(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 4 556 609 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
21.05.2025 Bulletin 2025/21

(21) Application number: **24210444.6**

(22) Date of filing: **03.11.2024**

(51) International Patent Classification (IPC):
D01H 11/00 *(2006.01)* ***B04C 5/12*** *(2006.01)*
B65H 54/70 *(2006.01)* ***D02G 1/02*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
D01H 11/005; B04C 5/12; B04C 11/00; B65H 54/702; D02G 1/0266

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

(30) Priority: **17.11.2023 JP 2023196126**

(71) Applicant: **TMT Machinery, Inc.**
Osaka-shi, Osaka 541-0041 (JP)

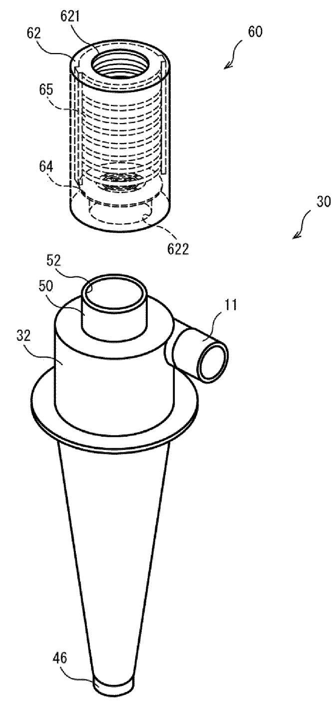
(72) Inventors:
- **IMANAKA, Akihito**
  Kyoto, 612-8686 (JP)
- **KITAGAWA, Shigeki**
  Kyoto, 612-8686 (JP)

(74) Representative: **Betten & Resch**
Patent- und Rechtsanwälte PartGmbB
Maximiliansplatz 14
80333 München (DE)

(54) FIBER WASTE COLLECTION DEVICE AND FALSE-TWISTING MACHINE

(57) To provide a fiber waste collection device and a false-twisting machine capable of reducing discharge sound to be generated by discharge of air. The fiber waste collection device includes: a fiber waste transfer pipe 11 for transferring fiber waste containing lint along with air; a fiber waste collection unit that collects the fiber waste having been transferred inside the fiber waste transfer pipe 11; a cyclone separator 30 provided between the fiber waste transfer pipe 11 and the fiber waste collection unit, the cyclone separator separating the fiber waste and the air having been transferred inside the fiber waste transfer pipe 11 from each other and collecting the fiber waste having been separated from the air into the fiber waste collection unit; and a discharge sound reducer 60 that reduces discharge sound to be generated by discharge of the air from which the fiber waste has been separated by the cyclone separator 30.

FIG.7



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Description

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

[0001] The present invention relates to a fiber waste collection device that collects fiber waste separated from air, and a false-twisting machine including the fiber waste collection device.

DESCRIPTION OF THE BACKGROUND ART

[0002] In a textile machine such as a false-twisting machine or a spinning machine, a fiber continues to be fed even when the fiber is threaded on the textile machine or even during replacement of a package formed by winding the fiber using a winder provided at the textile machine. Thus, in the textile machine, fiber waste has conventionally been sucked and collected during the yarn threading or package replacement.

[0003] As an example, Patent Document 1 discloses a suction device for continuously running multi-threads including a suction pipe provided with a plurality of suction ports, a fiber waste trapping container connected to an end portion of the suction pipe, and a negative-pressure pump or a suction blower connected to the fiber waste trapping container. In the suction device disclosed in Patent Document 1, a negative pressure is generated in the suction pipe in response to operation of the negative-pressure pump or the suction blower, and fiber waste taken into the suction pipe through the plurality of suction ports is sucked through the interior of the suction pipe and collected in the fiber waste trapping container.

(Priority Art Documents)

(Patent Documents)

[0004] Patent Document 1: Japanese Patent Application Publication No. 1994-40661

(Problems to be Solved)

[0005] In the suction device disclosed in Patent Document 1, fiber waste is sucked through the interior of the suction pipe and collected by the operation of the negative-pressure pump or the suction blower connected through the fiber waste trapping container to the suction pipe on a downstream end side of a suction direction. Such a suction device causes not only a possibility that the fiber waste will be discharged to the outside along with air but also a possibility that noise due to discharge sound to be generated by discharge of air will become troublesome.

SUMMARY OF THE INVENTION

[0006] The present invention has been made in view of the above-described problems, and is intended to provide a fiber waste collection device and a false-twisting machine capable of separating fiber waste and air preferably from each other and capable of reducing discharge sound to be generated by discharge of air.

(Means for Solving Problems)

[0007] A first aspect of the present invention is a fiber waste collection device comprising:

a fiber waste transfer pipe for transferring fiber waste containing lint along with air;
a fiber waste collection unit that collects the fiber waste having been transferred inside the fiber waste transfer pipe; and
a cyclone separator provided between the fiber waste transfer pipe and the fiber waste collection unit, the cyclone separator separating the fiber waste and the air having been transferred inside the fiber waste transfer pipe from each other and collecting the fiber waste having been separated from the air into the fiber waste collection unit, wherein the cyclone separator includes:

  a separation unit that separates the fiber waste and the air from each other; and
  a discharge sound reducer that reduces discharge sound to be generated by discharge of the air from which the fiber waste has been separated by the separation unit.

[0008] According to the above-described first aspect of the fiber waste collection device, it is possible to reduce discharge sound to be generated by air from which fiber waste has been separated by the separation unit.

[0009] A second aspect of the present invention is the fiber waste collection device in the above-described first aspect, wherein

it is preferable that the discharge sound reducer include a speed reducer of a cylindrical shape that reduces the speed of air in a flow direction of the air toward an opening part at one end on an opposite side to the separation unit when the air flows toward the opening part at the one end.

[0010] According to the above-described second aspect of the fiber waste collection device, as the flow velocity of air is reduced in the flow direction of the air toward the opening part at the one end on the opposite side to the separation unit, it is possible to reduce air discharge sound.

[0011] If the discharge sound reducer has a straight or tapered cylindrical shape, for example, the flow velocity of air flowing in an axis direction of the cylindrical shape is reduced. If the discharge sound reducer has a cylindrical shape with a bend, for example, the flow velocity of air flowing along the cylindrical shape is reduced.

[0012] A third aspect of the present invention is the fiber waste collection device in the above-described second aspect, wherein

it is preferable that the speed reducer include an interrupting unit that interrupts a flow of the air toward the opening part at the one end.

[0013] According to the above-described third aspect of the fiber waste collection device, as a flow of air is interrupted in a flow direction of the air toward the opening part at the one end, it is possible to reduce air discharge sound.

[0014] A fourth aspect of the present invention is the fiber waste collection device in the above-described second or third aspect, wherein

it is preferable that the speed reducer include a retention part that causes part of the air flowing toward the opening part at the one end to be retained in the discharge sound reducer.

[0015] According to the above-described fourth aspect of the fiber waste collection device, by causing part of air to be retained in the discharge sound reducer, it becomes possible to reduce the flow velocity of air flowing in the discharge sound reducer and eventually reduce discharge sound without requiring a complicated mechanism.

[0016] A fifth aspect of the present invention is the fiber waste collection device in any one of the above-described second to fourth aspects, wherein

> it is preferable that the discharge sound reducer have an inner wall surface having a section larger than an air discharge port through which the air is discharged from the separation unit, the section being perpendicular to the flow direction of the air toward the opening part at the one end, and
> the speed reducer be provided on the inner wall surface.

[0017] According to the above-described fifth aspect of the fiber waste collection device, as the inner wall surface is larger than the air discharge port, it is possible to reduce the flow velocity of air flowing toward the opening part at the one end while ensuring an airway for the air flowing in the discharge sound reducer. In particular, if the proportion of the flow rate of air discharged to the fiber waste collection unit from the separation unit becomes larger than the flow rate of air discharged from the air discharge port after fiber waste is separated from the air by the separation unit, it becomes impossible to separate the fiber waste and the air favorably at the separation unit. In this regard, as the airway for the air is ensured by making the inner wall surface of the discharge sound reducer larger than the air discharge port, the fiber waste and the air are separated favorably at the separation unit. Furthermore, providing the speed reducer on the inner wall surface allows reduction in a parts count without requiring an additional member for preparing the speed reducer.

[0018] A sixth aspect of the present invention is the fiber waste collection device in the above-described fifth aspect, wherein

it is preferable that the discharge sound reducer be configured to have an opening area of the opening part at the one end equal to or larger than an opening area of the air discharge port.

[0019] According to the above-described sixth aspect of the fiber waste collection device, as the opening area of the opening part at the one end is equal to or larger than the opening area of the air discharge port, it is possible to reduce the flow velocity of air flowing in the discharge sound reducer.

[0020] A seventh aspect of the present invention is the fiber waste collection device in the above-described sixth aspect, wherein

it is preferable that the discharge sound reducer have a straight or tapered cylindrical shape.

[0021] According to the above-described seventh aspect of the fiber waste collection device, air exits after flowing straight from the air discharge port to the opening part at the one end. This makes it possible to reduce the speed of air flowing toward the outside while ensuring an airway for the air flowing toward the outside.

[0022] An eighth aspect of the present invention is the fiber waste collection device in any one of the above-described second to seventh aspects, wherein it is preferable that the cyclone separator further include a fiber waste discharge unit that discharges the fiber waste along with air to the fiber waste collection unit after the fiber waste moves downward along an inner peripheral wall of the separation unit, and

the discharge sound reducer include a blocking member that blocks lint so as to prevent the lint from being discharged to the outside through the opening part while the lint moves toward the opening part without being discharged from the fiber waste discharge unit.

[0023] According to the above-described eighth aspect of the fiber waste collection device, it is possible to reduce a possibility that fiber waste having failed to move together with a downward flow along the inner peripheral wall of the separation unit will be discharged to the outside through the opening part while reducing air discharge sound to be generated by air flowing toward the outside.

[0024] A ninth aspect of the present invention is the fiber waste collection device in any one of the above-described first to eighth aspects, wherein

it is preferable that the discharge sound reducer reduce discharge sound by 5 dB or more.

[0025] According to the above-described ninth aspect of the fiber waste collection device, it is possible to reduce noise due to discharge sound.

[0026] The fiber waste collection device according to the present invention may be configured using only the configuration in the above-described first aspect of the fiber waste collection device, or may be configured by arbitrarily combining the configuration in the above-described first aspect with the configuration in any of the above-described second to ninth aspects within a range allowing achievement of consistency. In combining the configuration in the above-described first aspect with the configuration in any of the above-described second to ninth aspects, it is also possible to combine the configuration in the above-described first aspect entirely or partially with the configurations in the above-described second to ninth aspects entirely or partially.

[0027] A tenth aspect of the present invention is a false-twisting machine comprising the fiber waste collection device in any one of the above-described first to ninth aspects.

[0028] According to the above-described tenth aspect of the false-twisting machine, it is possible to reduce discharge sound to be generated by air from which fiber waste has been separated by the cyclone separator.

(Advantageous Effects of the Invention)

[0029] According to the present invention, it is possible to provide a fiber waste collection device and a false-twisting machine capable of separating fiber waste and air preferably and capable of reducing discharge sound to be generated by discharge of the air.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030]

FIG. 1 is a schematic view showing an example of a false-twisting machine as a textile machine where a fiber waste collection device is installed.

FIG. 2 is a schematic view showing an example of a fiber waste collection device according to an embodiment of the present invention.

FIG. 3 is a sectional view showing an example of a suction unit provided at a fiber waste transfer pipe.

FIG. 4 is a perspective view showing an example of a cyclone separator.

FIG. 5 is a plan view showing an example of the cyclone separator.

FIG. 6 is a front view showing an example of the cyclone separator.

FIG. 7 is a perspective view showing an example of the cyclone separator for describing a discharge sound reducer.

FIG. 8 is a view for describing the discharge sound reducer.

FIG. 9 is a view for describing principles of reducing discharge sound.

FIG. 10 is an example of a front view of the cyclone separator.

FIG. 11 shows an example of experimental result representing a relationship between a taper angle, the flow rate of air at an air discharge unit, and the flow rate of air at a fiber waste discharge unit.

FIG. 12 is a plan view of the cyclone separator and is a plan view showing exemplary variations of an opening ratio of a gap in a blocking member.

FIG. 13 shows an example of experimental result representing a relationship between the flow rate of air at the air discharge unit and the flow rate of air at the fiber waste discharge unit.

FIG. 14 is a schematic view showing a fiber waste collection device according to a first modification.

FIG. 15 is a schematic view showing a fiber waste collection device according to a second modification.

FIG. 16 is a plan view of a cyclone separator according to a third modification.
FIG. 17 is a perspective view of a cyclone separator according to a fourth modification.
FIG. 18 is a view showing a discharge sound reducer according to a fifth modification.
FIG. 19 is a view showing a discharge sound reducer according to the fifth modification.
FIG. 20 is a view showing a discharge sound reducer according to the fifth modification.
FIG. 21 is a view showing a discharge sound reducer according to the fifth modification.
FIG. 22 is a view showing result of a test conducted to confirm reduction in discharge sound achieved by the discharge sound reducer.

DESCRIPTIONS OF EMBODIMENTS OF THE INVENTION

[0031] Hereinafter, embodiments of the present invention will be described with reference to the drawings. The following description is based on the condition that a fiber waste collection device of the present invention is installed at a textile machine such as a false-twisting machine.

[False-Twisting Machine]

[0032] FIG. 1 is a schematic view of a false-twisting machine 101. For the convenience of description, each of an upward-and-downward direction, a forward-and-backward direction, and a rightward-and-leftward direction in relation to the false-twisting machine 101 is defined as shown in FIG. 1.

[0033] The false-twisting machine 101 is configured as a textile machine to produce highly-stretchable textured yarns by false-twisting thermoplastic synthetic fibers such as polyester and polyamide so as to impart crimps to the false-twisted fibers. The false-twisting machine 101 includes a main machine base 102, a yarn feeding creel 104, a false-twisting device 106, and a winder 107.

[0034] The main machine base 102 is arranged in such a manner as to extend in the upward-and-downward direction. The yarn feeding creel 104 is arranged in such a manner as to face the main machine base 102 across a work space 103. The false-twisting device 106 is arranged above the main machine base 102. The false-twisting device 106 false-twists a fiber Y as a yarn fed from the yarn feeding creel 104. The winder 107 is arranged at the main machine base 102 and winds the false-twisted fiber Y obtained by the false-twisting device 106.

[0035] The winders 107 are arranged in four stages in the upward-and-downward direction. In each of the stages from the first stage to the fourth stage, two or more winders 107 are juxtaposed in the forward-and-backward direction. The forward-and-backward direction in which the two or more winders 107 are juxtaposed in each of the four stages aligned in the upward-and-downward direction is a direction conforming to a horizontal direction, which is a direction vertical to a direction (rightward-and-leftward direction) in which the yarn feeding creel 104 and the main machine base 102 are juxtaposed.

[0036] A first feed roller 108, a shifter guide 109, a first heater 110, and a cooler 111 are arranged in this order from an upstream side of a yarn traveling direction along a yarn path from the yarn feeding creel 104 to the false-twisting device 106. A second feed roller 112, an interlace nozzle 113, a second heater 114, a third feed roller 115, and an oiling roller 116 are arranged in this order from an upstream side of a yarn traveling direction along a yarn path from the false-twisting device 106 to the winder 107.

[0037] The first feed roller 108 is arranged above the work space 103. The first heater 110 is arranged above the work space 103 and further above the first feed roller 108. The cooler 111 is arranged closer to the main machine base 102 side than the first heater 110 above the work space 103. The first heater 110 and the cooler 111 are arranged above the work space 103 in such a manner as to extend obliquely upward while getting further away from the main machine base 102. The shifter guide 109 is arranged between the first feed roller 108 and the first heater 110 in the upward-and-downward direction, and is used to pass the fiber Y through the interiors of the first heater 110 and the cooler 111 in threading a yarn on the false-twisting machine 101.

[0038] The second feed roller 112 is arranged above the main machine base 102. The interlace nozzle 113 is arranged above the main machine base 102 and below the second feed roller 112. The second heater 114 is arranged on the main machine base 102 and is arranged on a back side of the winder 107 as viewed from the work space 103 in such a manner as to extend in the upward-and-downward direction from the first stage to the fourth stage of the winders 107 in the four stages. The devices are laid out in this way, and a yarn path from the yarn feeding creel 104 to the winder 107 is formed in such a manner as to surround the work space 103.

[0039] In the false-twisting machine 101, the fibers Y as yarns fed from the yarn feeding creel 104 are carried through the above-described devices and wound by the winder 107, thereby forming a package 117. First, the first to third feed rollers (108, 112, 115) are rollers for feeding the fibers Y from an upstream side to a downstream side of the yarn traveling direction. Each yarn feed velocity is set in such a manner that a yarn feed velocity at the second feed roller 112 is higher than a yarn feed velocity at the first feed roller 108. Thus, the fibers Y are drawn between the first feed roller 108 and the second feed roller 112. Further, each yarn feed velocity is set in such a manner that a yarn feed velocity at the third feed roller 115 is lower than the yarn feed velocity at the second feed roller 112. Thus, the fibers Y are loosened between the second feed roller 112 and the third feed roller 115.

[0040] Next, the fibers Y drawn between the first feed roller 108 and the second feed roller 112 are twisted by the false-twisting device 106 that is, e.g., a friction disk-type twister and are then carried. The twist formed by the false-twisting device 106 propagates to the first feed roller 108, and the fibers Y twisted while being drawn are heated by the first heater 110 and then cooled by the cooler 111, thereby setting the twist. After passing through the false-twisting device 106, the twisted and heat-set fibers Y are untwisted before reaching the second feed roller 112.

[0041] The interlace nozzle 113 appropriately forms an entangled part at the fibers Y drawn and false-twisted in this way to provide the fibers Y with bundling properties. The fibers Y are thereafter subjected to relaxation heat treatment at the second heater 114 and wound on a paper tube by the winder 107 through the oiling roller 116, thereby forming the package 117. Then, the package 117 in a fully-wound state is removed from the winder 107 by a worker. A new paper tube is attached to the winder 107 by a worker, and a winding operation on the paper tube is restarted. The package 117 is replaced in this way. A fiber waste collection device of a present embodiment is installed at the above-described false-twisting machine 101 and used. The fiber waste collection device of a present embodiment will be described below.

[Outline of Fiber Waste Collection Device]

[0042] FIG. 2 is a schematic view showing an example of a fiber waste collection device 1 according to an embodiment of the present invention. The fiber waste collection device 1 mainly includes, for example, a plurality of fiber waste transfer pipes 11 (11a to 11d), one fiber waste collection container 13 provided for the plurality of fiber waste transfer pipes 11 (11a to 11d), and a plurality of cyclone separators 30 provided for corresponding ones of the plurality of fiber waste transfer pipes 11 (11a to 11d). The cyclone separators 30 are arranged between the fiber waste transfer pipes 11 (11a to 11d) and the fiber waste collection container 13. Each of the cyclone separators 30 separates fiber waste from air having been transferred inside the fiber waste transfer pipe 11 and collects the separated fiber waste into the fiber waste collection container 13. Details of the cyclone separator 30 will be described later. The term "fiber waste" includes thread-like cotton and relatively short fiber waste, and additionally, fiber waste composed of a collection of relatively short fiber waste, relatively long lint, and others. The above-described "fiber waste collection container 13" corresponds to a "fiber waste collection unit" of the present invention.

