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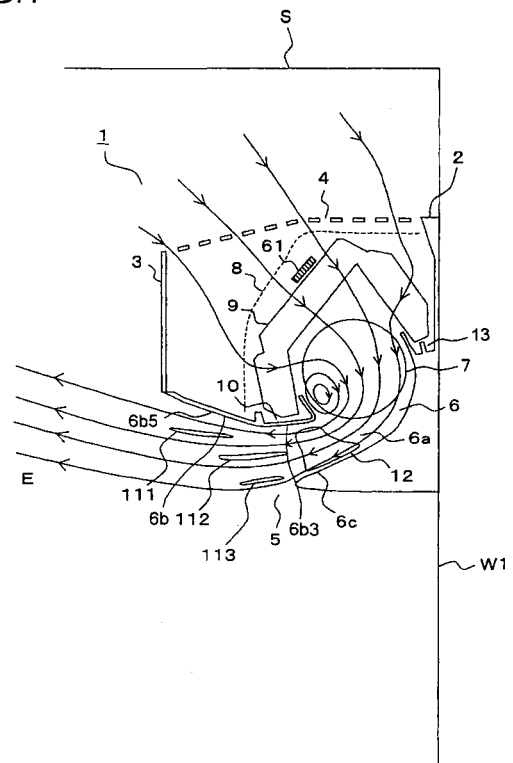
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(54) **AIR CONDITIONER**

(57) An air conditioner comprises an air intake port (4) for introducing the air in a room into the casing of an indoor unit (1), an air discharge port (5) formed at the lower part of the casing, an air flow path (6) for communicating the air intake port (4) with the air discharge port (5), an indoor heat exchanger (9) that has a refrigerant tube bent in a plurality of stages and rows and that is disposed curvedly along the inner surface of the casing so as to face the air intake port (4), and cross flow fan (7) disposed between the indoor heat exchanger (9) in the air flow path (6) and the air discharge port (5). The air flow path (6) includes a forward guide section (6a) which guides the air to the forward lower side and is gradually increased in its flow passage area toward the downstream side. The sum of the lengths of the upper wall (6b) and the lower wall (6c) of the air flow path (6) closer to the downstream side than the cross flow fan (7) is set to 3.5 times the diameter of the cross flow fan (7) or more.

FIG.1



Description

Technical Field

[0001] The present invention relates to an air conditioner for conditioning air taken in from inside a room and discharging the conditioned air into the room.

Background Art

[0002] Examples of conventional air conditioners are disclosed in Patent Documents 1 and 2 listed below. In the air conditioner disclosed in Patent Document 1, pressure loss of an air-blower fan is reduced by improving the thickness distribution in a blade of the air-blower fan, and this makes the air conditioner energy saving. The air conditioner disclosed in Patent Document 2 has a movable panel that closes the air intake port formed in the front face of the casing of the indoor unit. When the air conditioner is in operation, the movable panel is moved to open the air intake port wide to take in air from inside a room. Thereby, pressure loss occurring when air is taken in is reduced, and this makes the air conditioner energy saving.

Patent Document 1: JP-A-2003-028089

Patent Document 2: JP-A-2000-111082

Disclosure of the Invention

Problems to be Solved by the Invention

[0003] There has recently been a demand for preservation of the global environment, and further energy saving is strongly desired to be achieved in so-called white goods. With respect to the conventional air conditioners described above, however, there is an inconvenience that energy saving required of air conditioners cannot be achieved as much as desired for the following reason. That is, in the above described air conditioners, conditioned air rushes into the atmosphere inside a room from an air discharge port. At this time, suddenly coming out of a path enclosed by wall surfaces, kinetic energy of the conditioned air is lost into the ambient air due to the viscosity of air, and as a result, the static pressure of the conditioned air falls to be equal to the atmospheric pressure. This phenomenon instantly occurs the moment an air flow is discharged from the air discharge port, and this greatly disturbs the air flow in the vicinity of the air discharge port, which results in a pressure loss.

[0004] An object of the present invention is to provide an air conditioner with an enhanced energy-saving feature.

Means for Solving the Problem

[0005] To achieve the above object, according to one aspect of the present invention, an air conditioner includes: an air intake port through which air is taken in

from inside a room into a casing of an indoor unit; an air discharge port formed at a bottom of the casing; an air flow path through which the air intake port and the air discharge port communicate with each other; an indoor heat exchanger that has a refrigerant tube bent in a plurality of stages and rows and that is disposed in the air flow path so as to face the air intake port, the indoor heat exchanger being bent along an inner surface of the casing; and a cross flow fan that is disposed between the indoor heat exchanger and the air discharge port in the air flow path. Here, the air flow path has a forward guide section that guides air forward and downward and whose flow passage area is enlarged toward a downstream side, and a sum of lengths of an upper wall and a lower wall of the air flow path that extend on a downstream side of the cross flow fan is 3.5 times as great as a diameter of the cross flow fan or greater.

