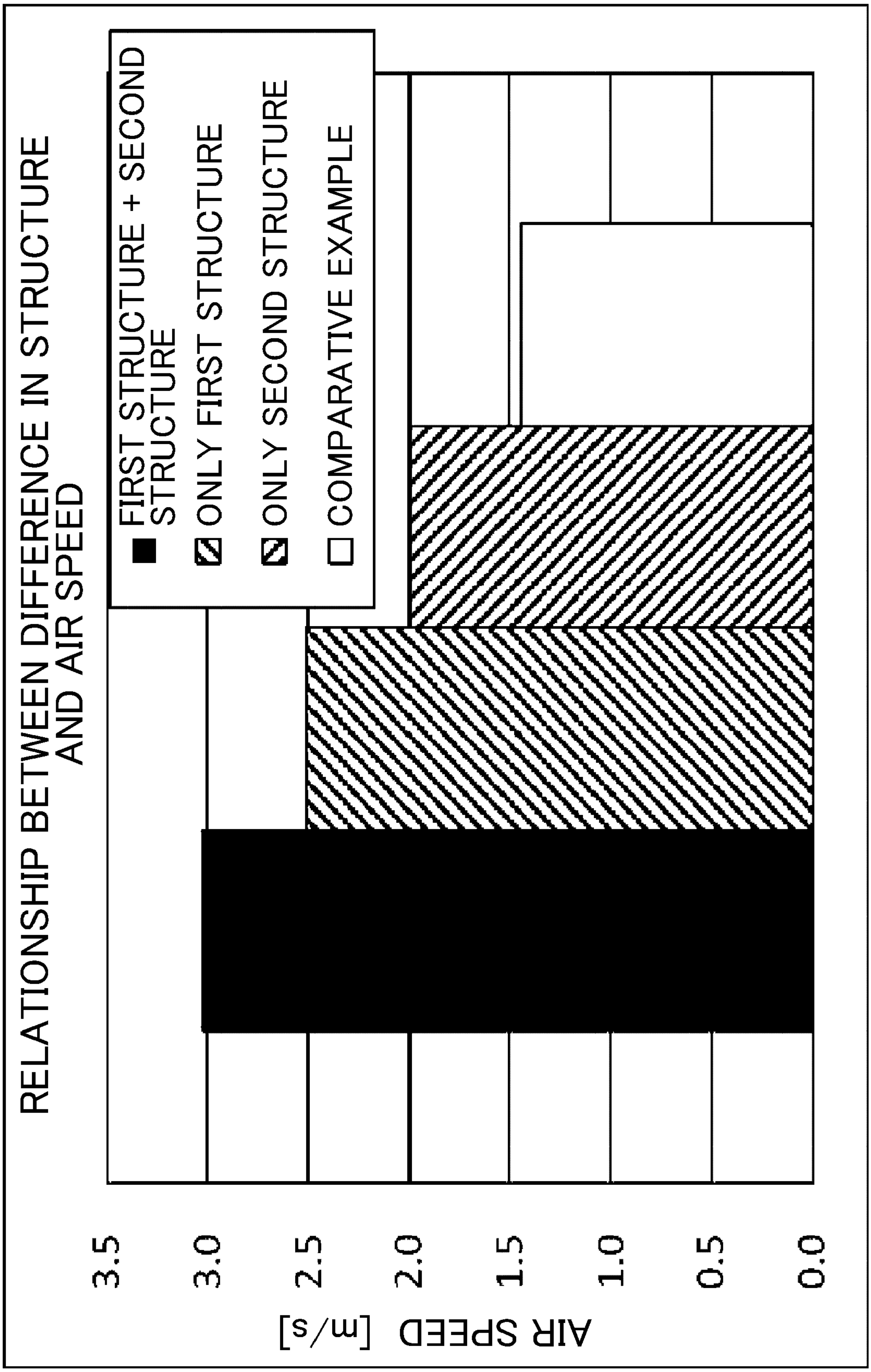

POWER CONSUMPTION vs AVERAGE AIR SPEED
EXAMPLE
COMPARATIVE EXAMPLE
POWER CONSUMPTION [kW]
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
0.5
1
1.5
2
2.5
3
3.5
AIR SPEED [m/s]

FIG.11


RELATIONSHIP BETWEEN DIFFERENCE IN STRUCTURE AND AIR SPEED
FIRST STRUCTURE + SECOND STRUCTURE
ONLY FIRST STRUCTURE
ONLY SECOND STRUCTURE
COMPARATIVE EXAMPLE
AIR SPEED [m/s]
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2011047074 A **[0002]**
- JP 2009074219 A **[0090]**