[0043] The plurality of fiber waste transfer pipes 11 of the fiber waste collection device 1 is arranged in response to each stage of the winders 107 aligned in the four stages in the upward-and-downward direction, for example, in the false-twisting machine 101. For this reason, the fiber waste collection device 1 of a present embodiment with the winders 107 arranged in the four stages is equipped with the four fiber waste transfer pipes 11 (11a to 11d). Each fiber waste transfer pipe 11 (11a to 11d) is arranged in such a manner as to extend in the forward-and-backward direction. In each stage of the winders 107 from the first stage to the fourth stage, the winders 107 are juxtaposed in the forward-and-backward direction and each fiber waste transfer pipe 11 (11a to 11d) is also arranged in such a manner as to extend in the forward-and-backward direction in which the winders 107 are juxtaposed. In each stage of the winders 107 vertically aligned in the four stages, each fiber waste transfer pipe 11 (11a to 11d) sucks the fiber Y (see FIG. 1) from regions near the corresponding winders 107 juxtaposed in the forward-and-backward direction, and transfers the fiber Y along with air. All the four fiber waste transfer pipes 11 (11a to 11d) are connected in common to the fiber waste collection container 13. Furthermore, the air containing the fiber Y and having been transferred inside each fiber waste transfer pipe 11 (11a to 11d) is separated at the cyclone separator 30 into fiber waste as the fiber Y and clean air generated after separating the fiber waste. The fiber waste separated from the air is collected in the fiber waste collection container 13. The clean air generated after separating the fiber waste is discharged from an air discharge unit 50 (see FIG. 4 referred to later) to the outside.

[0044] By providing the cyclone separator 30 and discharging air from which fiber waste has been separated to the outside from the air discharge unit 50 (see FIG. 4 referred to later), it becomes possible to make the number of the fiber waste collection containers 13 smaller than that of the fiber waste transfer pipes 11 (11a to 11d) and to achieve a compact configuration of the fiber waste collection device 1 as a whole. Specifically, providing the cyclone separator 30 makes it possible to form fiber waste into a ball shape to be discharged. This achieves reduction in a volume occupied by fiber waste inside the fiber waste collection container 13. Furthermore, by making separation between fiber waste and air and discharging the air from the air discharge unit 50 from which the fiber waste has been separated, it further becomes possible to reduce a volume occupied by air, compared to a system incapable of separating air such as a conventional fiber waste collection device configured by connecting a blower to the fiber waste transfer pipe 11 (11a to 11d), for example. As a result, the fiber waste collection device 1 of a present embodiment is capable of accumulating a larger amount of fiber waste in the fiber waste collection container 13 than a conventional fiber waste collection device, thereby allowing reduction in the number of the fiber waste collection containers 13. A smaller number of the fiber waste collection containers 13 further achieves reduction in a burden on a worker such as reduction in a replacement frequency, for example. In a present embodiment, one fiber waste collection container 13 is provided for all of the plurality of fiber waste transfer pipes 11 (11a to 11d). However, the number of the fiber waste collection containers 13 is not limited to this but can be any number smaller than that of the fiber waste transfer pipes 11 (11a to 11d).

[0045] The fiber waste collection device 1 is to keep a yarn so as not to cut the yarn during yarn changing at the winder 107 of the false-twisting machine 101 and to collect the yarn as fiber waste. Specifically, as shown in FIG. 1, in threading the fiber Y on the false-twisting machine 101 or during replacement of the package 117 formed by the winder 107 of the false-twisting machine 101, the fiber waste collection device 1 is used for collecting the fiber Y as fiber waste from a suction unit while the fiber Y is continuously fed from the yarn feeding creel 104 to a region near the winder 107 via each device (110, 111, 106, 114) and others. By doing so, it becomes possible to collect the fiber Y continuously fed to the region near the winder 107 during replacement of the package 117 at the winder 107 of the false-twisting machine 101. This allows the false-twisting machine 101 to run continuously without the need of cutting the yarn. The configuration of the fiber waste collection device 1 will be described below in more detail.

[Fiber Waste Transfer Pipe]

[0046] Referring to FIG. 2, the fiber waste transfer pipe 11 (11a to 11d) is configured as a pipe that is provided with a plurality of suction units 15 for sucking the fiber Y (see FIG. 1) arranged near the corresponding winders 107 and is used for transferring the fiber Y sucked through the plurality of suction units 15. The suction unit 15 to suck the fiber Y will be described later. The fiber waste transfer pipe 11 is formed into a hollow circular pipe shape, for example. The fiber waste transfer pipe 11 includes a plurality of the fiber waste transfer pipes 11 (11a to 11d), in a present embodiment, four fiber waste transfer pipes 11 as described above.

[0047] The four fiber waste transfer pipes 11 (11a to 11d) include a first fiber waste transfer pipe 11a corresponding to the winder 107 in the first stage as a bottom stage, a second fiber waste transfer pipe 11b corresponding to the winder 107 in the second stage from the bottom, a third fiber waste transfer pipe 11c corresponding to the winder 107 in the third stage from the bottom, and a fourth fiber waste transfer pipe 11d corresponding to the winder 107 in the fourth stage as a top stage. Each fiber waste transfer pipe 11 (11a to 11d) is arranged in the false-twisting machine 101 in such a manner that a longitudinal direction thereof conforms to the forward-and-backward direction. Furthermore, each of the first to fourth fiber waste transfer pipes 11 (11a to 11d) is arranged at a position corresponding to each of the first to fourth stages of the winders 107 in such a manner as to extend in the forward-and-backward direction. In a present embodiment, the cyclone separator 30 includes a first cyclone separator 30a arranged between the first fiber waste transfer pipe 11a and the fiber waste collection container 13, a second cyclone separator 30b arranged between the second fiber waste transfer pipe 11b and the fiber waste collection container 13, a third cyclone separator 30c arranged between the third fiber waste transfer pipe 11c and the fiber waste collection container 13, and a fourth cyclone separator 30d arranged between the fourth fiber waste transfer pipe 11d and the fiber waste collection container 13.

[0048] Each fiber waste transfer pipe 11 (11a to 11d) is closed at its end on one side (backward-side end shown in FIG. 2) in the longitudinal direction conforming to the forward and backward direction, and is connected to the cyclone separator 30 at its end on the other side (forward-side end shown in FIG. 2).

[Suction Unit]

[0049] Referring to FIG. 2, the suction unit 15 is provided as a mechanism for sucking the fiber Y (see FIG. 1), and includes a plurality of the suction units 15 arranged at each fiber waste transfer pipe 11 (11a to 11d). Each of the plurality of suction units 15 arranged at each fiber waste transfer pipe 11 has a configuration including a suction pipe 16 and an opening/closing mechanism 17 (see FIG. 3 referred to later). The suction units 15 at each fiber waste transfer pipe 11 (11a to 11d) are juxtaposed in the longitudinal direction of each fiber waste transfer pipe 11. Each of the plurality of suction units 15 juxtaposed at each fiber waste transfer pipe 11 (11a to 11d) is arranged at a position on each fiber waste transfer pipe 11 (11a to 11d) corresponding to the winder 107. More specifically, at each fiber waste transfer pipe 11 (11a to 11d), each of the plurality of suction units 15 is arranged at a position corresponding to each of the winders 107 juxtaposed in the forward-and-backward direction in each stage of the winders 107 (see FIG. 1) vertically aligned in the four stages, for example, in the false-twisting machine 101 (see FIG. 1).

[0050] All the suction units 15 provided at the first to fourth fiber waste transfer pipes 11 (11a to 11d) are configured in the same way. Two or more of the suction units 15 juxtaposed at each fiber waste transfer pipe 11 (11a to 11d) are also configured in the same way.

[0051] The suction pipe 16 is provided as a pipe member for sucking the fiber Y (see FIG. 1), has a smaller pipe diameter than the fiber waste transfer pipe 11 (11a to 11d), and is provided in such a manner as to extend with a bend in the middle. The suction pipe 16 communicates with the fiber waste transfer pipe 11 (11a to 11d) at one end thereof, and is provided with a suction port (not shown in the drawings) at the other end thereof arranged near the winder 107 (see FIG. 1) and used for sucking the fiber Y. The fiber Y sucked through the suction port flows into the fiber waste transfer pipe 11.

[0052] FIG. 3 is a sectional view showing an example of the suction unit 15 provided at the fiber waste transfer pipe 11.

FIG. 3 shows a state where an opening/closing member 19 is pushed upward to open a suction port 16a. Referring to FIG. 3, the suction pipe 16 is connected to the fiber waste transfer pipe 11 (11a to 11d) in an obliquely leaned state. The suction pipe 16 is connected to the fiber waste transfer pipe 11 (11a to 11d) at an acute angle with respect to a direction from an upstream side (backward side shown in FIG. 3) toward a downstream side (forward side shown in FIG. 3) of a flow of air passing through inside the fiber waste transfer pipe 11. Specifically, the suction pipe 16 is connected to the fiber waste transfer pipe 11 (11a to 11d) at an acute angle with respect to a direction from the end on one side (backward side shown in FIG. 3) toward the end on the other side (forward side shown in FIG. 3) connected to the fiber waste collection container 13. As a result, when the fiber Y (see FIG. 1) sucked through the suction port (not shown in the drawings) flows into the fiber waste transfer pipe 11, the sucked fiber Y enters in the direction from the upstream side toward the downstream side of a flow of air inside the fiber waste transfer pipe 11. After flowing into the fiber waste transfer pipe 11, the fiber Y is transferred downstream by the flow of air passing through inside the fiber waste transfer pipe 11.

[0053] The suction pipe 16 is provided with a compressed air injection nozzle hole 16d and a guide path 16e. The compressed air injection nozzle hole 16d is provided between one end side where an outlet opening 16b is provided and the other end side where the suction port 16a is provided, and functions as a nozzle hole for injecting compressed air into the suction pipe 16. The compressed air injection nozzle hole 16d is configured to inject compressed air in the suction pipe 16 toward the one end side where the outlet opening 16b is provided. In a present embodiment, two compressed air injection nozzle holes 16d are provided. Each of the two compressed air injection nozzle holes 16d communicates with a suction flow path 16c by extending from a side closer to the suction port 16a toward a side closer to the outlet opening 16b and extending from an outer periphery toward an inner periphery of the suction pipe 16. In this way, each of the two compressed air injection nozzle holes 16d is configured to inject compressed air toward the outlet opening 16b inside the suction pipe 16. The number of the compressed air injection nozzle holes 16d is not limited to two.

[0054] The guide path 16e of the suction pipe 16 is provided in the suction pipe 16 and functions as a flow path for compressed air extending in an annular shape in a peripheral direction of the suction pipe 16. The guide path 16e communicates with the compressed air injection nozzle hole 16d and with a cylinder chamber 20 described later. Compressed air supplied to the cylinder chamber 20 enters the guide path 16e, flows into the compressed air injection nozzle hole 16d from the guide path 16e, and is then injected into the suction flow path 16c.

[0055] The cylinder chamber 20 is formed as a circular cylindrical space inside a body part 18, and is configured to receive compressed air supplied thereto. The cylinder chamber 20 communicates with the guide path 16e of the suction pipe 16 via a communication path 20a provided inside the body part 18. Thus, compressed air supplied to the cylinder chamber 20 flows into the guide path 16e and further flows into the compressed air injection nozzle hole 16d. Furthermore, a compressed air supply pipe 23 for supplying compressed air to be injected from the compressed air injection nozzle hole 16d of the suction pipe 16 is connected to and communicates with the cylinder chamber 20. The compressed air supply pipe 23 is connected to a compressed air source (not shown in the drawings) to supply compressed air. The compressed air supply pipe 23 is provided with a solenoid valve 24 that controls supply of compressed air to the cylinder chamber 20 by being opened and closed to make a switch between a communicable state and a shut-off state. Opening the solenoid valve 24 brings the compressed air supply pipe 23 into the communicable state so compressed air is supplied from the compressed air supply pipe 23 to the cylinder chamber 20. Closing the solenoid valve 24 brings the compressed air supply pipe 23 into the shut-off state to shut off supply of compressed air from the compressed air supply pipe 23 to the cylinder chamber 20.

[0056] At the suction unit 15, in a state where the solenoid valve 24 is closed and the compressed air supply pipe 23 is shut off so compressed air is not supplied to the cylinder chamber 20, the opening/closing member 19 rotates about a rotary shaft 29 in response to biasing force of a spring member 22 arranged in a spring chamber 25, thereby closing the suction port 16a. In this state, the suction unit 15 does not make the motion of sucking the fiber Y (see FIG. 1). On the other hand, in a state where the solenoid valve 24 is opened and the compressed air supply pipe 23 is communicable so compressed air is supplied to the cylinder chamber 20, a piston 21 is displaced upward to push the opening/closing member 19 upward, thereby opening the suction port 16a. Furthermore, in the state where the compressed air is supplied to the cylinder chamber 20, the compressed air flows into the compressed air injection nozzle hole 16d and the compressed air is injected from the compressed air injection nozzle hole 16d to the suction flow path 16c of the suction pipe 16. The compressed air is injected to the suction flow path 16c in such a manner as to travel toward the outlet opening 16b. The compressed air injected in this way into the suction pipe 16 from the compressed air injection nozzle hole 16d generates an air flow by which the fiber Y is transferred toward the fiber waste transfer pipe 11 side in the suction pipe 16, and further generates an air flow by which the fiber Y is transferred toward the cyclone separator 30 (forward side shown in FIG. 3) in the fiber waste transfer pipe 11. In this way, it is possible for the fiber Y sucked through the suction port 16a to be transferred inside the fiber waste transfer pipe 11.

[0057] As long as it is possible to suck the fiber Y (see FIG. 1) through the suction port and to transfer the sucked fiber Y into the fiber waste transfer pipe 11 (11a to 11d), the corresponding configuration is not limited to a particular configuration. For example, compressed air may be injected into the suction pipe 16 like in the above case, or a negative pressure may be generated inside the fiber waste transfer pipe 11 through suction using a blower, for example.

[0058] The flow velocity of air inside the fiber waste transfer pipe 11 (11a to 11d) is preferably equal to or greater than 1000 m/min. Thus, if the flow velocity of air inside the fiber waste transfer pipe 11 is less than 1000 m/min, the fiber waste transfer pipe 11 (11a to 11d) may be configured in such a manner that a connection part for supplying compressed air is provided at the end on one side (backward-side end, for example) of the fiber waste transfer pipe 11 (11a to 11d) to allow the compressed air supplied from the compressed air source (not shown in the drawings) to be supplied to the fiber waste transfer pipe 11 (11a to 11d) from the end on one side of the fiber waste transfer pipe 11 (11a to 11d). In another configuration, a conventionally used blower may be provided near the cyclone separator 30 to make suction from the interior of the fiber waste transfer pipe 11 (11a to 11d), thereby compensating for a shortfall required for fulfilling the flow velocity of air such as 1000 m/min, for example.

[Example of Cyclone Separator]

[0059] FIG. 4 is a perspective view showing an example of the cyclone separator 30. FIG. 5 is a plan view showing an example of the cyclone separator 30. FIG. 6 is a front view showing an example of the cyclone separator 30. Illustration of a discharge sound reducer described later is omitted from FIGS. 4 to 6. A connection part for connection to the fiber waste transfer pipe 11 is further shown in FIGS. 4 to 6. In a present embodiment, the cyclone separator 30 includes the first cyclone separator 30a to the fourth cyclone separator 30d as described above, and all the first cyclone separator 30a to the fourth cyclone separator 30d have the same configuration.

[0060] Referring to FIG. 4, the cyclone separator 30 has a configuration including a circular cylindrical body unit 32, a tapered unit 42 provided under the body unit 32, a fiber waste discharge unit 46 for discharging fiber waste having been separated from air to the fiber waste collection container 13 (see FIG. 2), and an air discharge unit 50 for discharging air from which fiber waste has been separated to the outside. The cyclone separator 30 further includes a discharge sound reducer 60 (see FIG. 7 referred to later) for reducing discharge sound to be generated by discharge of air from which fiber waste has been separated, as will be described later in detail. An idea covering both the "body unit 32" and the "tapered unit 42" described above corresponds to a "separation unit" of the present invention.

[0061] The body unit 32 includes a circular cylindrical part 34 forming a side wall, and an upper surface part 36 forming an upper end surface of the circular cylindrical part 34. An opening part 38 concentric with the circular cylindrical part 34 and having a smaller diameter than the circular cylindrical part 34 is formed at the upper surface part 36 of the body unit 32. The body unit 32 causes fiber waste to move downward along a wall surface of the circular cylindrical part 34 using centrifugal force and to cause air from which the fiber waste has been separated to flow out through the opening part 38. The cyclone separator 30 is not to separate air and fiber waste completely but the fiber waste from which the air has been separated still contains air. For this reason, not only fiber waste but also air left unseparated is discharged from the fiber waste discharge unit 46 along with the fiber waste.

[0062] The tapered unit 42 includes an upper end portion of a circular shape having the same diameter as the circular cylindrical part 34, and a lower end portion of a circular shape having a smaller diameter than the upper end portion. The tapered unit 42 is opened at the upper end portion and the lower end portion thereof, and has an inclined part 44 tapered linearly from the upper end portion toward the lower end portion in a front view. As will be described later in detail, the inclined part 44 makes an acute angle θ between a vertical direction and a direction of the inclined part 44 (hereinafter called a "taper angle θ") that is preferably within a range from 7 to 10 [°] (covering upper and lower limits). The tapered unit 42 is connected at its upper end portion to a lower end portion of the circular cylindrical part 34. There is no member between the tapered unit 42 and the body unit 32 for dividing the respective interiors thereof so the interior of the tapered unit 42 and the interior of the body unit 32 communicate with each other.

[0063] The fiber waste discharge unit 46 has a circular cylindrical shape opened at both ends. The fiber waste discharge unit 46 has an inner diameter same as the inner diameter of the lower end portion of the tapered unit 42. The fiber waste discharge unit 46 is connected at an upper end portion thereof to the lower end portion of the tapered unit 42 in such a manner as to be concentric with the lower end portion of the tapered unit 42. The fiber waste discharge unit 46 is connected at a lower end portion thereof to the fiber waste collection container 13 (see FIG. 2). There is no member between the fiber waste discharge unit 46 and the tapered unit 42 for dividing the respective interiors thereof so the interior of the fiber waste discharge unit 46 and the interior of the body unit 32 communicate with each other.

[0064] The air discharge unit 50 has a circular cylindrical pipe member opened at both ends. The air discharge unit 50 has an inner diameter equal to the diameter of the opening part 38. The air discharge unit 50 is connected at a lower end portion thereof to the opening part 38 in such a manner as to be concentric with the opening part 38. More specifically, the air discharge unit 50 is connected to the body unit 32 in such a manner that the circular cylindrical part of the air discharge unit 50 does not get into the body unit 32 and the lower end portion of the circular cylindrical part of the air discharge unit 50 becomes flush with a lower surface of the upper surface part 36 of the body unit 32. The air discharge unit 50 is for discharging air having flowed in through the opening part 38 of the body unit 32 toward the outside after fiber waste is separated from the air. More specifically, the air discharge unit 50 is provided with the discharge sound reducer 60 (see FIG. 7) and air having flowed out through the opening at the upper end portion of the air discharge unit 50 is discharged to the outside through the discharge sound reducer 60.

[0065] FIG. 7 is a perspective view showing an example of the cyclone separator 30 for describing the discharge sound reducer 60. FIG. 8 is a view for describing the discharge sound reducer 60. FIG. 7 shows a state where the discharge sound reducer 60 is detached from the air discharge unit 50.

[0066] The discharge sound reducer 60 has a function of preventing lint having flowed into the air discharge unit 50 from the body unit 32 from being discharged to the outside, and a function of reducing discharge sound to be generated by discharge of air to the outside. The discharge sound reducer 60 includes an external fit member 62, a blocking member 64, and a speed reducer 65 integrated with each other.

[0067] The external fit member 62 has a straight circular cylindrical shape with opening parts 621 and 622 provided at an upper end portion and a lower end portion thereof respectively and having diameters substantially equal to each other. The external fit member 62 forms an airway therein for air having been discharged from the air discharge unit 50. The discharge sound reducer 60 is mounted on the cyclone separator 30 by fitting the opening part 622 of the external fit member 62 around the air discharge unit 50 as a circular cylindrical piper member, specifically, by arranging the opening part 622 radially externally to the air discharge unit 50. By fitting the external fit member 62 around the air discharge unit 50, air having been discharged from the air discharge unit 50 flows into the external fit member 62 through the opening part 622 at the lower end of the external fit member 62 and is then discharged to the outside through the opening part 621 at the upper end of the external fit member 62. As the blocking member 64 and the speed reducer 65 are integrated with the external fit member 62, it is possible to fulfill both the function of preventing lint from being discharged to the outside and the function of reducing discharge sound simply by arranging the discharge sound reducer 60 radially externally to the air discharge unit 50. The above-described "opening part 621" corresponds to an "opening part at one end" of the present invention.