[0006] With this structure, when the cross flow fan is driven, air is taken in from inside the room through the air intake port into the casing to flow through the air flow path. The air exchanges heat with the indoor heat exchanger, and thereby the air is conditioned. The indoor heat exchanger is formed of a refrigerant tube that is bent to meander in a plurality of stages in the up/down direction and a plurality of rows in the depth direction, and causes a large pressure loss. The conditioned air flows from the air discharging side of the cross flow fan through the forward guide section, flowing along the upper and the lower walls of the air flow path, with the flow passage area increasing toward the downstream side, and is discharged from the air discharge port. At this time, portions of the air flow along the upper and the lower walls gradually slow down, and their kinetic energy is converted into and collected as static pressure.

[0007] According to the present invention, it is preferable that the air conditioner having the above structure be further provided with a first wind direction plate for changing up and down a wind direction in which air is discharged from the air discharge port. Here, a front edge of the upper wall, a front edge of the first wind direction plate, and a front edge of the lower wall are arranged in this order from upper front when the air conditioner is in operation. With this structure, collection of kinetic energy from an air flow flowing through the air flow path takes place in the order from a lower portion of the air flow path where the air flow flows at a low speed.

[0008] According to the present invention, it is preferable that the air conditioner having the above structure be further provided with a second wind direction plate. Here, the second wind direction plate is positioned below the first wind direction plate such that a front edge of the first wind direction plate is located before a front edge of the second wind direction plate.

[0009] According to the present invention, it is preferable that the air conditioner having the above described structure be further provided with a first and a second wind direction plate for changing up and down a wind direction in which air is discharged from the air discharge

port. Here, the upper wall includes: an upper surface of the forward guide section; a bent portion that is located at an end of the upper surface of the forward guide section; and a tilted surface that extends from the bent portion to be tilted forward and upward. The first wind direction plate is positioned such that a rear edge thereof is located before the bent portion, and the second wind direction plate is positioned below the first wind direction plate such that a rear edge thereof is located behind the bent portion.

[0010] With this structure, a portion of an air flow flowing through the air flow path, the portion flowing along the upper wall of the air flow path, is bent by the second wind direction plate, and flows forward and upward along the tilted surface. The kinetic energy of a lower portion of the portion of the air flow bent by the second wind direction plate is converted into and collected as static pressure through a flow path formed between the first and the second wind direction plates. The kinetic energy of an upper portion of the portion of the air flow bent by the second wind direction plate is converted into and collected as static pressure through a flow path formed between the first wind direction plate and the tilted surface.

[0011] According to the present invention, it is preferable that, in the air conditioner having the above described structure, an angle formed by the tilted surface and the first wind direction plate and an angle formed by the first and the second wind direction plates be between 10° and 15° . With this structure, an air flow flows smoothly along the wall surface of the first and the second wind direction plates and the tilted surface of the air flow path without separating therefrom.

[0012] According to the present invention, it is preferable that the air conditioner having the above described structure be further provided with a third wind direction plate. Here, the third wind direction plate is positioned below the second wind direction plate, and an angle formed by the second and the third wind direction plates is between 10° and 15° . With this structure, an air flow flows smoothly along the wall surfaces of the second and the third wind direction plates without separating therefrom.

[0013] According to the present invention, it is preferable that, in the air conditioner having the above described structure, an angle formed by a wind direction plate positioned lowest and a line tangent to the lower wall at an end thereof is between 10° and 15° . With this structure, an air flow flows smoothly along the wall surface of the wind direction plate positioned lowest without separating therefrom.

[0014] According to the present invention, it is preferable that the upper wall be 1.5 times as long as the diameter of the cross flow fan or longer.

[0015] According to another aspect of the present invention, an air conditioner includes: an air intake port through which air is taken in from inside a room into a casing of an indoor unit; an air discharge port formed at a bottom of the casing; an air flow path through which

the air intake port and the air discharge port communicate with each other; an indoor heat exchanger that has a refrigerant tube bent in a plurality of stages and rows and that is disposed in the air flow path so as to face the air intake port, the indoor heat exchanger being bent along an inner surface of the casing; a cross flow fan that is disposed between the indoor heat exchanger and the air discharge port in the air flow path; and a first and a second wind direction plate for changing up and down a wind direction in which air is discharged from the air discharge port. Here, the air flow path has a forward guide section that guides air from the cross flow fan forward and downward, and whose flow passage area is enlarged toward a downstream side. An upper wall of the air flow path, the upper wall extending on a downstream side of the cross flow fan, is 1.5 times as long as a diameter of the cross flow fan or longer. The upper wall includes: an upper surface of the forward guide section; a bent portion that is located at an end of the upper surface of the forward guide section; and a tilted surface that extends from the bent portion to be tilted forward and upward. The first wind direction plate is positioned such that a rear edge thereof is located before the bent portion, and the second wind direction plate is positioned below the first wind direction plate such that a rear edge of the second wind direction plate is located behind the bent portion.

[0016] With this structure, when the cross flow fan is driven, air is taken in from inside the room through the air intake port into the casing to flow through the air flow path. The air exchanges heat with the indoor heat exchanger to be conditioned; the indoor heat exchanger is formed of a refrigerant tube that is bent to meander in a plurality of stages in the up/down direction and a plurality of rows in the depth direction, and causes a large pressure loss. The conditioned air flows as an air flow from the air discharging side of the cross flow fan through the forward guide section, flowing along the upper and the lower walls of the air flow path with the flow passage area increasing toward the downstream side. A portion of the air flow flowing through the air flow path, the portion flowing along the upper wall of the air flow path, is bent by a second wind direction plate to flow forward and upward along the tilted surface. A lower portion of the portion of the air flow bent by the second wind direction plate is gradually slowed down and its kinetic energy is converted into and collected as static pressure through a flow path formed between the first and the second wind direction plates. An upper portion of the portion of the air flow bent by the second wind direction plate is gradually slowed down, and its kinetic energy is converted into and collected as static pressure through a flow path formed between the first wind direction plate and the tilted surface.

[0017] According to the present invention, it is preferable that, in the air conditioner having the above described structure, an angle formed by the tilted surface and the first wind direction plate and an angle formed by the first and the second wind direction plates be between 10° and 15° .

[0018] According to the present invention, it is preferable that the air conditioner having the above described structure be further provided with a third wind direction plate. Here, the third wind direction plate is positioned below the second wind direction plate, and an angle formed by the second and the third wind direction plates is between 10 ° and 15 °.

[0019] According to the present invention, it is preferable that, in the air conditioner having the above described structure, an angle formed by a wind direction plate that is positioned lowest and a line tangent to the lower wall at an end thereof be between 10 ° and 15 °.

[0020] According to the present invention, it is preferable that, in the air conditioner having the above described structure, a front edge of the upper wall, a front edge of the first wind direction plate, a front edge of the second wind direction plate, and a front edge of the lower wall be arranged in this order from upper front when the air conditioner is in operation. With this structure, collection of kinetic energy from an air flow flowing through the air flow path takes place in the order from a lower portion of the air flow path where the air flow flows at a low speed.

[0021] According to another aspect of the present invention, an air conditioner includes: an air intake port through which air is taken in from inside a room into a casing of an indoor unit; an air discharge port formed at a bottom of the casing; an air flow path through which the air intake port and the air discharge port communicate with each other; an indoor heat exchanger that is disposed in the air flow path so as to face the air intake port; and a cross flow fan that is disposed between the indoor heat exchanger and the air discharge port in the air flow path. Here, an upper wall of the air flow path, the upper wall extending on a downstream side of the cross flow fan, is 1.5 times as long as a diameter of the cross flow fan or longer.

[0022] With this structure, when the cross flow fan is driven, air is taken in from inside the room through the air intake port into the casing to flow through the air flow path. The air exchanges heat with the indoor heat exchanger to be conditioned. The conditioned air flows as an air flow from the air discharging side of the cross flow fan along the upper wall and the lower wall of the air flow path to be discharged from the air discharge port. At this time, portions of the air flow flowing along the air flow path, the portions flowing along the upper and the lower walls of the air flow path, gradually slow down, and their kinetic energy is converted into and collected as static pressure.

[0023] According to another aspect of the present invention, an air conditioner includes: an air intake port through which air is taken in from inside a room into a casing of an indoor unit; an air discharge port formed at a bottom of the casing; an air flow path through which the air intake port and the air discharge port communicate with each other; an indoor heat exchanger that is disposed in the air flow path so as to face the air intake port; and a cross flow fan that is disposed between the indoor

heat exchanger and the air discharge port in the air flow path. Here, a sum of lengths of an upper wall and a lower wall of the air flow path that extend on a downstream side of the cross flow fan is 3.5 times as great as a diameter of the cross flow fan or greater.