[0068] The external fit member 62 is configured to have an inner wall surface arranged radially externally to the edges of the opening parts 621 and 622. Specifically, when the cyclone separator 30 is mounted on the air discharge unit 50, the external fit member 62 accommodates the opening part 38 of the body unit 32 inside the inner wall surface thereof as viewed in an axis direction. The external fit member 62 configured in this way forms an airway extending in the axis direction for air having been discharged from the air discharge unit 50. A clearance between the air discharge unit 50 and the external fit member 62 defined by fitting the external fit member 62 around the air discharge unit 50 is preferably as small as possible.

[0069] The blocking member 64 is provided at a position inside the external fit member 62 and separated upward by a predetermined distance from the opening part 622. When the external fit member 62 is arranged radially externally to the air discharge unit 50, the blocking member 64 is located directly above an opening region 52 of the air discharge unit 50. The opening region 52 is an opening region defined at an end portion of the circular cylindrical air discharge unit 50, specifically, at a boundary between the air discharge unit 50 and the discharge sound reducer 60. The blocking member 64 is configured to block the opening region 52 partially so as to prevent discharge of lint to the outside while maintaining discharge of air to the outside from the air discharge unit 50 when the blocking member 64 is located at the opening region 52. More specifically, the blocking member 64 has a plurality of gaps 66 and a grid part 68. The grid part 68 is a part formed in a grid pattern, and is provided perpendicularly to a Y direction (positive direction) corresponding to a flow direction of air to be discharged to the outside from the air discharge unit 50. Air is discharged to the outside through the plurality of gaps 66. Lint is trapped at the grid part 68 so is unlikely to be discharged to the outside. The "opening region 52" corresponds to an "air discharge port" of the present invention.

[0070] While the above-described blocking member 64 is configured to block the opening region 52 partially when located at the opening region 52, the blocking member 64 is not limited to this. The blocking member 64 may be provided at any position between the opening region 52 and the opening part 621 so as to prevent discharge of fiber waste to the outside. Specifically, the blocking member 64 is simply required to prevent discharge of fiber waste to the outside at least through the opening part 621.

[0071] The speed reducer 65 disturbs a flow of air toward the outside to reduce a flow velocity in an axis direction of the air discharge unit 50, namely, an axis direction of the discharge sound reducer 60. The speed reducer 65 is provided above the blocking member 64 and on the inner wall surface of the external fit member 62. The speed reducer 65 has a plurality of corrugation members 651 projecting obliquely upward and radially internally from the inner wall surface of the external fit member 62. These corrugation members 651 are spaced uniformly in the axis direction. Each of the corrugation members 651 has a flange 651A and the respective flanges 651A are coupled to each other by a support member 651B extending in the axis direction. By fixing the support member 651B to the inner wall surface of the external fit member 62, the corrugation members 651 become supported inside the external fit member 62. Providing the speed reducer 65 on the inner wall surface of the external fit member 62 allows reduction in a parts count without requiring an additional member for preparing the speed reducer 65. The plurality of corrugation members 651 may be formed directly on the inner wall surface of the external fit member 62.

[0072] Discharge sound generated by air flowing toward the outside is to be reduced by the plurality of corrugation members 651. Specifically, a flow of air in the discharge sound reducer 60 from the opening region 52 toward the opening part 621 is interrupted by the plurality of corrugation members 651. As a result, discharge sound is reduced. The above-described "corrugation member" corresponds to an "interrupting unit" of the present invention.

[0073] FIG. 9 is a view for describing principles of reducing discharge sound. In FIG. 9, a section of the discharge sound reducer 60 viewed from a lateral side thereof is shown in a simplified manner.

[0074] As represented by an open arrow in FIG. 9, air discharged from the air discharge unit 50 passes through the blocking member 64 and is discharged linearly through the opening part 621 of the external fit member 62 to the outside. Specifically, an airway for the air extends linearly. At this time, as represented by black arrows in FIG. 9, part of the air to be discharged toward the outside passes through near the plurality of corrugation members 651 to collide with the plurality of corrugation members 651, deviates from the airway, and flows toward the inner wall of the external fit member 62. After reflecting on the inner wall of the external fit member 62, this part of the air flows into a mainstream of the air represented by the open arrow in FIG. 9. Specifically, the speed reducer 65 causes part of the air directed toward the opening part 621 to be retained in or circulated through a place between the corrugation member 651 and the corrugation member 651 next to each other in the upward-and-downward direction. In this way, the discharge sound reducer 60 generates a disturbance in a flow of air without providing a complicated mechanism, thereby making it possible to reduce the flow velocity of air to be discharged toward the opening part 621, which eventually allows attenuation of the energy of the air flowing inside the discharge sound reducer 60 toward the opening part 621. By doing so, discharge sound generated by discharge of air through the opening part 621 of the discharge sound reducer 60 is reduced. Furthermore, by causing part of air directed toward the opening part 621 to be retained in or circulated through the place between the corrugation member 651 and the corrugation member 651 next to each other in the upward-and-downward direction, it becomes possible to cause the air to stay inside the discharge sound reducer 60, thereby allowing reduction in discharge of the air through the opening part 621. The above-described "place between the corrugation member 651 and the corrugation member 651" corresponds to a "retention part" of the present invention.

[0075] The discharge sound reducer 60 is configured in such a manner that the opening part 621 of the circular cylindrical external fit member 62 has a diameter equal to or greater than that of the opening region 52 of the air discharge unit 50. In this configuration, air exits after flowing straight from the opening region 52 of the air discharge unit 50 to the opening part 621 of the external fit member 62. This makes it possible to reduce the flow velocity of air while ensuring an airway for the air to be discharged toward the outside, which eventually allows reduction in discharge sound.

[0076] It is not essential for the diameter of the opening part 621 to be equal to the diameter of the smallest section perpendicular to a direction of air flowing inside the discharge sound reducer 60 toward the outside. The diameter of the opening part 621 may be configured to be larger than the diameter of the smallest section perpendicular to the direction of air flowing inside the discharge sound reducer 60 toward the outside. Specifically, in one configuration, an opening area of the opening part 621 may be larger than a sectional area of the smallest section perpendicular to the direction of air flowing inside the discharge sound reducer 60 toward the outside. More specifically, each of the plurality of corrugation members 651 may be configured to have a radially-internal distal end portion that is located radially internally to the opening part 621 of the external fit member 62 as viewed in the axis direction of the discharge sound reducer 60. Even in this configuration, it is still possible to reduce the flow velocity of air while ensuring an airway for the air to be discharged toward the outside, which eventually allows reduction in discharge sound.

[0077] The plurality of corrugation members 651 is configured not to overlap the opening region 52 (see FIG. 7) in the axis direction. This provides an airway for air having at least the same area as that of the opening region 52 of the air discharge unit 50 as viewed in the axis direction of the external fit member 62, thereby avoiding hindrance to discharge of air. In this way, it is possible for the discharge sound reducer 60 to reduce discharge sound while imposing no hindrance to discharge of air. In this case, the plurality of corrugation members 651 is preferably provided to the discharge sound reducer 60 so as to allow a reduction of at least 5 dB or more in discharge sound.

[0078] While the external fit member 62, the blocking member 64, and the speed reducer 65 of the discharge sound reducer 60 are integrated with each other, the blocking member 64 is omissible. As an example, the blocking member 64 may be a member separate from the discharge sound reducer 60. Furthermore, it is not essential for the blocking member 64 to be provided at an end portion of the external fit member 62 in the axis direction. As long as the blocking member 64 can be arranged in such a manner as to partially block the opening region 52 when the external fit member 62 is fitted around the air discharge unit 50, the blocking member 64 may be provided at any position in the axis direction of the external fit member 62. Additionally, it is not essential for the grid part 68 to be provided perpendicularly to a flow direction of air but the grid part 68 may be provided in a leaned state from the flow direction of air. Furthermore, it is not essential for the blocking member 64 to always include the grid part 68 formed in a grid pattern. The grid part 68 formed in a grid pattern may be replaced by a part having a mesh pattern, a part having a shape defined by a grid pattern and a mesh pattern in combination, or a part having a different shape.

[0079] While the blocking member 64 is configured to partially block the opening region 52, the blocking member 64 is not limited to this configuration. Specifically, a part to be blocked partially is not always limited to the opening region 52 and what is simply required is to block lint so as to prevent the lint from being discharged to the outside from the air discharge unit 50. As long as lint can be trapped along a route as a pathway for the lint from entry into the air discharge unit 50 from the body unit 32 to discharge to the outside, such lint can become unlikely to be unintentionally discharged to the outside. For this reason, in one configuration, the opening part 38 (see FIG. 4) or a lower end portion 50a of the circular cylindrical part of the air discharge unit 50 (see FIG. 6) may be blocked partially. Specifically, by adopting a configuration where an arbitrary part between the lower end portion 50a of the circular cylindrical part of the air discharge unit 50 and the opening region 52 is partially blocked, it is possible to prevent lint from being discharged to the outside through the air discharge unit 50.

[0080] As shown in FIG. 6, regarding the air discharge unit 50, it is preferable that the lower end portion 50a of the circular cylindrical part of the air discharge unit 50 be above an upper end portion 11U of the fiber waste transfer pipe 11. This is for the following reason. According to the findings of the inventors of the present application, arranging the lower end portion 50a of the circular cylindrical part of the air discharge unit 50 below the upper end portion 11U of the fiber waste transfer pipe 11 causes entanglement of fiber waste at the circular cylindrical part of the air discharge unit 50 to disable favorable separation between the fiber waste and air. In this regard, arranging the lower end portion 50a of the circular cylindrical part of the air discharge unit 50 at least above the upper end portion 11U of the fiber waste transfer pipe 11 makes it possible to prevent entanglement of fiber waste at the circular cylindrical part of the air discharge unit 50, thereby allowing favorable separation between the fiber waste and air. In a present embodiment, as shown in FIG. 4 referred to above, the lower end portion of the circular cylindrical part of the air discharge unit 50 and the lower surface of the upper surface part 36 of the body unit 32 (see FIG. 4) are flush with each other. Thus, the lower end portion 50a of the circular cylindrical part of the air discharge unit 50 becomes located above the upper end portion 11U of the fiber waste transfer pipe 11, thereby allowing fiber waste and air to be separated favorably from each other.

[0081] Connecting the plurality of fiber waste transfer pipes 11 (11a to 11d) to one cyclone separator 30 imposes limitation on a position of connection between the fiber waste transfer pipe 11 (11a to 11d) and the cyclone separator 30. For example, a position of connection between one fiber waste transfer pipe 11a of the plurality of fiber waste transfer pipes 11 (11a to 11d) and the cyclone separator 30 is subjected to limitation by the other fiber waste transfer pipes 11b to 11d. This causes a possibility of failing to connect the one fiber waste transfer pipe 11a to the cyclone separator 30 in such a manner as to locate the fiber waste transfer pipe 11a below the lower end portion of the circular cylindrical part of the air discharge unit 50. In this regard, by connecting the plurality of fiber waste transfer pipes 11 (11a to 11d) to the cyclone separators 30 in a one-to-one relationship, it becomes possible to form connection between the fiber waste transfer pipe 11 (11a to 11d) and the cyclone separator 30 at an appropriate position allowing favorable separation between fiber waste and air, specifically, at a position where the fiber waste transfer pipe 11 (11a to 11d) is located below the lower end portion of the circular cylindrical part of the air discharge unit 50.

[0082] There is no member between the air discharge unit 50 and the body unit 32 for dividing the respective interiors thereof so the interior of the air discharge unit 50 and the interior of the body unit 32 communicate with each other. Furthermore, according to the findings of the inventors, the inner diameter of the fiber waste discharge unit 46 (namely, the inner diameter of the lower end portion of the tapered unit 42) being larger than the inner diameter of the air discharge unit 50 (namely, the diameter of the opening part 38) results in insufficient separation between fiber waste and air, causing a possibility that the fiber waste will be discharged from the air discharge unit 50. For this reason, it is preferable that the inner diameter of the fiber waste discharge unit 46 (namely, the inner diameter of the lower end portion of the tapered unit 42) be smaller than the inner diameter of the air discharge unit 50 (namely, the diameter of the opening part 38).

[0083] In a present embodiment, the air discharge unit 50 and the fiber waste discharge unit 46 both have circular cylindrical shapes. However, the shapes are not limited to these but may be rectangular prism shapes. In this case, it is preferable that a part communicating with the interior of the body unit 32 (namely, a part of connection to the upper surface part 36) have an opening area defined along the horizontal direction larger than an opening area of the fiber waste discharge unit 46 defined along the horizontal direction.

[0084] As shown in FIG. 5, the fiber waste transfer pipe 11 is connected to the body unit 32 of the cyclone separator 30 at the top of the body unit 32 in such a manner that the longitudinal direction of the fiber waste transfer pipe 11 extends along an inner peripheral wall 35 of the body unit 32. In other words, the fiber waste transfer pipe 11 is connected to the body unit 32 in such a manner as to become a tangent to the circular cylindrical part 34 of the body unit 32 of the cyclone separator 30 in a plan view. In still other words, the fiber waste transfer pipe 11 and the body unit 32 of the cyclone separator 30 are connected to each other in such a manner as to cause air containing fiber waste having been transferred inside the fiber waste transfer pipe 11 to travel in a direction along the inner peripheral wall 35 of the circular cylindrical part 34. As shown in FIG. 4, connecting the fiber waste transfer pipe 11 and the cyclone separator 30 in this way causes air containing fiber waste having been transferred inside the fiber waste transfer pipe 11 to move in a peripheral direction along the inner peripheral wall 35 of the circular cylindrical part 34. As a result, the fiber waste contained in the air is transferred downward while being rotated in the peripheral direction along the inner peripheral wall 35 of the circular cylindrical part 34 by the action of centrifugal force, namely, by the action of centrifugal separation. The fiber waste having moved downward while being rotated along the inner peripheral wall 35 of the circular cylindrical part 34 is further transferred toward the fiber waste discharge unit 46 along an inner wall 45 of the inclined part 44. The fiber waste having been transferred toward the fiber waste discharge unit 46 is transferred from the fiber waste discharge unit 46 into the fiber waste collection container 13 (see FIG. 2). In this way, fiber waste is separated from air containing the fiber waste having been transferred inside the fiber waste transfer pipe 11 and the separated fiber waste is collected in the fiber waste collection container 13. The air from which the fiber waste has been separated is discharged to the outside from the air discharge unit 50.

[0085] By connecting the plurality of fiber waste transfer pipes 11 (11a to 11d) to the cyclone separators 30 in a one-to-one relationship, it becomes possible to ensure the inner peripheral wall 35 of the circular cylindrical part 34 as well as to form connection between the fiber waste transfer pipe 11 (11a to 11d) and the cyclone separator 30 at an appropriate position, thereby allowing fiber waste to be fed reliably to the tapered unit 42.

[Operation and Effect]

[0086] According to the fiber waste collection device 1 of a present embodiment, the fiber Y sucked through the suction unit 15 is transferred inside the fiber waste transfer pipe 11, passed to the cyclone separator 30 connected to the fiber waste transfer pipe 11, and collected as fiber waste in the fiber waste collection container 13. At the cyclone separator 30, the fiber waste is separated from air having been transferred inside the fiber waste transfer pipe 11. The separated fiber waste is collected in the fiber waste collection container 13 and the air from which the fiber waste has been separated is discharged from the air discharge unit 50. By providing the cyclone separator 30 between the fiber waste transfer pipe 11 and the fiber waste collection container 13 in this way, fiber waste and air are separated from each other preferably and fiber waste can become unlikely to be discharged to the outside from the air discharge unit 50.

[0087] According to the fiber waste collection device 1 of a present embodiment, the fiber waste transfer pipe 11 is connected to the body unit 32 in such a manner that the longitudinal direction of the fiber waste transfer pipe 11 extends along the inner peripheral wall 35 of the circular cylindrical part 34. Thus, air moves in the peripheral direction along the inner peripheral wall 35 of the circular cylindrical part 34, and fiber waste having been transferred inside the fiber waste transfer pipe 11 is moved downward along the inner peripheral wall 35 of the circular cylindrical part 34 and the inner wall 45 of the inclined part 44 by the action of centrifugal force, namely, by the action of centrifugal separation to be separated from the air. The fiber waste separated from the air is collected in the fiber waste collection container 13 through the fiber waste discharge unit 46. Clean air generated after separating the fiber waste is discharged from the air discharge unit 50. The air discharge unit 50 does not get into the body unit 32 and is connected to the body unit 32 while the interior of the air discharge unit 50 and the interior of the body unit 32 communicate with each other in such a manner that the lower end portion of the air discharge unit 50 becomes flush with the upper surface part 36 of the body unit 32. This prevents entanglement of fiber waste at the air discharge unit 50 to allow favorable separation between fiber waste and air.

[0088] According to the fiber waste collection device 1 of a present embodiment, the tapered unit 42 includes the inclined part 44 that becomes smaller in diameter from a position of connection to the body unit 32 toward the fiber waste discharge unit 46. As fiber waste and air can be separated from each other at the inclined part 44, it becomes possible to further reduce a possibility that fiber waste will be discharged to the outside from the air discharge unit 50. By forming the inclined part 44 into a tapered shape that makes an angle within a range from 7 to 10 [°] (covering upper and lower limits) together with the vertical direction, it becomes possible to prevent the fiber waste discharge unit 46 from being clogged with fiber waste while separating the fiber waste and air from each other with high accuracy, thereby allowing the fiber waste to be discharged favorably from the fiber waste discharge unit 46.

[0089] According to the fiber waste collection device 1 of a present embodiment, the inner diameter of the fiber waste discharge unit 46 (namely, the inner diameter of the lower end portion of the tapered unit 42) is smaller than the inner diameter of the air discharge unit 50 (namely, the diameter of the opening part 38). This allows fiber waste and air to be separated preferably from each other, making it possible to more effectively reduce a possibility that fiber waste will be discharged to the outside from the air discharge unit 50.

[0090] According to the fiber waste collection device 1 of a present embodiment, by providing the discharge sound reducer 60 to the cyclone separator 30, it becomes possible to separate fiber waste and air preferably and to reduce discharge sound to be generated during discharge of air by at least 5 dB or more. Furthermore, according to the fiber waste collection device 1 of a present embodiment, as an airway is ensured in the discharge sound reducer 60 for air having been discharged from the air discharge unit 50, it is possible to reduce discharge sound without hindering discharge of air.

[Experimental Examples about Cyclone Separator 30]

[0091] The following experimental examples were conducted to support a present embodiment. Result about these experimental examples will be described. FIG. 10 is an example of a front view of the cyclone separator 30. FIG. 11 shows an example of experimental result representing a relationship between the taper angle θ, the flow rate of air at the air discharge unit 50, and the flow rate of air at the fiber waste discharge unit 46. A 75 denier false-twisted yarn was used as fiber in an experimental example 1, an experimental example 2, and an experimental example 3 described later.

[0092] In FIGS. 10 and 11, an upward-and-downward direction is defined as a Y direction, in particular, an upward direction is defined as a Y direction (positive direction) and a downward direction is define as a Y direction (negative direction). The flow rates shown in FIG. 11 represent flow rates of vector components in the Y direction. A flow rate having a positive value means that air flows in the Y direction (positive direction). A flow rate having a negative value means that air flows in the Y direction (negative direction).

[0093] Referring to FIG. 10, the respective dimensions of the parts of the cyclone separator 30 are defined as follows: the length of the cyclone separator 30 as a whole in the Y direction is a, the length of the body unit 32 in the Y direction is b, the inner diameter of the body unit 32 is c, the length of the air discharge unit 50 in the Y direction is d, the inner diameter of the air discharge unit 50 is e, the length of the inclined part 44 in the Y direction is f, the length of the fiber waste discharge unit 46 in the Y direction is g, the inner diameter of the fiber waste discharge unit 46 is h, and a taper angle is θ. Regarding the experimental example 2 described later, the inner diameter of an inlet of the fiber waste transfer pipe 11 as a part of connection to the cyclone separator 30 is defined as i.