[0024] With this structure, when the cross flow fan is driven, air is taken in from the room through the air intake port into the casing to flow through the air flow path. The air exchanges heat with the indoor heat exchanger to be conditioned. The conditioned air flows as an air flow from the air discharging side of the cross flow fan along the upper wall and the lower wall of the air flow path to be discharged from the air discharge port. At this time, portions of the air flow flowing through the air flow path, the portions flowing along the upper and the lower wall, gradually slow down, and their kinetic energy is converted into and collected as static pressure.

Advantages of the Invention

[0025] According to the present invention, the sum of the lengths of the upper wall and the lower wall of the air flow path that extend on the downstream side of the cross flow fan is 3.5 times as great as the diameter of the cross flow fan or greater. This allows air to smoothly flow a long distance along the upper and the lower walls of the air flow path when the air conditioner is in operation. This helps reduce air flow disturbance occurring in the vicinity of the air discharge port, and thus the pressure loss caused thereby is reduced. In addition, the speeds of the portions of the air flow flowing along the lower wall and the upper wall which is long are reduced to be low enough, and the kinetic energy of the portions is converted into static pressure. As a result, an ample amount of kinetic energy can be collected from the air flow, and an amount of static pressure rise the cross flow fan is required to produce can be reduced. Thus, an energy-saving air conditioner can be realized.

[0026] Even in the case where an indoor heat exchanger has a refrigerant tube bent in a plurality of stages and rows and causing a large pressure loss is used, a sufficient amount of kinetic energy is collected from an air flow, and thus an energy-saving air conditioner can be realized. In addition, the provision of the forward guide section that guides air forward and downward and whose flow passage area is enlarged toward the downstream side makes it possible to gradually reduce the speed of an air flow, and thus to collect sufficient amount of kinetic energy.

[0027] According to the present invention, the front edge of the upper wall, the front edge of the first wind direction plate, and the front edge of the lower wall are arranged in this order from upper front when the air conditioner is in operation. This allows efficient collection of kinetic energy in which kinetic energy is collected from an air flow in the order from low-density kinetic energy of an air flow flowing at a low speed through a lower portion of the air flow path.

[0028] According to the present invention, the second wind direction plate is positioned below the first wind direction plate such that the front edge thereof is before the front edge of the second wind direction plate. This allows efficient collection of kinetic energy in which kinetic energy is collected from an air flow in the order from low-density kinetic energy of an air flow flowing at a low speed through a lower portion of the air flow path.

[0029] According to the present invention, the first wind direction plate is positioned such that the rear edge thereof is before the bent portion, which is located between the upper surface of the forward guide section and the tilted surface, and the second wind direction plate is positioned such that the rear edge thereof is behind the bent portion. This allows the second wind direction plate to bend an air flow to make it flow along the tilted surface. In addition, this allows efficient collection of kinetic energy in which kinetic energy is collected from an air flow in the order from low-density kinetic energy of an air flow flowing at a low speed through a lower portion of the air flow path.

[0030] According to the present invention, since the angle formed by the tilted surface and the first wind direction plate and the angle formed by the first and the second wind direction plates are between 10° and 15° , the flow path between the tilted surface and the first wind direction plate and the flow path between the first and the second wind direction plates are continuously enlarged, and this allows an air flow to smoothly flow along the wall surfaces without separating therefrom. This makes it possible to smoothly convert the kinetic energy of the air flow into static pressure, and thus to efficiently collect kinetic energy.

[0031] According to the present invention, since the angle formed by the second wind direction plate and the third wind direction plate below the second wind direction plate is between 10° and 15° , the flow path between the second and third wind direction plates is continuously enlarged, and this allows an air flow to smoothly flow along the wall surfaces without separating therefrom. This makes it possible to smoothly convert the kinetic energy of the air flow into static pressure, and thus to efficiently collect kinetic energy.

[0032] According to the present invention, since the angle formed by the wind direction plate that is positioned lowest and the line tangent to the lower wall at the end thereof is between 10° and 15° , the flow path between the lowermost wind direction plate and the lower wall of the air flow path is continuously enlarged, and this allows an air flow to smoothly flow along the wall surfaces without separating therefrom. This makes it possible to smoothly convert the kinetic energy of the air flow into static pressure, and thus to efficiently collect kinetic energy.

[0033] According to the present invention, since the upper wall of the air flow path, the upper wall extending on the downstream side of the cross flow fan, is 1.5 times as long as the diameter of the cross flow fan or longer, air smoothly flows a long distance along the upper and

the lower walls of the air flow path when the air conditioner is in operation. This helps reduce air flow disturbance occurring in the vicinity of the air discharge port, and accordingly the pressure loss caused thereby is reduced. In addition, the speeds of air flows flowing along the long upper wall and the lower wall are reduced to be low enough, and the kinetic energy of the air flows is converted into static pressure. As a result, an ample amount of kinetic energy can be collected from an air flow, and an amount of static pressure rise the cross flow fan is required to produce can be reduced. Thus, an energy-saving air conditioner can be realized.

[0034] It is also possible to increase the distance an air flow can travel after its kinetic energy has been collected and its flowing speed has been reduced. As a result, air discharged from the air discharge port reaches the ceiling of a room, the surface of a wall facing the indoor unit of the air conditioner, the floor, and the surface of a wall on which the indoor unit of the air conditioner is mounted, in this order. Thus, the conditioned air reaches every corner of the room, and greatly circulates inside the room. As a result, a comfortable living space can be realized in the room where the temperature distribution is uniform except in the upper portion thereof and hardly any wind blows directly on the user.

[0035] Even in the case where an indoor heat exchanger bent in a plurality of stages and rows and causing a large pressure loss is used, an ample amount of kinetic energy is collected from an air flow, and thus an energy-saving air conditioner can be realized. In addition, the provision of the forward guide section that guides air forward and downward and whose flow passage area is enlarged toward the downstream side makes it possible to gradually reduce the speed of an air flow, and thus to collect an ample amount of kinetic energy.

[0036] Furthermore, the first wind direction plate is positioned such that the rear edge thereof is located before the bent portion, which is located between the upper surface of the forward guide section and the tilted surface, and the second wind direction plate is positioned such that the rear edge thereof is located behind the bent portion. This allows the second wind direction plate to bend an air flow to make it flow along the tilted surface. In addition, efficient collection of kinetic energy can be performed by collecting in the order from low-density kinetic energy of a portion of the air flow flowing at a low speed through a lower portion of the air flow path.

[0037] According to the present invention, the front edge of the upper wall, the front edge of the first wind direction plate, the front edge of the second wind direction plate, and the front edge of the lower wall are arranged in this order from upper front when the air conditioner is in operation. As a result, efficient collection of kinetic energy can be performed by collecting in the order from low-density kinetic energy of a portion of the air flow flowing at a low speed through a lower portion of the air flow path.

Brief Description of Drawings

[0038]

[Fig. 1] is a side sectional view showing a state of an indoor unit of an air conditioner according to a first embodiment of the present invention when the air conditioner is in operation;

[Fig. 2] is a side sectional view showing in detail an air flow path in the indoor unit of the air conditioner according to the first embodiment of the present invention;

[Fig. 3] is a side sectional view showing in detail a bent portion of the air flow path in the indoor unit of the air conditioner according to the first embodiment of the present invention;

[Fig. 4] is a side sectional view showing the state of the indoor unit of the air conditioner according to the first embodiment of the present invention when the air conditioner is not in operation;

[Fig. 5] is a side sectional view showing in detail the vicinity of an air discharge port in the indoor unit of the air conditioner according to the first embodiment of the present invention;

[Fig. 6] is a diagram showing the relationship between the air flow rate of a cross flow fan and the input of a fan driving motor in the indoor unit of the air conditioner according to the first embodiment of the present invention;

[Fig. 7] is a side sectional view showing a comparative example of the indoor unit of the air conditioner according to the first embodiment of the present invention;

[Fig. 8] is a diagram for illustrating how static pressure changes in the comparative example of the indoor unit of the air conditioner according to the first embodiment of the present invention;

[Fig. 9] is a diagram showing how the state of static pressure changes in the comparative example of the indoor unit of the air conditioner according to the first embodiment of the present invention;

[Fig. 10] is a diagram for illustrating how static pressure changes in the indoor unit of the air conditioner according to the first embodiment of the present invention;

[Fig. 11] is a diagram showing how static pressure changes in the indoor unit of the air conditioner according to the first embodiment of the present invention;

[Fig. 12] is a diagram showing a relationship among the lengths of an upper and a lower wall of the air flow path and power consumption of the cross flow fan in the indoor unit of the air conditioner according to the first embodiment of the present invention;

[Fig. 13] is a diagram showing a relationship among the distance an air flow discharged from the cross flow fan travels and the lengths of the upper and lower walls of the air flow path in the indoor unit of

the air conditioner according to the first embodiment of the present invention;

[Fig. 14] is a side sectional view showing a state of the indoor unit of an air conditioner according to a second embodiment of the present invention when the air conditioner is not in operation;

[Fig. 15] is a side sectional view showing a state of the indoor unit of the air conditioner according to the second embodiment of the present invention when the air conditioner is in operation;

[Fig. 16] is a side sectional view showing a state of the indoor unit of an air conditioner according to a third embodiment of the present invention when the air conditioner is not in operation;

[Fig. 17] is a side sectional view showing a state of the indoor unit of the air conditioner according to the third embodiment of the present invention when the air conditioner is in operation;

[Fig. 18] is a side sectional view showing a state of an indoor unit of an air conditioner according to a fourth embodiment of the present invention when the air conditioner is in operation; and

[Fig. 19] is a side sectional view showing a state of an indoor unit of an air conditioner according to a fifth embodiment of the present invention when the air conditioner is in operation.