(Experimental Example 1)

[0094] In the experimental example 1, the respective dimensions of the parts of the cyclone separator 30 were set as follows: a = 280 mm, b = 80 mm, c (inner diameter) = 80 mm, d = 50 mm, e (inner diameter) = 48 mm, g = 10 mm, and h (inner diameter) = 31 mm. Then, by changing the taper angle θ, goodness of fiber waste discharged from the fiber waste discharge unit 46 (hereinafter called "goodness of fiber waste discharge") was examined. The examination was conducted with the taper angle θ set to 10°, 15°, 30°, and 40°. The length f of the inclined part 44 in the Y direction is a dimension determined by the taper angle θ.

[0095] Result of the examination obtained by the experimental example 1 is shown in Table 1. Table 1 shows an example of experimental result representing a relationship between the taper angle θ and the goodness of fiber waste discharge. What is important for discharging fiber waste favorably from the fiber waste discharge unit 46 is to gather the fiber waste into a ball shape. A case where fiber waste was formed into a ball shape and discharged favorably from the fiber waste discharge unit 46 was judged to be good, a case where fiber waste was not formed into a ball shape and was not discharged from the fiber waste discharge unit 46 was judged to be bad, and a case where fiber waste was gathered into a ball shape but the fiber waste discharge unit 46 was clogged at a frequency of once out of five times was judged to be middle.

Table 1

Taper angle θ	10°	15°	30°	45°
Goodness of fiber waste discharge	Middle	Bad	Bad	Bad

[0096] As shown in Table 1, the goodness of fiber waste discharge was judged to be bad with the taper angle θ exceeding 10°. According to the experimental example 1, with the taper angle θ of 10°, the fiber waste discharge unit 46 was clogged with fiber waste at a frequency of once out of five times so the judgment of middle was given. Meanwhile, fiber waste was gathered into a ball shape four times out of five times and was discharged from the fiber waste discharge unit 46, so that this judgment can be considered to be approximate to good. While not shown in Table 1, in all cases where the taper angle θ is less than 10°, the goodness of fiber waste discharge was judged to be good.

[0097] The examination result given above shows that, from the viewpoint of the goodness of waste yarn discharged from the fiber waste discharge unit 46, the taper angle θ is preferably equal to or less than 10°.

(Experimental Example 2)

[0098] In the experimental example 2, the respective dimensions of the parts of the cyclone separator 30 were set as follows: a = 300.1 mm, b = 90 mm, c = 90 mm, d = 30 mm, e = 48 mm, f = 170.1 mm, g = 10 mm, and i = 21 mm. Then, by changing only the taper angle θ, change in the flow rate of air in the Y direction at the air discharge unit 50 and change in the flow rate of air in the Y direction at the fiber waste discharge unit 46 were examined. The examination was conducted with the taper angle θ set to 10°, 9°, 7°, and 5°. The inner diameter h of the fiber waste discharge unit 46 is a dimension determined by the taper angle θ. Assuming the flow velocity of air inside the fiber waste transfer pipe 11 to be 1000 m/min, a mass flow rate of air at the inlet of the fiber waste transfer pipe 11 was set to 0.014896 kg/s.

[0099] Result of the examination obtained by the experimental example 2 shows that, assuming the inner diameter e of the air discharge unit 50 and the inner diameter h of the fiber waste discharge unit 46 to be constant, the flow rate of air discharged from the air discharge unit 50 decreases as the flow rate of air discharged from the fiber waste discharge unit 46 increases, as shown in FIG. 11. The flow rate of air discharged from the air discharge unit 50 decreases as the taper angle θ becomes smaller. On the other hand, with the taper angle θ of 7° as a turning point, the flow rate of air discharged from the fiber waste discharge unit 46 does not decrease but levels off even with the taper angle θ less than 7°. By setting the constant inner diameter e of the air discharge unit 50 and the constant inner diameter h of the fiber waste discharge unit 46 and reducing the taper angle θ, the length f of the inclined part 44 in the Y direction is increased accordingly. The increase in the length f of the inclined part 44 in the Y direction increases the length a of the cyclone separator 30 as a whole in the Y direction, and this is considered to increase pressure loss. For this reason, making the taper angle θ less than 7° is considered to increase the proportion of the flow rate of air discharged from the fiber waste discharge unit 46 to the flow rate of air discharged from the air discharge unit 50. According to the findings of the inventors, when the flow rate of air discharged from the fiber waste discharge unit 46 becomes larger than the flow rate of air discharged from the air discharge unit 50, fiber waste and air are not separated from each other favorably. Thus, a lower limit of the taper angle θ is preferably equal to or greater than 7°.

[0100] By considering the above-described examination results obtained by the experimental example 1 and the experimental example 2 comprehensively, it becomes known that the taper angle θ is preferably within a range from 7 to 10° (covering upper and lower limits).

(Experimental Example 3)

[0101] In the experimental example 3, examination was conducted on a relationship between the inner diameter h of the fiber waste discharge unit 46 and the proportion of the flow rate of air discharged from the fiber waste discharge unit 46 to the flow rate of air discharged from the air discharge unit 50. The air discharge unit 50 is simply required to fulfill the role of discharging air from which fiber waste has been separated to external air, so that the inner diameter e of the air discharge unit 50 was set to a constant diameter of 48 mm, for example. While result of the experiment is not illustrated in the drawings, the flow rate of air (absolute value) in the Y direction (negative direction) at the fiber waste discharge unit 46 increases with increase in the inner diameter h of the fiber waste discharge unit 46, and decreases with reduction in the inner diameter h of the fiber waste discharge unit 46. Meanwhile, the flow rate of air (absolute value) in the Y direction (positive direction) at the air discharge unit 50 tends to decrease with increase in the inner diameter h of the fiber waste discharge unit 46, and tends to increase with reduction in the inner diameter h of the fiber waste discharge unit 46. As described above, according to the findings of the inventors, the inner diameter h of the fiber waste discharge unit 46 is preferably smaller than the inner diameter e of the air discharge unit 50. Meanwhile, the inner diameter h of the fiber waste discharge unit 46 of equal to or less than 27 mm was found to impose difficulty in discharging fiber waste from the fiber waste discharge unit 46. If the inner diameter h of the fiber waste discharge unit 46 is 27 mm, a ratio between the flow rate of air discharged from the air discharge unit 50 and the flow rate of air discharged from the fiber waste discharge unit 46 is approximately 7 : 3. This ratio decreases with increase in the inner diameter h of the fiber waste discharge unit 46. If the inner diameter h of the fiber waste discharge unit 46 is within a range from 27 to 35 mm, for example, a ratio between the flow rate of air discharged from the air discharge unit 50 and the flow rate of air discharged from the fiber waste discharge unit 46 decreases with increase in the inner diameter h of the fiber waste discharge unit 46. The inner diameter h of the fiber waste discharge unit 46 of 35 mm is found to result in a ratio of approximately 1:1 between the flow rate of air discharged from the air discharge unit 50 and the flow rate of air discharged from the fiber waste discharge unit 46. As described above, with increase in the proportion of the flow rate of air discharged from the fiber waste discharge unit 46 to the flow rate of air discharged from the air discharge unit 50, fiber waste and air are not separated from each other favorably. For this reason, the inner diameter h of the fiber waste discharge unit 46 is preferably equal to or less than 35 mm.

[0102] As described above, the result of each of the foregoing experimental example 1, experimental example 2, and experimental example 3 was obtained using a 75 denier false-twisted yarn. The present inventors further conducted similar examination on other fibers. As a result, regarding a false-twisted fiber, a polyester fiber, and a polyamide fiber, by forming the inclined part 44 into a tapered shape that makes an angle within a range from 7 to 10 [°] (covering upper and lower limits) together with the vertical direction, it became possible to separate fiber waste and air from each other with high accuracy and to prevent clogging of the fiber waste discharge unit 46 with fiber waste, thereby allowing fiber waste to be discharged favorably from the fiber waste discharge unit 46. In particular, significant results were confirmed to be obtained with a false-twisted fiber of denier from 75 to 450, 150 denier PET, and nylon.

[0103] FIG. 12 is a plan view of the cyclone separator 30 and is a plan view showing exemplary variations of an opening ratio of the gap 66 in the blocking member 64. The opening ratio is 20% in FIG. 12(A). The opening ratio is 40% in FIG. 12(B). The opening ratio is 60% in FIG. 12(C). The opening ratio is 80% in FIG. 12(D). The opening ratio is 100% in FIG. 12(E). The opening ratio is the proportion of a total area of the plurality of gaps 66 to an opening area of the opening region 52 (see FIG. 7) in a plan view. The blocking member 64 is absent from the air discharge unit 50 shown in FIG. 12(E).

[0104] As shown in FIGS. 12(A) to 12(D), it is preferable for the plurality of gaps 66 to be arranged uniformly in the opening region 52. For example, arranging gaps not uniformly but in an imbalanced manner in a particular place in the opening region 52 might cause adverse influence on a flow of air to cause adverse influence on separation between air and fiber waste by the cyclone separator 30. If one of the semicircular portions of the opening region 52 circular in a plan view is completely blocked and the other semicircular portion is opened, for example, air is unintentionally caused to flow toward the other semicircular portion. In response to this, providing the plurality of gaps 66 uniformly in the opening region 52 makes it possible to minimize influence on separation between air and fiber waste, which is eventually considered to reduce discharge of lint from the air discharge unit 50.

[Experimental Examples about Cyclone Separator 30]

[0105] As described above, when the flow rate of air discharged from the fiber waste discharge unit 46 becomes larger than the flow rate of air discharged from the air discharge unit 50, fiber waste and air are not separated from each other favorably. Meanwhile, in the presence of the blocking member 64, the flow rate of air discharged to the outside from the air discharge unit 50 is smaller than in a case without the blocking member 64. For this reason, even with the uniform arrangement of the plurality of gaps 66, excess of the flow rate of air discharged from the fiber waste discharge unit 46 over the flow rate of air discharged from the air discharge unit 50 might still cause adverse influence on separation between air and fiber waste by the cyclone separator 30.

[0106] In response to this, experiment to find a preferred opening ratio was conducted on the cyclone separator 30 of a present embodiment. Result of this experimental example will be described by referring to FIG. 13. FIG. 13 shows an example of experimental result representing a relationship between the flow rate of air at the air discharge unit 50 and the flow rate of air at the fiber waste discharge unit 46. The flow rates shown in FIG. 13 represent flow rates of vector components in the Y direction (see FIG. 6). A flow rate having a positive value means that air flows in the Y direction (positive direction). A flow rate having a negative value means that air flows in the Y direction (negative direction).

[0107] In this experiment, the flow rate of air at the air discharge unit 50 and the flow rate of air at the fiber waste discharge unit 46 were measured with an opening ratio to an opening area of the opening region 52 in a plan view changed between 0%, 20%, 40%, 60%, 80%, and 100%. Assuming the flow velocity of air inside the fiber waste transfer pipe 11 (see FIG. 12) to be 1000 m/min, a mass flow rate, an area flow rate, and density of air at the inlet of the fiber waste transfer pipe 11 were set to 0.014896 kg/s, 0.754768 m^3/min (0.012579 m^3/sec), and 1.18415 kg/m^3 respectively.

[0108] As shown in FIG. 13, the flow rate of air at the air discharge unit 50 increases with increase in the opening ratio. The flow rate of air (absolute value) at the fiber waste discharge unit 46 decreases with increase in the opening ratio.

[0109] As described above, excess of the flow rate of air (absolute value) discharged from the fiber waste discharge unit 46 over the flow rate of air discharged from the air discharge unit 50 is known to prohibit favorable separation between fiber waste and air. Referring to FIG. 13, with the opening ratio of 40% as a rough boundary, the flow rate of air discharged from the air discharge unit 50 and the flow rate of air (absolute value) discharged from the fiber waste discharge unit 46 are reversed. Specifically, if the opening ratio is equal to or greater than 40%, the flow rate of air discharged from the air discharge unit 50 is larger than the flow rate of air (absolute value) discharged from the fiber waste discharge unit 46. By contrast, if the opening ratio is less than 40%, the flow rate of air (absolute value) discharged from the fiber waste discharge unit 46 is larger than the flow rate of air discharged from the air discharge unit 50. For this reason, the opening ratio at the blocking member 64 is preferably equal to or greater than 40% for favorable separation between fiber waste and air.

[0110] In a present embodiment, the discharge sound reducer 60 is provided at the air discharge unit 50. The discharge sound reducer 60 reduces discharge sound while ensuring an airway for air flowing inside the discharge sound reducer 60, as described above. Thus, in the presence of the discharge sound reducer 60 at the air discharge unit 50, fiber waste and air are separated favorably from each other at the cyclone separator 30.

[0111] As described above, by setting the opening ratio at the blocking member 64 equal to or greater than 40% so as to maintain the relationship according to which the flow rate of air discharged from the air discharge unit 50 is larger than the flow rate of air discharged from the fiber waste discharge unit 46, it becomes possible to reduce a possibility that lint will be discharged to the outside through the air discharge unit 50 while maintaining favorable separation between fiber waste and air. This eventually makes it possible to prevent a worker from being entangled with a yarn having been discharged to the outside through the air discharge unit 50.

[0112] Preferably, each of the plurality of gaps 66 has a size disabling passage of lint therethrough. Specifically, it is preferable for the plurality of gaps 66 to be formed uniformly at the blocking member 64 in such a manner as to provide the opening ratio of equal to or greater than 40% and to make lint difficult to pass therethrough. The size of one gap 66 is preferably smaller than the diameter of lint in order for the lint to be trapped at the blocking member 64. However, as the lint has flexibility and deflects, it is not essential for the size of one gap 66 to be smaller than the wire diameter of the lint.

[Modifications]

[0113] While embodiments of the present invention have been described above, the present invention is not limited to the above-described embodiments and is changeable in various ways within the scope of the claims. For example, the present invention may be changed and implemented as follows.

[First Modification]

[0114] FIG. 14 is a schematic view showing a fiber waste collection device 1A according to a first modification. Referring to FIG. 14, in a configuration of the first modification, the fiber waste collection device 1A includes a plurality of fiber waste collection containers 13 (13a to 13d) and a plurality of cyclone separators 30 (30a to 30d) both provided for corresponding ones of a plurality of fiber waste transfer pipes 11 (11a to 11d).

[0115] More specifically, the fiber waste collection container 13 includes a first fiber waste collection container 13a corresponding to a first fiber waste transfer pipe 11a, a second fiber waste collection container 13b corresponding to a second fiber waste transfer pipe 11b, a third fiber waste collection container 13c corresponding to a third fiber waste transfer pipe 11c, and a fourth fiber waste collection container 13d corresponding to a fourth fiber waste transfer pipe 11d. The cyclone separator 30 (30a to 30d) includes a first cyclone separator 30a provided between the first fiber waste transfer pipe 11a and the first fiber waste collection container 13a, a second cyclone separator 30b provided between the second fiber waste transfer pipe 11b and the second fiber waste collection container 13b, a third cyclone separator 30c provided between the third fiber waste transfer pipe 11c and the third fiber waste collection container 13c, and a fourth cyclone separator 30d provided between the fourth fiber waste transfer pipe 11d and the fourth fiber waste collection container 13d. Each of the first fiber waste transfer pipe 11a to the fourth fiber waste transfer pipe 11d is connected to a body unit (no reference sign) of the cyclone separator 30 in such a manner that a longitudinal direction thereof extends along an inner peripheral wall (no reference sign) of the body unit (no reference sign). In other words, like the fiber waste transfer pipe 11 (11a to 11d) described by referring to FIG. 5, each of the first fiber waste transfer pipe 11a to the fourth fiber waste transfer pipe 11d is connected to the body unit in such a manner as to become a tangent to a circular cylindrical part of the body unit of the cyclone separator 30 (30a to 30d) in a plan view.

[0116] Even in this configuration described in the first modification, it is still possible to separate fiber waste preferably from air, discharge the fiber waste favorably from the fiber waste discharge unit 46 (see FIG. 4), and favorably discharge the air from the air discharge unit 50 (see FIG. 4) from which the fiber waste has been separated.

[Second Modification]

[0117] FIG. 15 is a schematic view showing a fiber waste collection device 1B according to a second modification. Referring to FIG. 15, in a configuration of the second modification, the fiber waste collection device 1B includes a plurality of fiber waste transfer pipes 11 (11a to 11d), one fiber waste collection container 13, and one cyclone separator 30.

[0118] The cyclone separator 30 is provided between the plurality of fiber waste transfer pipes 11 (11a to 11d) and the fiber waste collection container 13. These fiber waste transfer pipes 11 (11a to 11d) merge with each other on an upstream side from the cyclone separator 30. A pipe resulting from the merge is connected to a body unit (no reference sign) of the cyclone separator 30 in such a manner that a longitudinal direction of the pipe extends along an inner peripheral wall (no reference sign) of the body unit. In other words, like the fiber waste transfer pipe 11 described by referring to FIG. 5, the pipe resulting from the merge (no reference sign) is connected to the body unit in such a manner as to become a tangent to a circular cylindrical part of the body unit of the cyclone separator 30 in a plan view.

[0119] Even in this configuration described in the second modification, it is still possible to separate fiber waste preferably from air, discharge the fiber waste favorably from the fiber waste discharge unit 46 (see FIG. 4), and discharge the air favorably from the air discharge unit 50 (see FIG. 4) from which the fiber waste has been separated.

[0120] In the configuration of the second modification, all the plurality of fiber waste transfer pipes 11 (11a to 11d) merge with each other on an upstream side from one cyclone separator 30. This may be replaced by a configuration where a plurality of cyclone separators 30 is provided and two or more fiber waste transfer pipes of the plurality of fiber waste transfer pipes 11 (11a to 11d) merge with each other on an upstream side from the cyclone separator 30. For example, two fiber waste transfer pipes may merge with each other on an upstream side from one of the cyclone separators and may be connected to the one cyclone separatorwhile merging with each other, and the other two fiber waste transfer pipes may merge with each other on an upstream side from a different one of the cyclone separators and may be connected to the different cyclone separator while merging with each other.

[Third Modification]

[0121] FIG. 16 is a plan view of a cyclone separator 30 according to a third modification. For the sake of convenience, the air discharge unit 50 is further illustrated in FIG. 16. Like the fiber waste collection device 1B of the second modification, a fiber waste collection device (no reference sign) of the third modification includes a plurality of fiber waste transfer pipes 11 (11a to 11d), one fiber waste collection container (no reference sign), and one cyclone separator 30. In the second modification, these fiber waste transfer pipes 11 (11a to 11d) merge with each other on an upstream side from the cyclone separator 30. Instead of this, in the third modification, these fiber waste transfer pipes 11 (11a to 11d) are connected to one cyclone separator 30.

[0122] More specifically, referring to FIG. 16, in a configuration of the third modification, a first fiber waste transfer pipe 11a, a second fiber waste transfer pipe 11b, a third fiber waste transfer pipe 11c, and a fourth fiber waste transfer pipe 11d are connected to positions along the body unit 32 of one cyclone separator 30 shifted from each other in a peripheral direction. Each of the first fiber waste transfer pipe 11a to the fourth fiber waste transfer pipe 11d is connected to the body unit 32 of the cyclone separator 30 in such a manner that a longitudinal direction thereof extends along the inner peripheral wall 35 of the body unit 32. In other words, like the fiber waste transfer pipe 11 described by referring to FIG. 5, each of the first fiber waste transfer pipe 11a to the fourth fiber waste transfer pipe 11d is connected to the body unit 32 in such a manner as to become a tangent to the circular cylindrical part 34 of the body unit 32 of the cyclone separator 30 in a plan view. Even in this configuration described in the third modification, it is still possible to separate fiber waste preferably from air, discharge the fiber waste favorably from the fiber waste discharge unit 46, and discharge the air favorably from the air discharge unit 50 from which the fiber waste has been separated.

[0123] Preferably, each of the first fiber waste transfer pipe 11a to the fourth fiber waste transfer pipe 11d shown in FIG. 16 is connected to the top of the body unit 32. However, it is not essential for all of the first fiber waste transfer pipe 11a to the fourth fiber waste transfer pipe 11d to be at the same position in the upward-and-downward direction. One or all of the first fiber waste transfer pipe 11a to the fourth fiber waste transfer pipe 11d may be connected at positions shifted from each other in the upward-and-downward direction.