List of Reference Symbols

[0039]

1	indoor unit
2	cabinet
3	front panel
4	air intake port
5	air discharge port
6	air flow path
6a	forward guide section
6b	upper wall
6b5	tilted surface
6c	lower wall
7	cross flow fan
8	air filter
9	indoor heat exchanger
10, 13	drain pans
111, 112, 113	horizontal louvers
12	vertical louver
21	movable panel
22, 23	pivot shafts
61	thermal sensor

Best Mode for Carrying Out the Invention

<First Embodiment>

[0040] Embodiments of the present invention will hereinafter be described with reference to the accompanying drawings. Fig. 1 is a side sectional view showing an in-

door unit of an air conditioner according to a first embodiment of the present invention. In the indoor unit 1 of the air conditioner, a main body is supported by a cabinet 2, a front panel 3 is detachably attached to the cabinet 2, and the cabinet 2 and the front panel 3 form the casing of the indoor unit 1.

[0041] A claw (not shown) is formed on the rear face of the cabinet 2, and the cabinet 2 is supported by engaging the claw with an attachment panel (not shown) that is fitted to a side wall W 1 of a room. In a gap between the lower edge of the front panel 3 and the lower edge of the cabinet 2, there is formed an air discharge port 5. The air discharge port 5 is formed in a substantially rectangular shape that extends in the width direction of the indoor unit 1, and faces forward and downward. In the top surface of the front panel 3, an air intake port 4 is formed in a grid shape.

[0042] Inside the casing of the indoor unit 1, there is formed an air flow path 6 through which the air intake port 4 and the air discharge port 5 communicate with each other. In the air flow path 6, there is disposed a cross flow fan 7 that discharges air. The air flow path 6 is enclosed by an upper wall 6b and a lower wall 6c on the downstream side of the cross flow fan 7. The air flow path 6 also has a forward guide section 6a for guiding air discharged from the cross flow fan 7 forward and downward. The forward guide section 6a is formed such that the flow passage area is enlarged toward the downstream.

[0043] Fig. 2 is a side sectional view showing in detail a portion of the air cross flow 6 on the downstream side of the cross flow fan 7. The upper wall 6b of the air flow path 6 has a stabilizer section 6b7 formed to extend along the periphery of the cross flow fan 7. The stabilizer section 6b7 is formed such that it extends in the air discharging direction of the cross flow fan 7, and is continuous at the lower end thereof with an upper surface 6b3 of the forward guide section 6a.

[0044] The upper surface 6b3 of the forward guide section 6a is tilted forward and downward. The upper surface 6b3 of the forward guide section 6a continues, at its end, via a bent portion 6b4, to a tilted surface 6b5 that is tilted forward and upward. The bent portion 6b4 is formed as a smooth gently-curved surface.

[0045] The lower wall 6c of the air flow path 6 has a rear guider section 6c5 that extends along the periphery of the cross flow fan 7. The rear guider section 6c5 is formed to extend in the air discharging direction of the cross flow fan 7, and the lower wall 6c is formed as a spirally curved surface that extends from the lower end of the rear guider section 6c5 and includes the lower surface 6c3 of the forward guide section 6a.

[0046] An angle α formed by the upper surface 6b3 and the lower surface 6c3 of the forward guide section 6a is approximately 20° . An angle β formed by the tilted surface 6b5 and a horizontal plane is approximately 20° . An angle γ formed by the upper surface 6b3 of the forward guide section 6a and a horizontal plane is 5° . Thus, an

angle $(\beta + \gamma)$ formed by the upper surface 6b3 of the forward guide section 6a and the tilted surface 6b5 is 25° . It is preferable that the angles α , β , and γ be formed to be approximately between 15° and 20° , 30° or less, and approximately between 0° and 10° , respectively.

[0047] If the angle $(\beta + \gamma)$ is 17° or less, air flowing along a surface of a flow path is allowed to smoothly flow without separating therefrom and with a small pressure loss. As will be described later, however, a plurality of flow paths are formed by horizontal louvers 111, 112, and 113, and hence the angle $(\beta + \gamma)$ is larger than 17° . To deal with this, the horizontal louver 112, which is a middle horizontal louver, is positioned to face the bent portion 6b4, and thereby separation of air flow is prevented.

[0048] As shown in Fig. 3, the bent portion 6b4 may have at least one flat surface 6f whose two ends each continue to a curved surface 6e. In this case, an angle $\theta 5$ formed by the upper surface 6b3 of the forward guide section 6a and the flat surface 6f and an angle $\theta 6$ formed by the flat surface 6f and the tilted surface 6b5 are 17° or less. In the case where a plurality of flat surfaces 6f are formed, an angle formed by any two adjacent flat surfaces 6f is 17° or less. This allows air flowing along the wall surfaces of the flow path to flow without separating therefrom and with a small pressure loss. This helps achieve an improved energy-saving feature.

[0049] The upper wall 6b and the lower wall 6c of the air flow path 6 on the downstream side of the cross flow fan 7 are formed to be 1.9D long and 2.1D long, respectively, the reference symbol "D" denoting the diameter of the cross flow fan 7. Edges 6b1 and 6c1 of the stabilizer section 6b7 and the rear guider section 6c5, respectively, are located substantially along the direction of a diameter of the cross flow fan 7 that is perpendicular to the air discharging direction thereof. From the edges 6b1 and 6c1, the upper wall 6b and the lower wall 6c start to extend, respectively. In the case where the stabilizer section 6b7 and the rear guider section 6c5 are formed to extend as far as to the air intake side of the cross flow fan 7, the upper wall 6b and the lower wall 6c may start to extend at a portion of a front gap 6b2 and at a portion of a rear gap 6c2 at which the front gap 6b2 between the stabilizer section 6b7 and the cross flow fan 7 and the rear gap 6c2 between the rear guider section 6c5 and the cross flow fan 7 are narrowest, respectively.

[0050] The front edge of the tilted surface 6b5 is in contact with the bottom edge of the front panel 3 to form an end 6b6 of the upper wall 6b. A bottom front end of the cabinet 2 is formed with a small radius of curvature, with a point of inflection at an end 6c4 of the lower surface 6c3 of the forward guide section 6a. The lower wall 6c also ends at the end 6c4 (hereinafter, "6c4" may denote the end of the lower wall 6c). The reference numeral 98 denotes a line tangent to the forward guide section 6a at the end 6c4 thereof.

[0051] In Fig. 1, the forward guide section 6a is provided with a vertical louver 12 that is capable of changing

the angle at which air is discharged in the right/left direction. At the air discharge port are provided a plurality of horizontal louvers 111, 112, and 113 that are capable of changing the angle at which air is discharged in the up/down direction such that air is discharged in a forward and upward direction, in the horizontal direction, in a forward and downward direction, and in the direct downward direction. An air filter 8 is provided so as to face the front panel 3 for the purpose of collecting and removing dust in air taken in through the air intake port 4. In a space formed between the front panel 3 and the air filter 8, there is provided an air filter cleaner (not shown). The air filter cleaner removes dust accumulated on the air filter 8.

[0052] An indoor heat exchanger 9 is disposed between the cross flow fan 7 and the air filter 8 in the air flow path 6. The indoor heat exchanger 9 has a refrigerant tube (not shown) that is bent to meander in a plurality of stages in the up/down direction and a plurality of rows in the depth direction, and the indoor heat exchanger 9 is bent into a plurality of portions along the front panel 3. The indoor heat exchanger 9 is connected to a compressor (not shown) placed outdoors, and a refrigeration cycle is operated by driving the compressor. In a cooling operation, the indoor heat exchanger 9 is cooled down to a temperature lower than the ambient temperature by the operation of the refrigeration cycle, while the indoor heat exchanger 9 is heated up to a temperature higher than the ambient temperature in a heating operation.

[0053] Between the indoor heat exchanger 9 and the air filter 8 are provided an electric dust collector (not shown) and a thermal sensor 61 for detecting the temperature of air that has been taken in. At a side portion of the indoor unit 1 is provided a control section (not shown) for controlling the driving of the air conditioner. At the rear bottom and the front bottom of the indoor heat exchanger 9 are provided drain pans 10 and 13, respectively, in which is collected condensation dripping from the indoor heat exchanger 9.

[0054] In the air conditioner having the above described structure, when the air conditioner is not in operation, the horizontal louvers 111, 112, and 113 are positioned such that, as shown in Fig. 4, the horizontal louvers 111 and 112 closes an upper and a lower portion of the air flow path 6, respectively, while the horizontal louver 113 is positioned inside the air flow path 6. Thus, the air discharge port 5 is closed. In this state, the horizontal louvers 111 and 112 are formed substantially continuously with the front face of the front panel 3, and also the horizontal louver 112 is formed so as to connect the lower edge of the horizontal louver 111 to the lower surface of the cabinet 2. This prevents the appearance of the indoor unit 1 from being degraded.