[Fourth Modification]

[0124] FIG. 17 is a perspective view of a cyclone separator 30 according to a fourth modification. For the sake of convenience, the air discharge unit 50 is further illustrated in FIG. 17. Like the fiber waste collection device 1B of the second modification, a fiber waste collection device (no reference sign) of the fourth modification includes a plurality of fiber waste transfer pipes 11 (11a to 11d), one fiber waste collection container (no reference sign), and one cyclone separator 30.

[0125] Referring to FIG. 17, in a configuration of the fourth modification, a first fiber waste transfer pipe 11a, a second fiber waste transfer pipe 11b, a third fiber waste transfer pipe 11c, and a fourth fiber waste transfer pipe 11d are connected to positions along the body unit 32 of one cyclone separator 30 shifted from each other in the upward-and-downward direction. Each of the first fiber waste transfer pipe 11a to the fourth fiber waste transfer pipe 11d is connected to the body unit 32 of the cyclone separator 30 in such a manner that a longitudinal direction thereof extends along the inner peripheral wall 35 of the body unit 32. In other words, like the fiber waste transfer pipe 11 described by referring to FIG. 5, each of the first fiber waste transfer pipe 11a to the fourth fiber waste transfer pipe 11d is connected to the body unit 32 in such a manner as to become a tangent to the circular cylindrical part 34 of the body unit 32 of the cyclone separator 30 in a plan view. Even in this configuration described in the fourth modification, it is still possible to separate fiber waste preferably from air, discharge the fiber waste favorably from the fiber waste discharge unit 46, and discharge the air favorably from the air discharge unit 50 from which the fiber waste has been separated.

[0126] All of the first fiber waste transfer pipe 11a to the fourth fiber waste transfer pipe 11d shown in FIG. 17 are connected to the body unit 32 at the same position in the peripheral direction of the body unit 32 while being shifted from each other in the upward-and-downward direction. However, this is not essential. For example, at least one or all of the first fiber waste transfer pipe 11a to the fourth fiber waste transfer pipe 11d may be connected to the body unit 32 at positions shifted from each other in the peripheral direction of the body unit 32.

[Fifth Modification]

[0127] FIGS. 18 to 21 are views showing a first configuration to a fourth configuration respectively of a discharge sound reducer according to a fifth modification. Each of the discharge sound reducers shown in FIGS. 18 to 21 include an external fit member 62 and a blocking member 64 similar to those of the discharge sound reducer 60 shown in FIG. 8, and includes a speed reducer 65 having a different configuration from that of the discharge sound reducer 60. Thus, the following description is intended only for the configuration of the speed reducer 65.

[0128] In a speed reducer 65A of a discharge sound reducer 60A according to the first configuration shown in FIG. 18, the number of corrugation members 651 is smaller than that of the speed reducer 65 of the discharge sound reducer 60 shown in FIG. 8. Specifically, the length of the discharge sound reducer 60A in the axis direction is smaller than that of the discharge sound reducer 60 and is about half of the length of the discharge sound reducer 60. More specifically, if the length of the discharge sound reducer 60 in the axis direction shown in FIG. 8 is from 220 to 230 cm, the length of the discharge sound reducer 60A shown in FIG. 18 is from 110 to 115 cm.

[0129] A speed reducer 65B of a discharge sound reducer 60B according to the second configuration shown in FIG. 19 has a plurality of corrugation members 652 projecting obliquely downward and radially internally from the inner wall surface of the external fit member 62. These corrugation members 652 are spaced uniformly in the axis direction. In the speed reducer 65B, a flow is caused to enter a place between the corrugation member 652 and the corrugation member 652 to generate a vortex, thereby dispersing the flow like in the speed reducer 65 and the speed reducer 65A. By doing so, the flow velocity of air is reduced. Furthermore, each of the plurality of corrugation members 652 has a distal end portion that is located radially externally to the opening region 52 of the air discharge unit 50 as viewed in the axis direction. Specifically, an airway is ensured for air to be discharged toward the outside from the opening region 52 of the air discharge unit 50, so that air from the air discharge unit 50 is discharged to the outside without being interrupted by the plurality of corrugation members 652. The length of the discharge sound reducer 60B in the axis direction is not particularly limited. In the second configuration of the fifth modification, the above-described "place between the corrugation member 652 and the corrugation member 652" corresponds to the "retention part" of the present invention.

[0130] A speed reducer 65C of a discharge sound reducer 60C according to the third configuration shown in FIG. 20 has a plurality of honeycomb openings 653 formed on the inner wall surface of the external fit member 62. There are no particular limitations on the number of the openings 653 and positions where the openings 653 are formed. In this case, a flow of air is caused to enter the opening 653 to generate a vortex, thereby dispersing the flow. This makes it possible to reduce the flow velocity of air flowing toward the opening part 621 and to allow part of the air directed toward the opening part 621 to be retained in or circulated through the honeycomb opening 653. The plurality of openings 653 does not project from the inner wall surface of the external fit member 62. Thus, even if the inner wall surface of the external fit member 62 is flush with an outer edge of the opening region 52 of the air discharge unit 50, an airway for air is not narrowed in the external fit member 62. Specifically, an airway is ensured for air to be discharged toward the outside from the opening region 52 of the air discharge unit 50, so that air from the air discharge unit 50 is discharged to the outside without being interrupted by a plurality of corrugation members 652 such as those shown in FIG. 19. The length of the discharge sound reducer 60C in the axis direction is not particularly limited. In the third configuration of the fifth modification, the above-described "honeycomb opening 653" corresponds to the "retention part" of the present invention.

[0131] A speed reducer 65D of a discharge sound reducer 60D according to the fourth configuration shown in FIG. 21 has a plurality of cubic projections 654 provided on the inner wall surface of the external fit member 62. There are no particular limitations on the number of the projections 654 and positions where the projections 654 are formed. In this case, air flowing inside the external fit member 62 collides with the projection 654 to disperse the flow. The dispersed flow collides with a mainstream of the air. By doing so, the flow velocity of the air is reduced. Each of the plurality of projections 654 has a distal end portion that is located radially externally to the opening region 52 of the air discharge unit 50 as viewed in the axis direction. Specifically, an airway is ensured for air to be discharged toward the outside from the opening region 52 of the air discharge unit 50, so that air from the air discharge unit 50 is discharged to the outside without being interrupted by a plurality of corrugation members 652 such as those shown in FIG. 19. The length of the discharge sound reducer 60D in the axis direction is not particularly limited.

[0132] Each of the discharge sound reducers 60Ato 60D shown in FIGS. 18 to 21 is capable of reducing the flow velocity of air while ensuring an airway for the air to be discharged to the outside, thereby eventually allowing reduction in discharge sound. FIG. 22 is a view showing result of a test conducted to confirm reduction in discharge sound achieved by the discharge sound reducer. In FIG. 22, a vertical axis represents a sound pressure level (in units of dB). Signs along a horizontal axis in FIG. 22 correspond to the signs of the discharge sound reducers described by referring to FIGS. 8 and 18 to 21. "None" means that no discharge sound reducer is provided.

[0133] While not particularly shown in the drawings, in the discharge sound reducers 60 and 60A to 60D described by referring to FIGS. 8 and 18 to 21, the speed reducers 65 and 65Ato 65D are provided on the inner wall surface of the external fit member 62. However, the speed reducer is not limited to this. In one configuration, the speed reducer may be provided at a position overlapping the opening region 52 of the air discharge unit 50 in the axis direction, for example. In one configuration, the discharge sound reducer may have a columnar member provided above a central area of the opening region 52 (a radially internal area thereof) and extending in the axis direction, and the speed reducer may be provided to this columnar member.

[0134] While the external fit member 62 has a circular cylindrical shape in each of the cases described by referring to FIGS. 8 and 18 to 21, it is not limited to this shape but may have a rectangular prism shape. While the external fit member 62 defines a linear airway for air therein, it is not limited to this but may have a cylindrical shape with a bend (for example, an S-shaped cylindrical shape) to result in a bent airway for air. The speed reducer 65 is provided on the inner wall surface of the external fit member 62. Thus, even if the external fit member 62 has a cylindrical shape with a bend, for example, the flow velocity of air flowing toward the outside is still reduced along the cylindrical shape. The air discharge unit 50 is also free from the limitation to the circular cylindrical shape but may have a rectangular prism shape or may have a shape with a bend.

[0135] In any of the discharge sound reducers 60 and 60Ato 60D described above, a sound pressure level is reduced compared to a case without a discharge sound reducer, as shown in FIG. 22. Thus, the provision of the discharge sound reducers 60 and 60A to 60D was confirmed to reduce discharge sound. In particular, the provision of the discharge sound reducer 60 shown in FIG. 8 was confirmed to achieve the highest effectiveness.

[Other Modifications]

[0136] In the exemplary configuration shown in the above-described embodiment, the fiber waste collection device 1 is installed at the false-twisting machine 101. However, the installation is not limited to this. In one configuration, the fiber waste collection device 1 may be installed at a textile machine other than the false-twisting machine 101. In one configuration, the fiber waste collection device 1 may be installed at a spinning machine, for example.

[0137] In the exemplary configuration shown in the above-described embodiment, the winders 107 installed at the false-twisting machine 101 are aligned in four stages in the upward-and-downward direction. However, the installation is not limited to this. In one configuration, the winders 107 installed at the false-twisting machine 101 may be aligned in stages of a number equal to or less than three, or in stages of a number equal to or greater than five in the upward-and-downward direction. In this case, the number of the fiber waste transfer pipes 11 to be provided may be responsive to the number of stages of the winders 107 aligned in the upward-and-downward direction.

[0138] While the exemplary configuration shown in the above-described embodiment includes the plurality of fiber waste transfer pipes 11, the configuration is not limited to this. In one configuration, only one fiber waste transfer pipe 11 may be provided.

[0139] While the air discharge unit 50 shown in the above-described embodiment has a circular cylindrical shape, the air discharge unit 50 is simply required to have a prism shape and is not limited to a circular cylindrical shape. If the shape of the air discharge unit is a prism shape but not a circular cylindrical shape, the external fit member 62 preferably has a cylindrical shape allowing the external fit member 62 to be arranged radially externally to the cylindrical air discharge unit. Likewise, if the shape of the air discharge unit is a prism shape but not a circular cylindrical shape, the external fit member 62 also preferably has a cylindrical shape allowing the external fit member 62 to be arranged radially externally to the cylindrical air discharge unit.

[0140] An embodiment disclosed herein should be considered to be illustrative in all aspects and not restrictive. A basic scope of the present disclosure is defined not by the embodiment described above but by the scope of the claims, and is intended to cover all changes within a sense and a range equivalent to those of the scope of the claims.

(Reference Numerals)

[0141]

1	Fiber waste collection device
11	Fiber waste transfer pipe
13	Fiber waste collection container
15	Suction unit
30	Cyclone separator
32	Body unit
42	Tapered unit
44	Inclined part
46	Fiber waste discharge unit
50	Air discharge unit
52	Opening region
60	Discharge sound reducer
62	External fit member
64	Blocking member
65	Speed reducer
66	Gap
651	Corrugation member
Y	Fiber

Claims

1. A fiber waste collection device (1, 1A, 1B) comprising:

a fiber waste transfer pipe (11) for transferring fiber waste containing lint along with air;
a fiber waste collection unit (13) that collects the fiber waste having been transferred inside the fiber waste transfer pipe (11); and
a cyclone separator (30) provided between the fiber waste transfer pipe (11) and the fiber waste collection unit (13), the cyclone separator separating the fiber waste and the air having been transferred inside the fiber waste transfer pipe (11) from each other and collecting the fiber waste having been separated from the air into the fiber waste collection unit (13), wherein
the cyclone separator (30) includes:

a separation unit (32, 42) that separates the fiber waste and the air from each other; and
a discharge sound reducer (60, 60A to 60D) that reduces discharge sound to be generated by discharge of the air from which the fiber waste has been separated by the separation unit (32, 42).

2. The fiber waste collection device (1, 1A, 1B) as claimed in claim 1, wherein the discharge sound reducer (60, 60A to 60D) includes a speed reducer (65) of a cylindrical shape that reduces the speed of air in a flow direction of the air toward an opening part (621) at one end on an opposite side to the separation unit (32, 42) when the air flows toward the opening part (621) at the one end.

3. The fiber waste collection device (1, 1A, 1B) as claimed in claim 2, wherein the speed reducer (65) includes an interrupting unit (651) that interrupts a flow of the air toward the opening part (621) at the one end.

4. The fiber waste collection device (1, 1A, 1B) as claimed in claim 2 or 3, wherein the speed reducer (65) includes a retention part that causes part of the air flowing toward the opening part (621) at the one end to be retained in the discharge sound reducer (60, 60A to 60D).

5. The fiber waste collection device (1, 1A, 1B) as claimed in any one of claims 2 to 4, wherein

   the discharge sound reducer (60, 60A to 60D) has an inner wall surface having a section larger than an air discharge port through which the air is discharged from the separation unit (32, 42), the section being perpendicular to the flow direction of the air toward the opening part (621) at the one end, and
   the speed reducer (65) is provided on the inner wall surface.

6. The fiber waste collection device (1, 1A, 1B) as claimed in claim 5, wherein the discharge sound reducer (60, 60A to 60D) is configured to have an opening area of the opening part (621) at the one end equal to or larger than an opening area of the air discharge port.

7. The fiber waste collection device (1, 1A, 1B) as claimed in claim 6, wherein the discharge sound reducer (60, 60A to 60D) has a straight or tapered cylindrical shape.

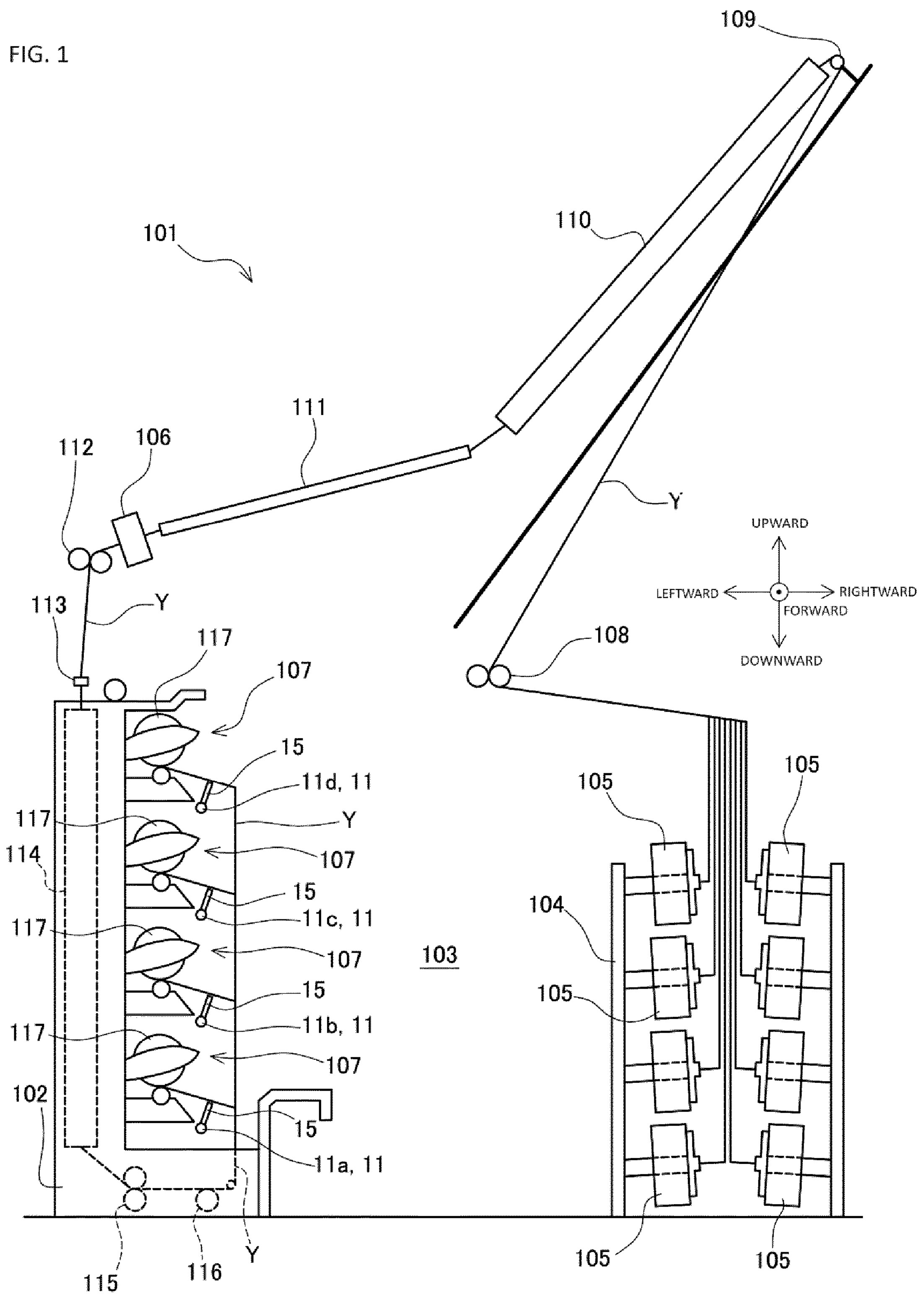
8. The fiber waste collection device (1, 1A, 1B) as claimed in any one of claims 2 to 7, wherein

   the cyclone separator (30) further includes a fiber waste discharge unit (46) that discharges the fiber waste along with air to the fiber waste collection unit (13) after the fiber waste moves downward along an inner peripheral wall of the separation unit (32, 42), and
   the discharge sound reducer (60, 60Ato 60D) includes a blocking member (64) that blocks lint so as to prevent the lint from being discharged to the outside through the opening part (621) while the lint moves toward the opening part (621) without being discharged from the fiber waste discharge unit (46).

9. The fiber waste collection device (1, 1A, 1B) as claimed in any one of claims 1 to 8, wherein the discharge sound reducer (60, 60A to 60D) reduces discharge sound by 5 dB or more.

10. A false-twisting machine comprising the fiber waste collection device (1, 1A, 1B) as claimed in any one of claims 1 to 9.

FIG. 1



109
110
101
111
112
106
113
Y
117
107
15
11d, 11
117
114
107
15
11c, 11
117
107
103
15
11b, 11
117
107
102
15
11a, 11
115
116
Y
108
UPWARD
LEFTWARD
RIGHTWARD
FORWARD
DOWNWARD
105
104

FIG. 2

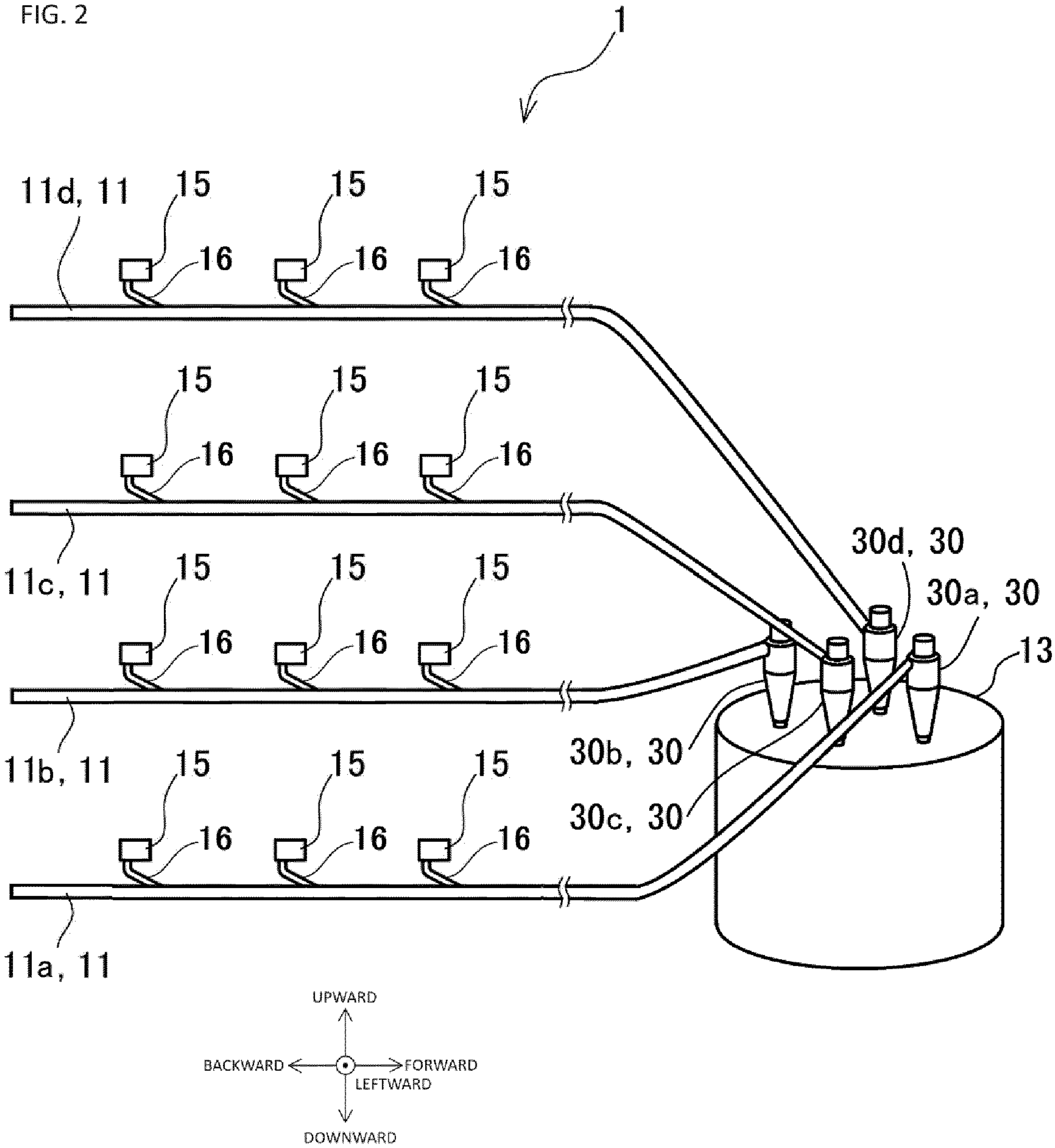

1
11d, 11
15
16
11c, 11
11b, 11
11a, 11
30d, 30
30a, 30
13
30b, 30
30c, 30
UPWARD
BACKWARD
FORWARD
LEFTWARD
DOWNWARD

FIG. 3

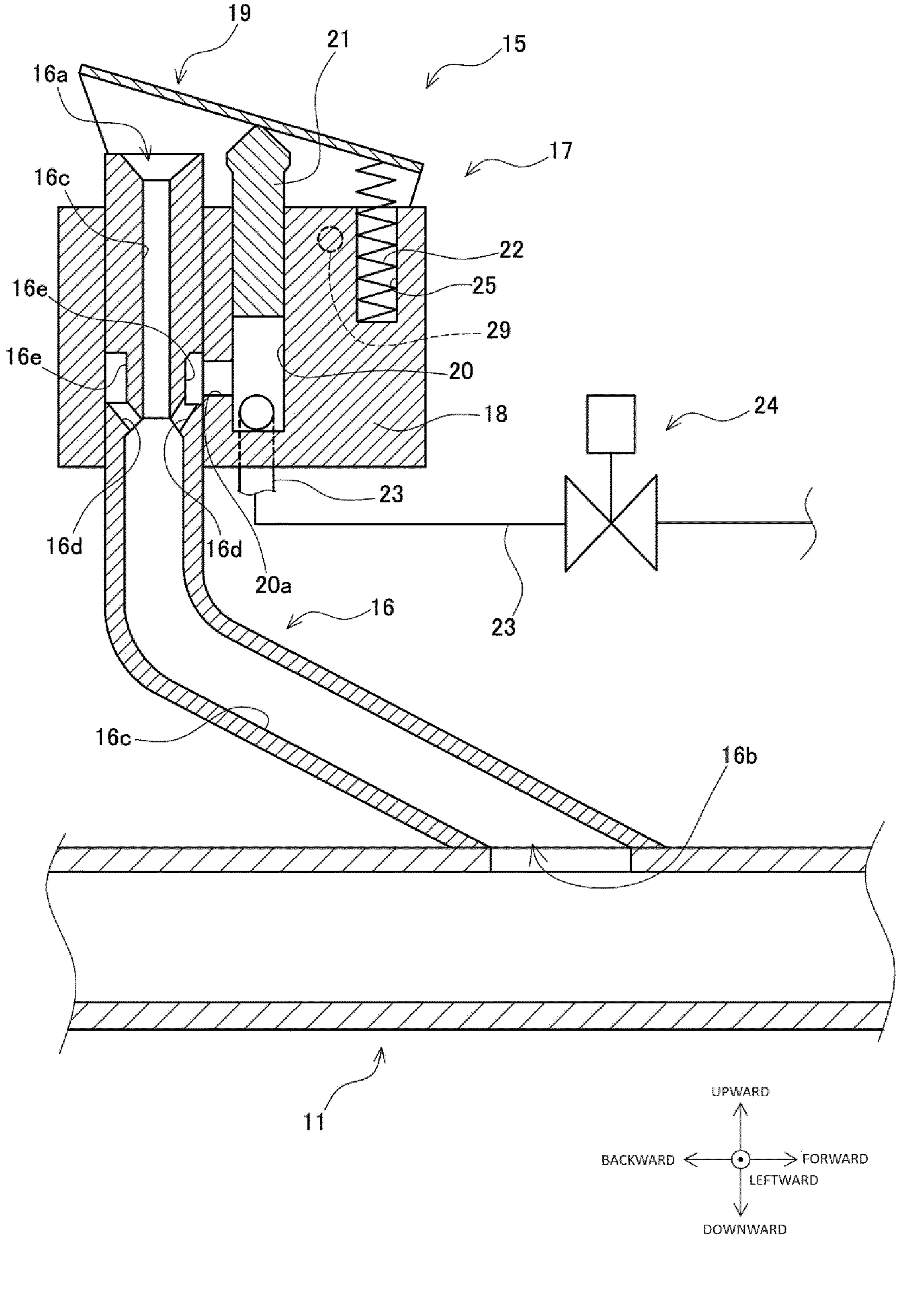

19
21
15
16a
17
16c
22
25
16e
29
16e
20
18
24
23
16d
16d
20a
16
23
16c
16b
11
UPWARD
BACKWARD
FORWARD
LEFTWARD
DOWNWARD

FIG. 4

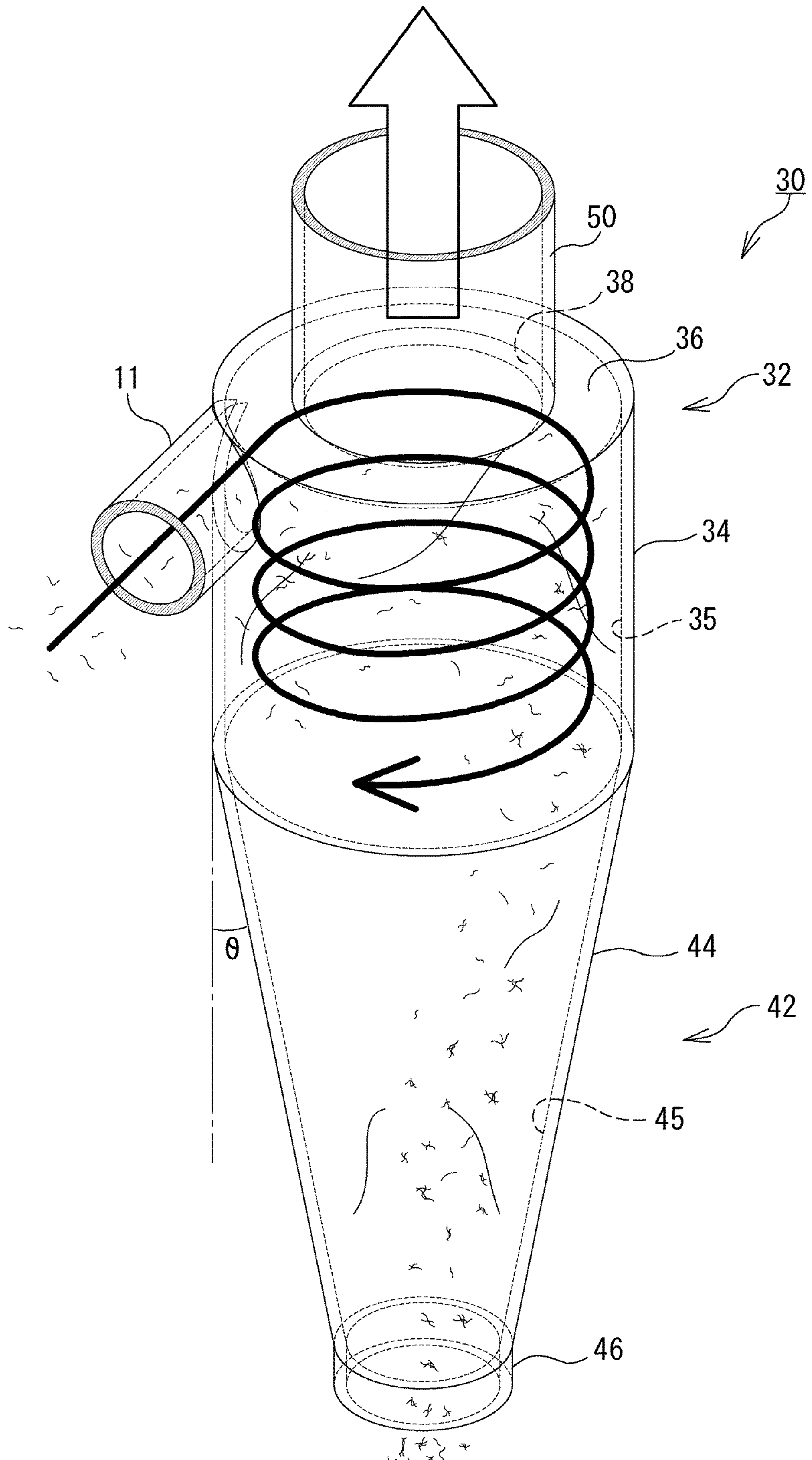


FIG. 5

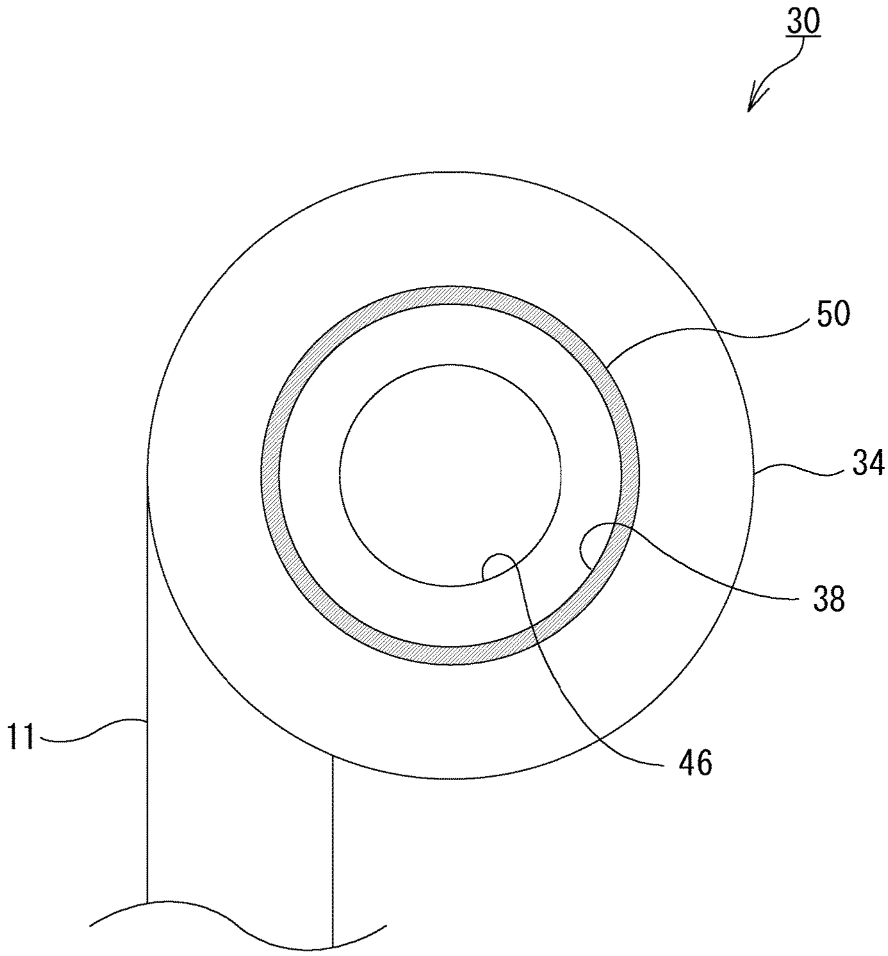


FIG. 6

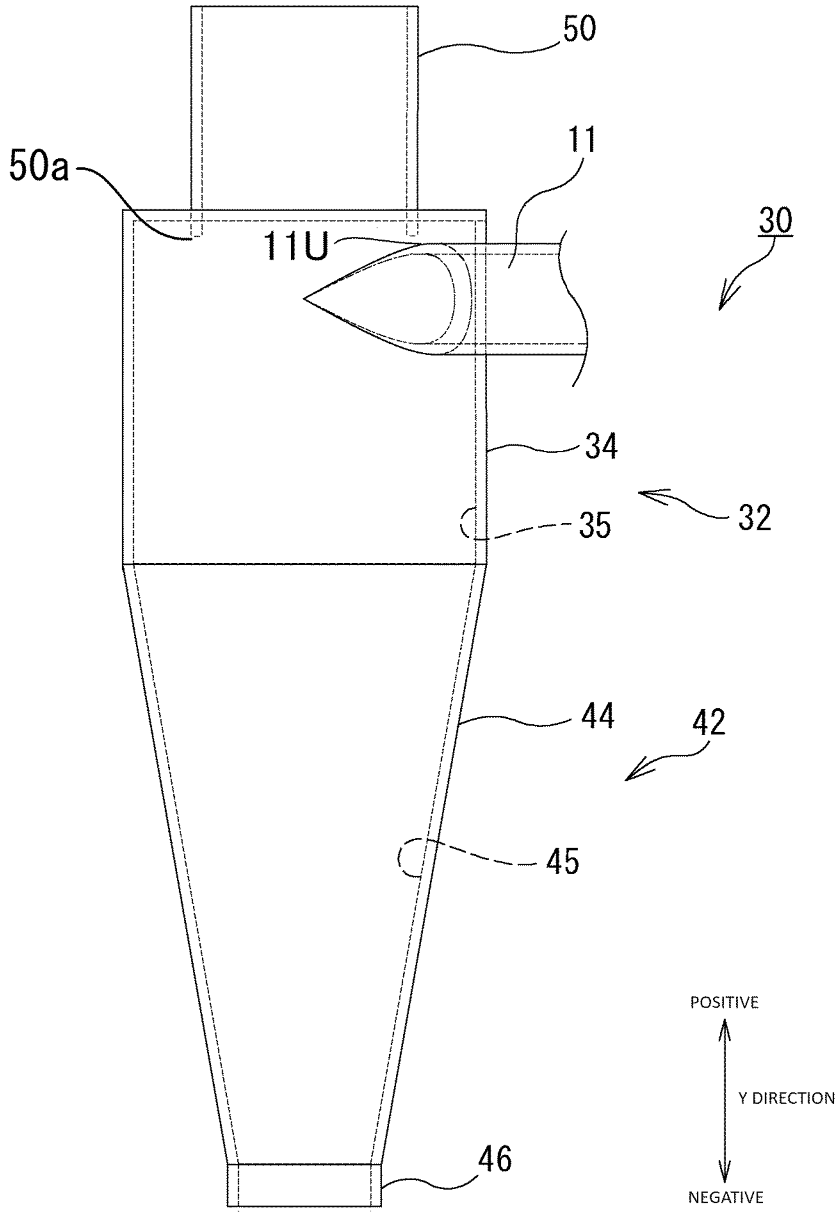

50
11
50a
11U
30
34
32
35
44
42
45
POSITIVE
Y DIRECTION
NEGATIVE
46

FIG.7

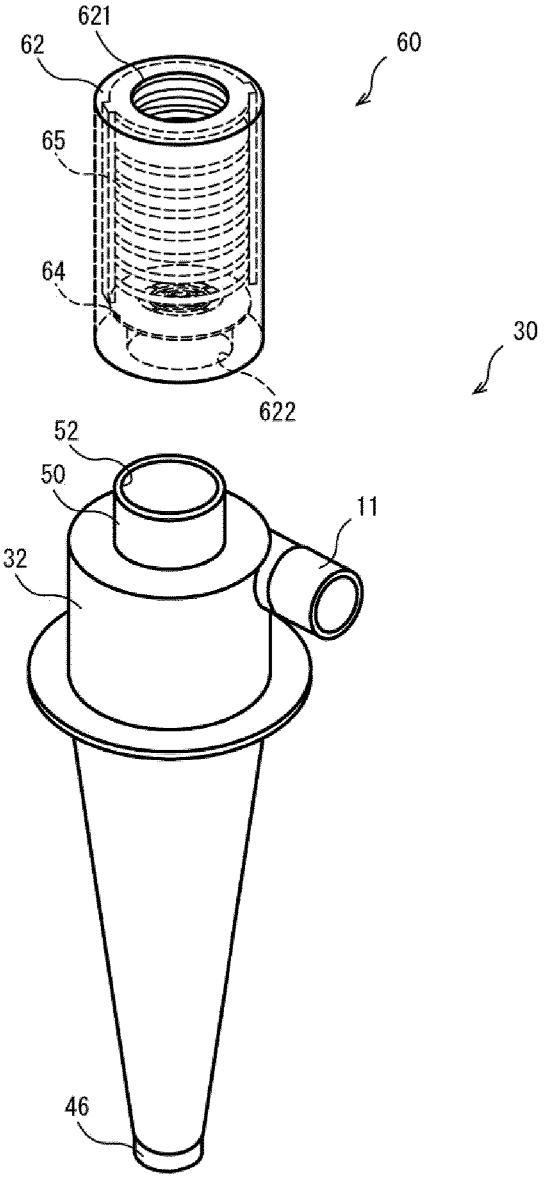


FIG. 8

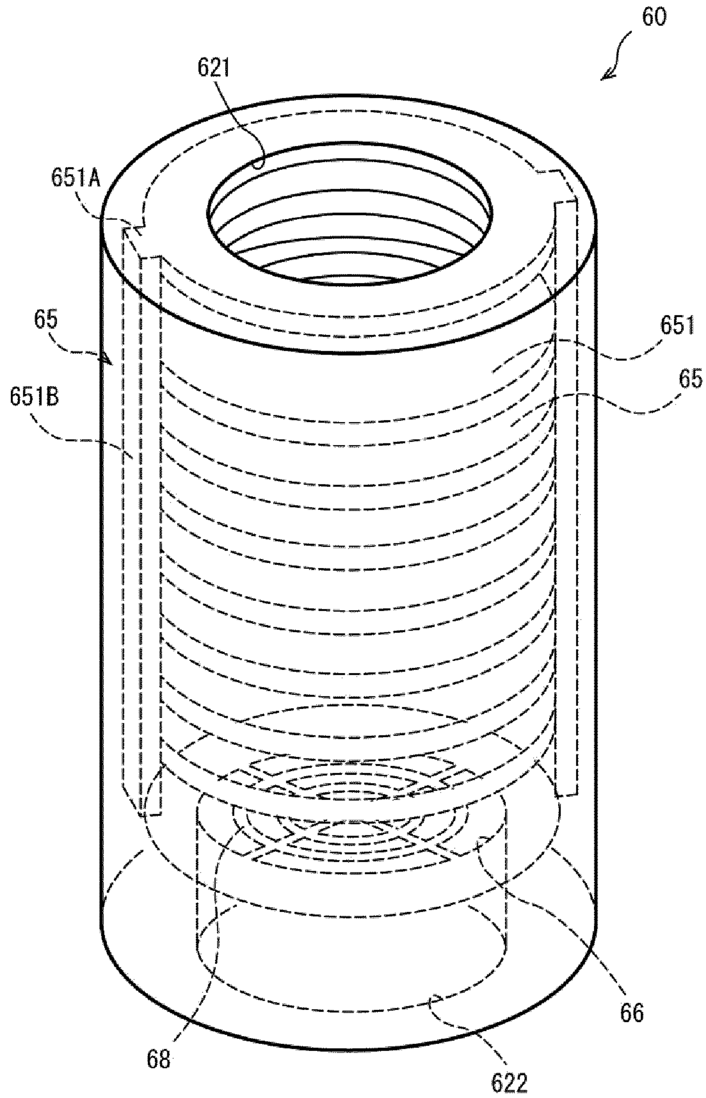


FIG. 9

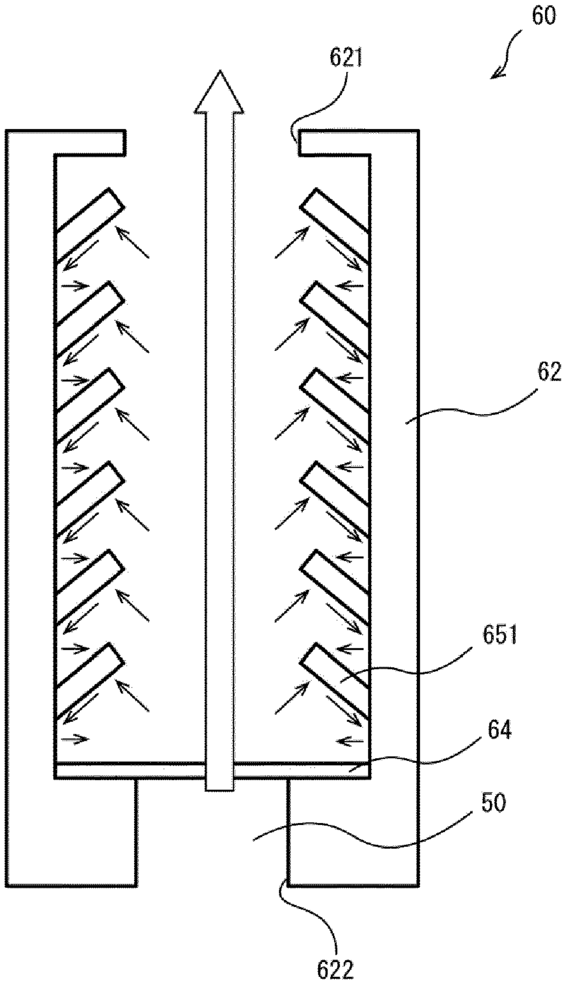


FIG. 10

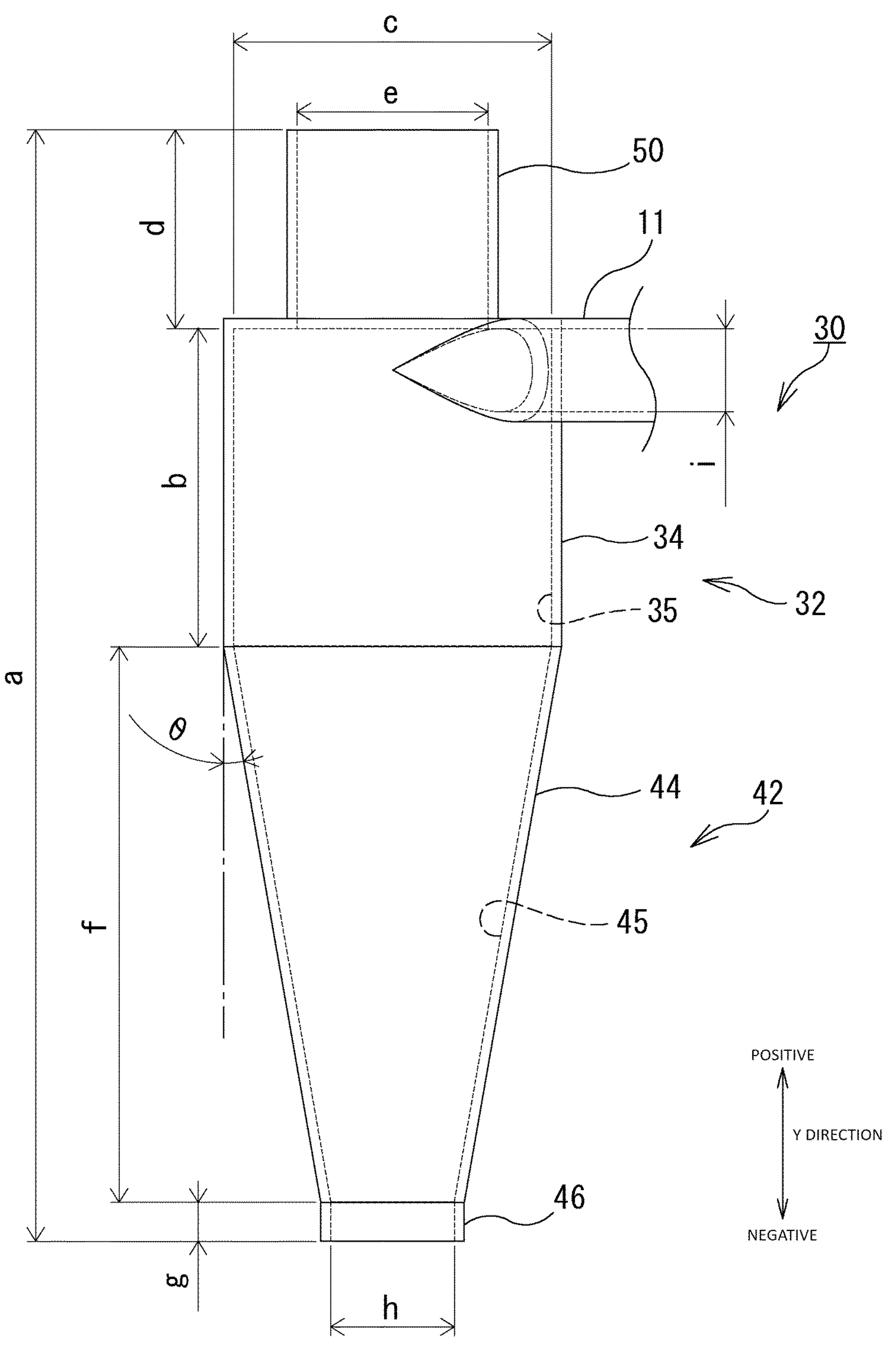

c
e
50
11
d
30
b
i
34
32
35
a
θ
44
42
45
f
POSITIVE
Y DIRECTION
NEGATIVE
46
g
h

FIG. 11

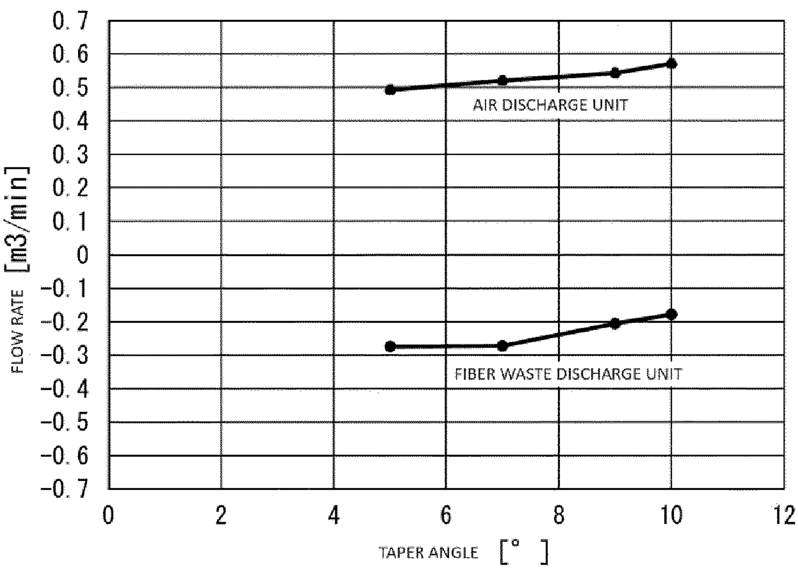

0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
FLOW RATE [m3/min]
AIR DISCHARGE UNIT
FIBER WASTE DISCHARGE UNIT
0
2
4
6
8
10
12
TAPER ANGLE [°]

FIG. 12

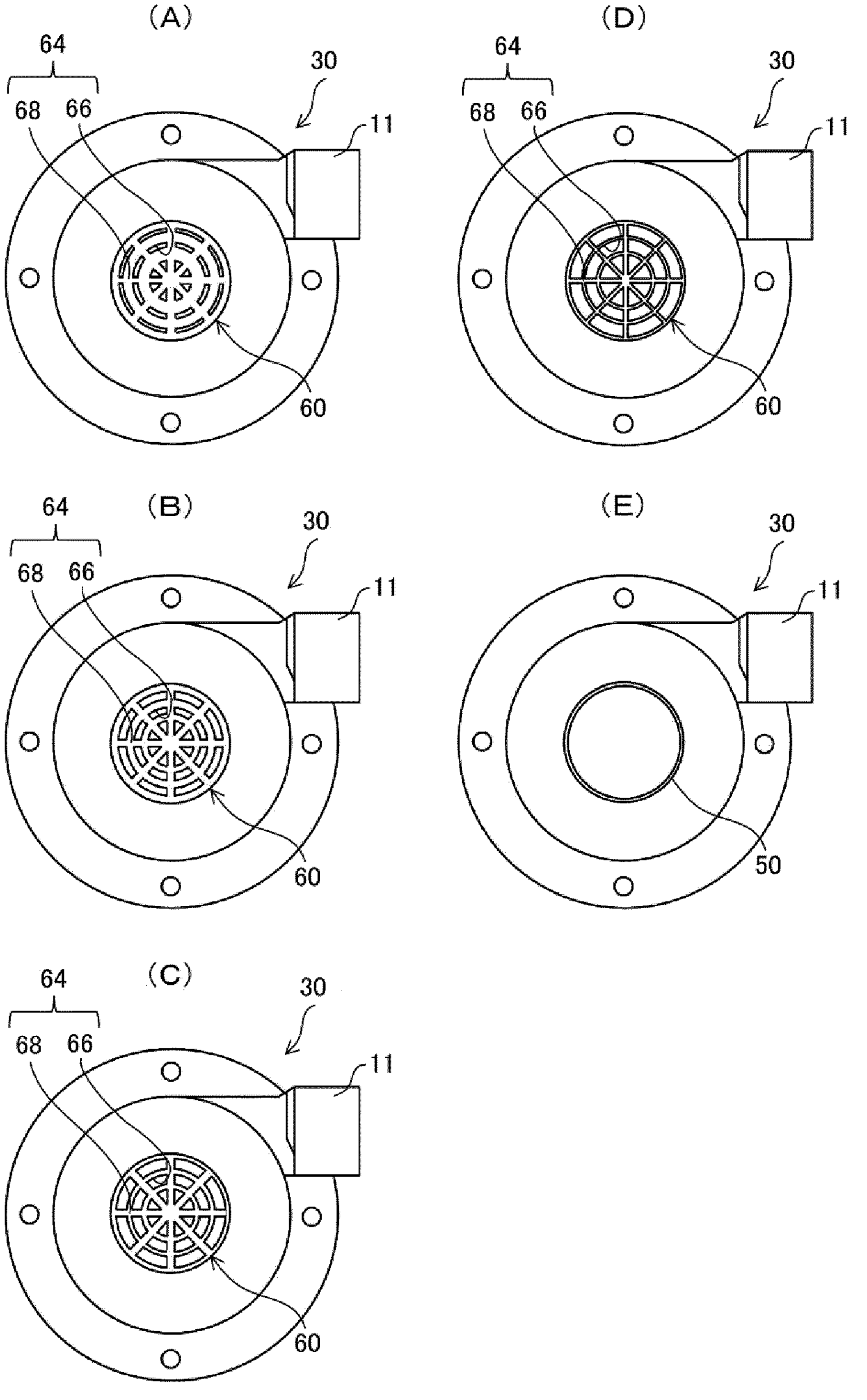

(A)
64
68
66
30
11
60
(D)
64
68
66
30
11
60
(B)
64
68
66
30
11
60
(E)
30
11
50
(C)
64
68
66
30
11
60

FIG. 13

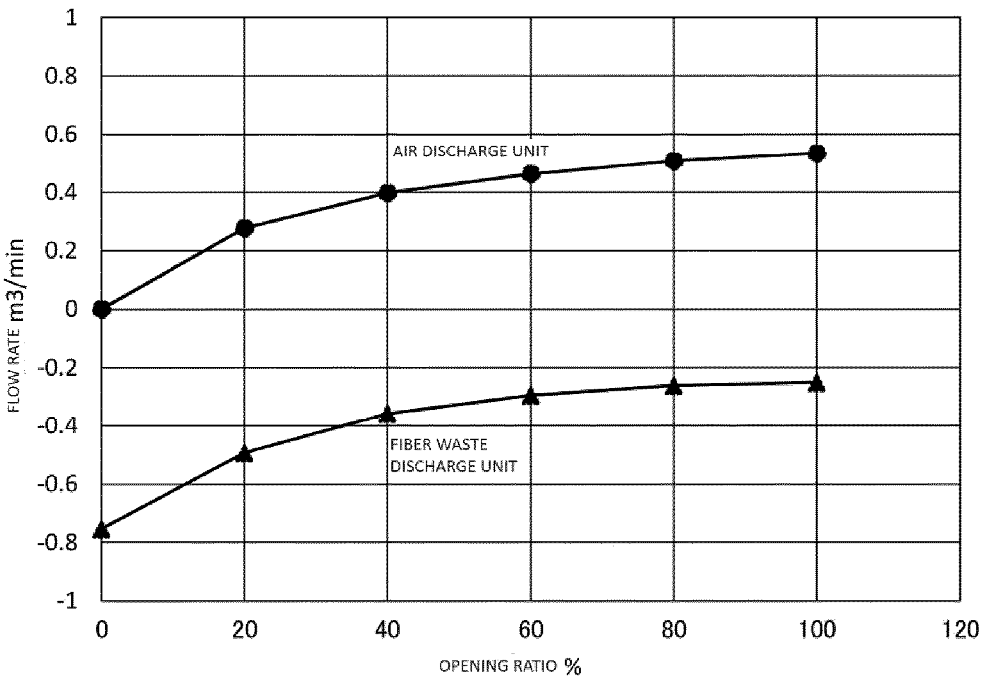

AIR DISCHARGE UNIT
FIBER WASTE DISCHARGE UNIT
FLOW RATE m3/min
OPENING RATIO %
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
20
40
60
80
100
120

FIG. 14

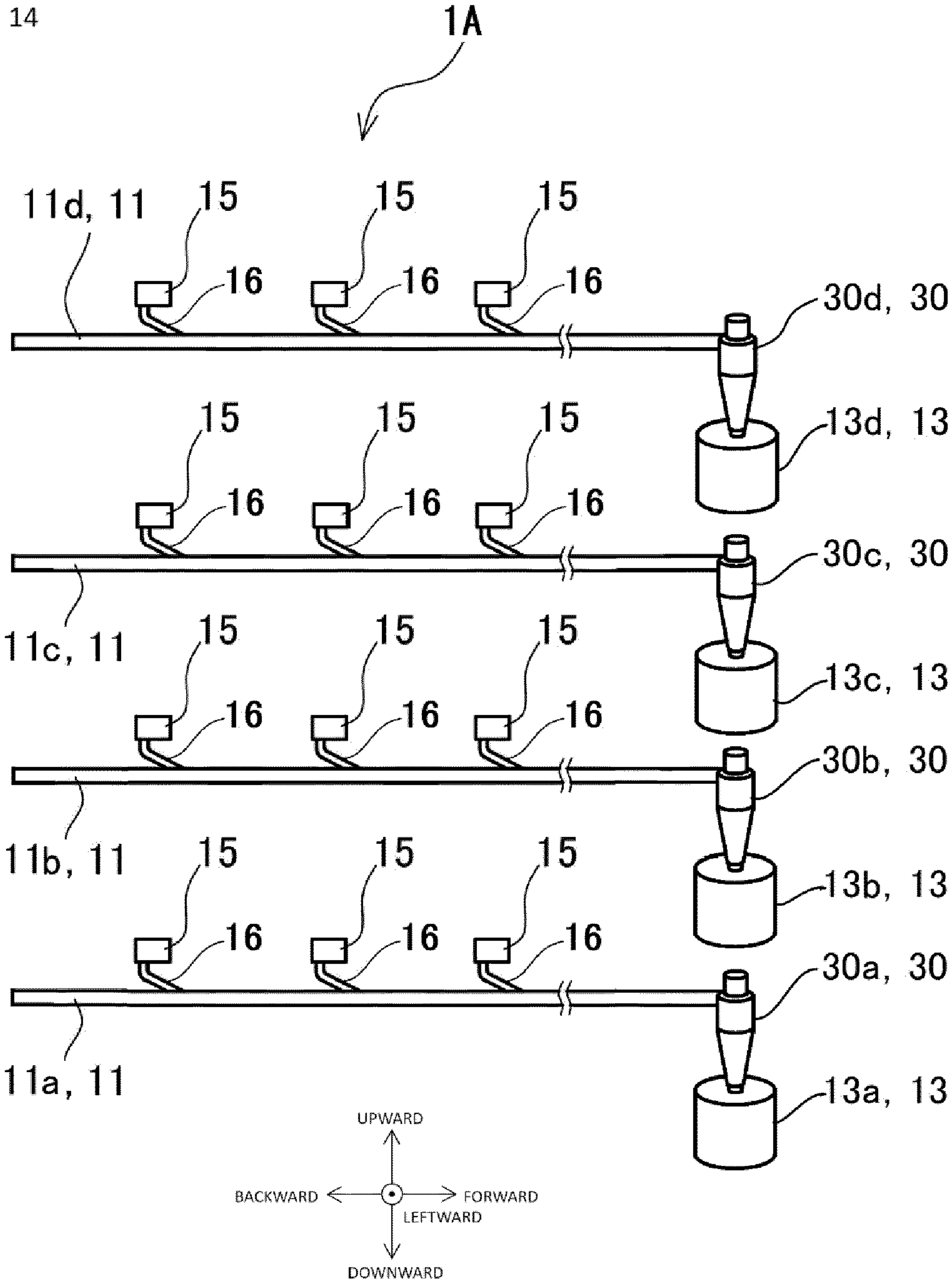

1A
11d, 11
15
16
30d, 30
13d, 13
30c, 30
11c, 11
13c, 13
30b, 30
11b, 11
13b, 13
30a, 30
11a, 11
13a, 13
UPWARD
BACKWARD
FORWARD
LEFTWARD
DOWNWARD

FIG. 15

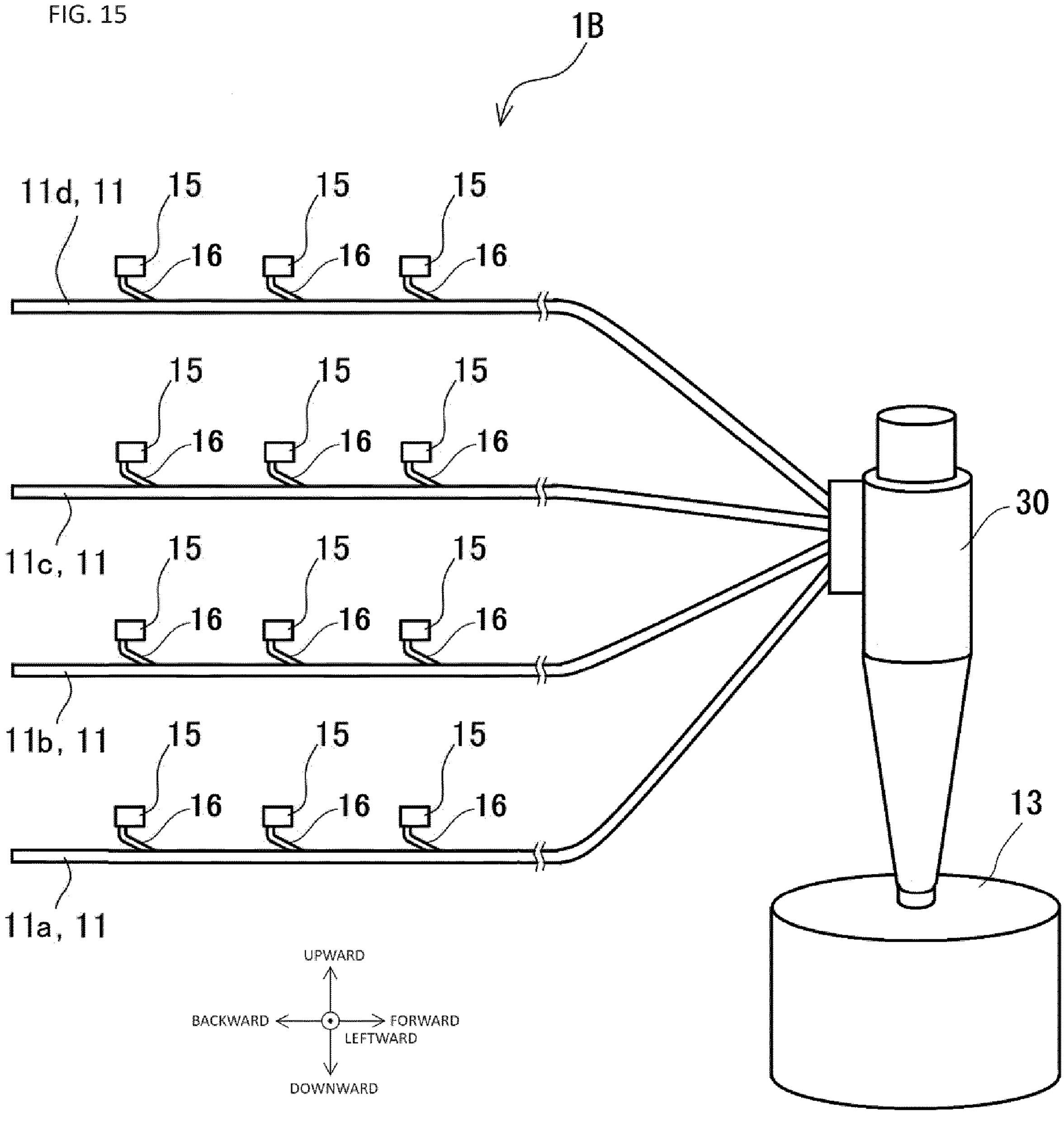

1B
11d, 11
15
16
15
16
15
16
15
16
15
16
15
16
11c, 11
15
16
15
16
15
16
11b, 11
15
16
15
16
15
16
11a, 11
30
13
UPWARD
BACKWARD
FORWARD
LEFTWARD
DOWNWARD

FIG. 16

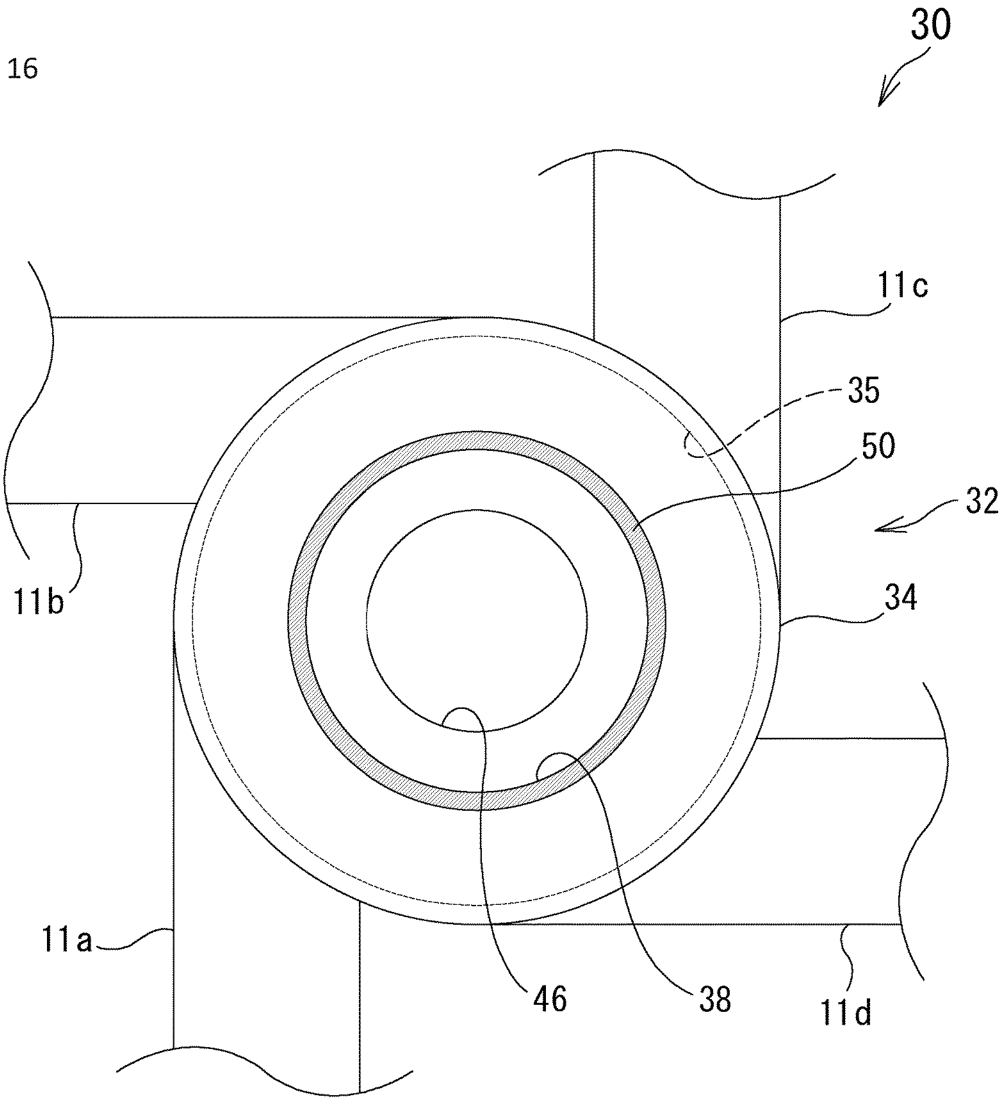


FIG. 17

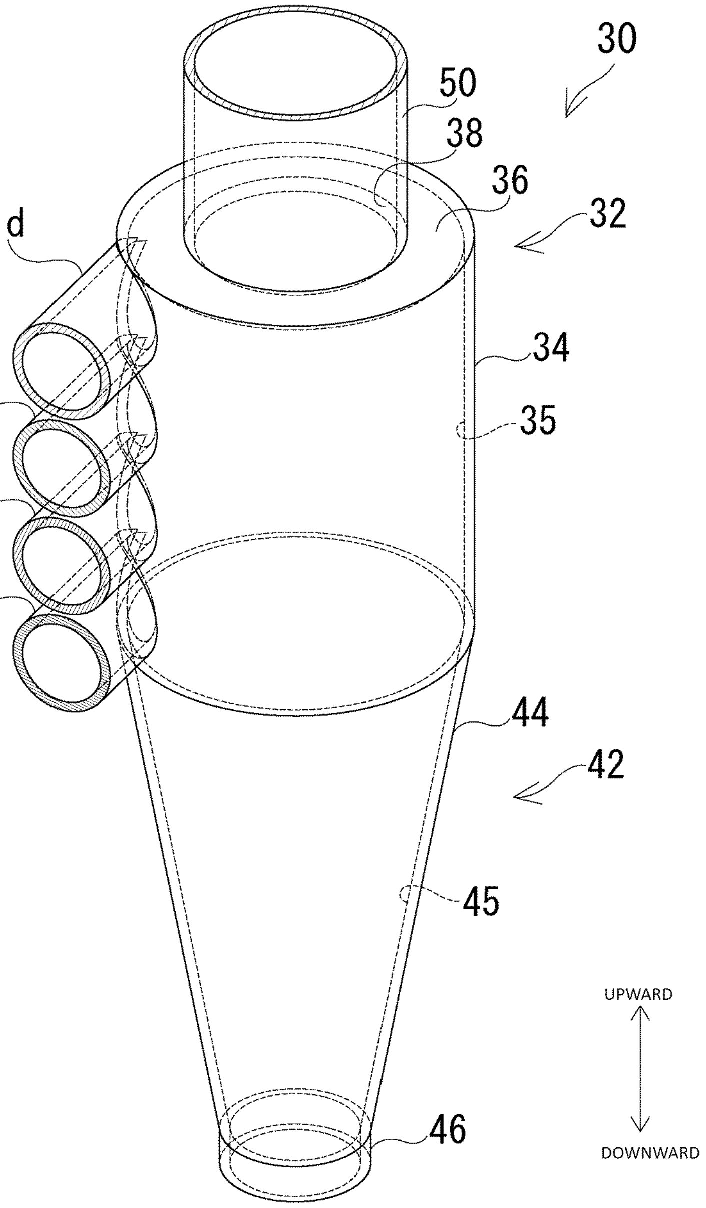


FIG. 18

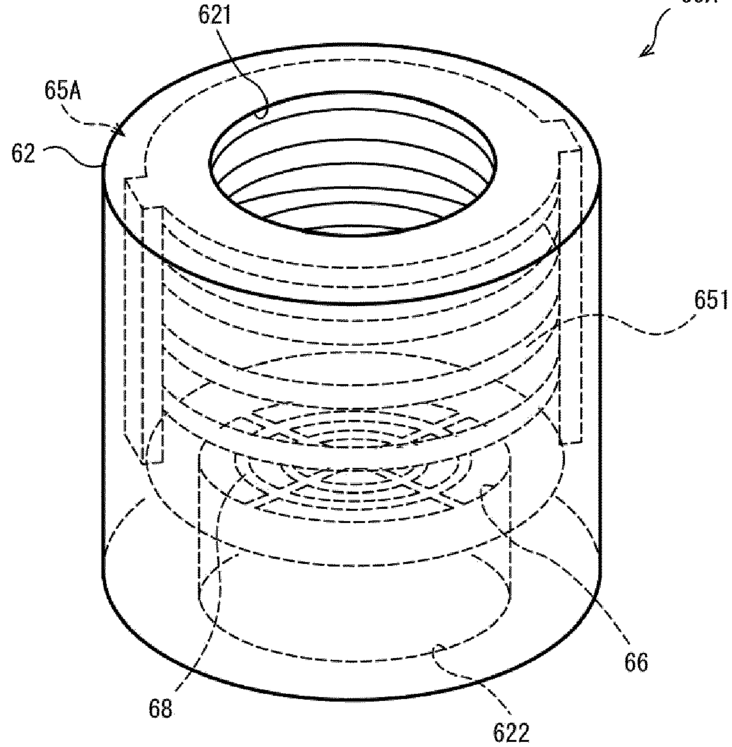


FIG. 19

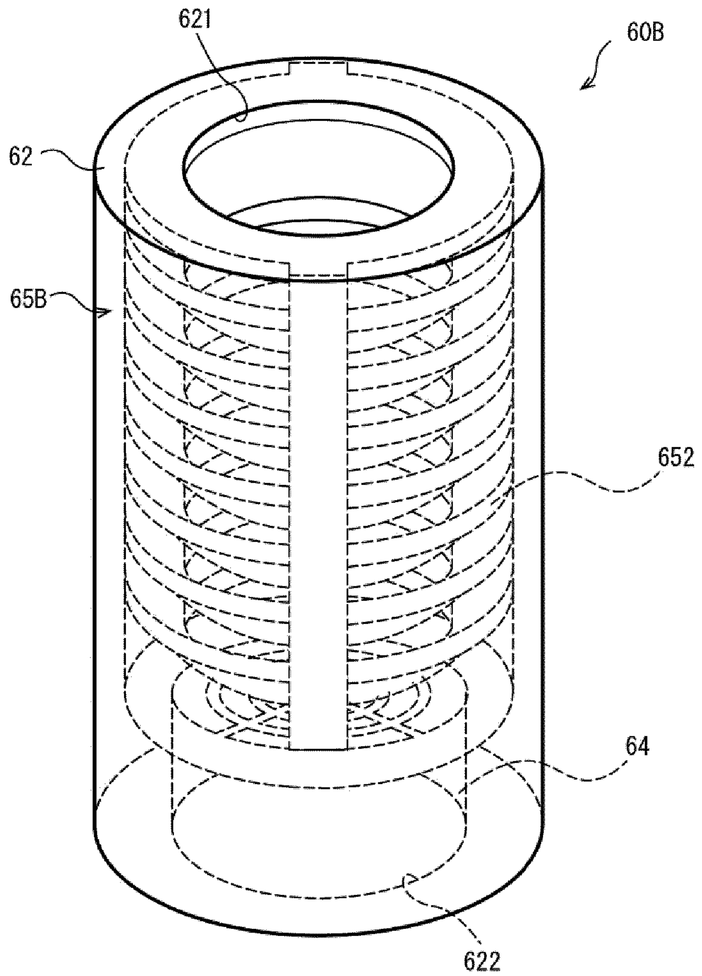


FIG. 20

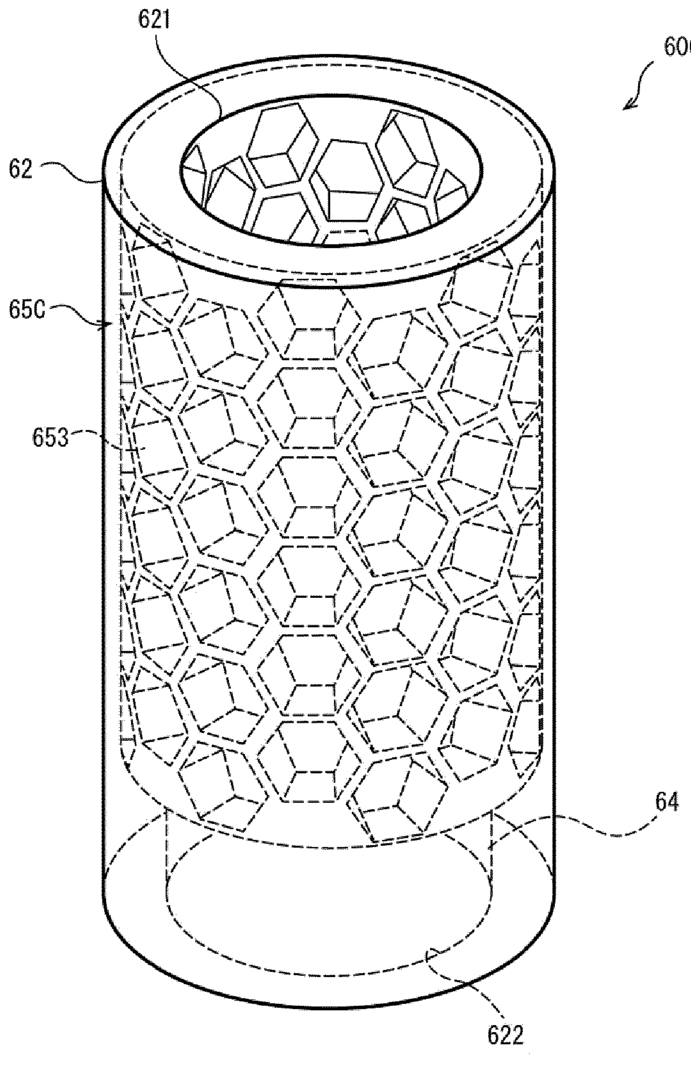


FIG. 21

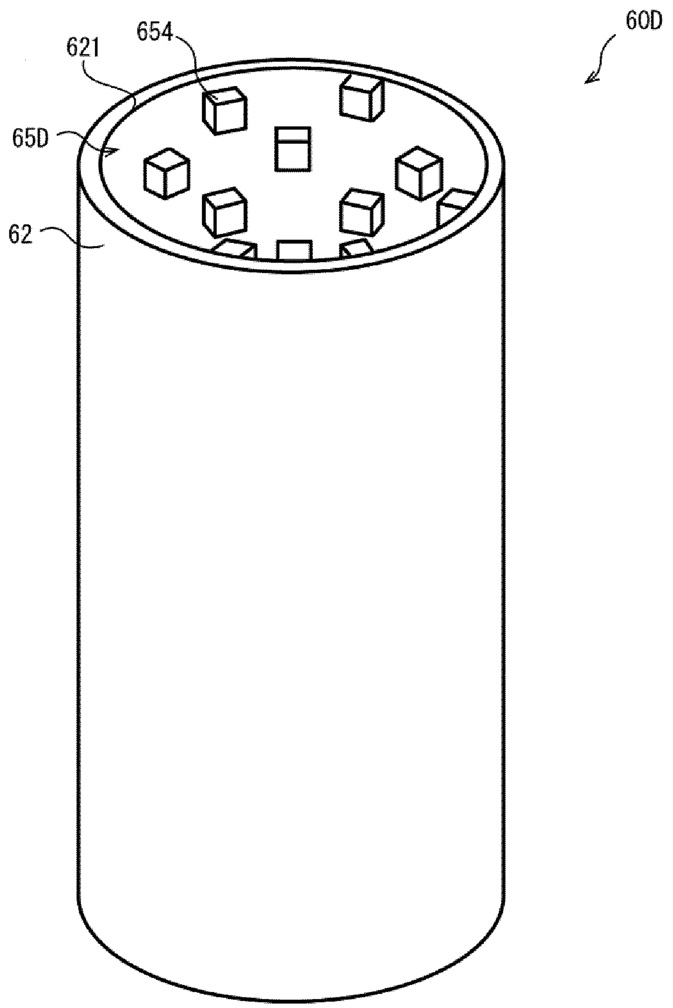
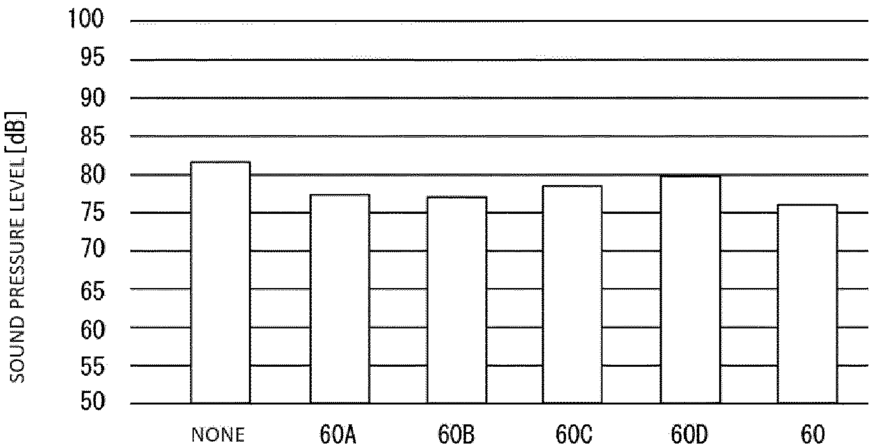


FIG. 22


100
95
90
85
80
75
70
65
60
55
50
SOUND PRESSURE LEVEL[dB]
NONE
60A
60B
60C
60D
60

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EUROPEAN SEARCH REPORT

Application Number
EP 24 21 0444

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Y	US 2006/037294 A1 (OH JANG-KEUN [KR] ET AL) 23 February 2006 (2006-02-23) * paragraph [0009] - paragraph [0014]; figures 1-7 * * paragraph [0025] - paragraph [0032] * * paragraph [0035] * -----	1-7,9,10	TECHNICAL FIELDS SEARCHED (IPC)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	28 February 2025	Wendl, Helen

1

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EP 24 21 0444

DOCUMENTS CONSIDERED TO BE RELEVANT

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			TECHNICAL FIELDS SEARCHED (IPC)

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	28 February 2025	Wendl, Helen

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		JP 2016533873 A	04-11-2016
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