[0055] A prevention against condensation is provided on the side of the upper wall 6b that does not face the air flow path 6. As a prevention against condensation, the upper wall 6b may be formed of a thermal insulating material, or, a thermal insulating material may be provided on top of the upper wall. A prevention against con-

densation other than a thermal insulating material may be provided. If, by any chance, condensation is formed on the side of the upper wall 6b that does not face the air flow path 6, the condensation will be led to the drain pan 10. As a result, it is possible to obtain a highly reliable air conditioner free from problems caused by condensation.

[0056] When the air conditioner is turned on, for example, for a cooling operation, the horizontal louvers 111, 112, and 113 are positioned, as shown in Fig. 1, so as to open the air discharge port 5. The vertical louver 12 is oriented to a predetermined direction. The cross flow fan 7 is driven, and the refrigeration cycle starts to be operated, so that a refrigerant flows from an outdoor unit (not shown) to the indoor heat exchanger 9. Air is taken in through the air intake port 4 into the indoor unit 1, and dust in the air is removed by the air filter 8. The air that has been taken in into the indoor unit 1 exchanges heat with the indoor heat exchanger 9 to be cooled thereby.

[0057] Conditioned air that has been cooled by the indoor heat exchanger 9, being restricted in horizontal and vertical movements by the vertical louver 12 and the horizontal louvers 111, 112, and 113, flows along the tilted surface 6b5 to be discharged forward and upward as indicated by arrow E into the room. At this time, the indoor unit is in a "forward upward discharging state", and discharges conditioned air forward and upward.

[0058] The conditioned air discharged forward and upward into the room from the air discharge port 5 along the tilted surface 6b5 reaches the surface of a ceiling S of the room (see Fig. 2). Then, due to the Coanda effect, the conditioned air flows from the surface of the ceiling S along a side wall that is opposite from the side wall W1 on which the indoor unit 1 is mounted, the floor surface, and the side wall W1 in this order; the conditioned air is then taken in into the indoor unit 1.

[0059] In this way, cold or warm wind can be prevented from continuously blowing directly on the user, and thus improved comfort can be provided. Furthermore, in the cooling operation, no local temperature fall occurs in any portion of the user's body, and thus is provided improved safety with respect to health. Moreover, since the air flow greatly circulates in the room, the temperature distribution inside the room becomes uniform at around a set temperature. Thus, the user can enjoy a comfortable living space realized in a room in which, except in the upper portion thereof, the temperature distribution is substantially uniform at a set temperature with little difference, with hardly any wind blowing directly on him/her.

[0060] Fig. 5 is a side sectional view showing in detail the vicinity of the air discharge port 5 in this state. The uppermost horizontal louver 111 is positioned such that it faces the tilted surface 6b5 and its rear edge is before the bent portion 6b4. The middle horizontal louver 112 is positioned such that it faces the bent portion 6b4 and its rear edge is behind the bent portion 6b4. The end 6b6 of the upper wall 6b, the front edge of the uppermost horizontal louver 111, the front edge of the middle hori-

zontal louver 112, the front edge of the lowermost horizontal louver 113, and the end 6c4 of the lower wall 6c are arranged in this order from upper front.

[0061] The uppermost horizontal louver 111 is positioned such that an angle θ_1 it forms with the tilted surface 6b5 is 13° . The middle horizontal louver 112 is positioned such that an angle θ_2 it forms with the uppermost horizontal louver 111 is 10° . The lowermost horizontal louver 113 is positioned such that an angle θ_3 it forms with the middle horizontal louver 112 is 10° . An angle θ_4 formed by the lowermost horizontal louver 113 and the tangent line 98 is 12° .

[0062] Since the horizontal louvers 111, 112, and 113 are positioned such that the angles θ_1 to θ_4 are 17° or less, air flows that flow through flow paths separated by the horizontal louvers 111, 112, and 113 are prevented as much as possible from separating from the wall surfaces of the flow paths. Thus, air flows smoothly, and thus the air conditioner can be more energy-saving.

[0063] Fig. 6 is a diagram showing the relationship between the air flow rate of the cross flow fan 7 and an input (i.e., power consumption) a cross flow fan 7 driving motor (not shown) needs in order to allow the cross flow fan 7 to achieve the air flow rate. The vertical axis indicates the input (in W) of the fan driving motor, and the horizontal axis indicates the air flow rate (in m^3/min) of the cross flow fan 7.

[0064] In the figure, K1 indicates this embodiment where the horizontal louvers 111, 112, and 113 are positioned as shown in Fig. 5. K2 indicates the fourth embodiment that is shown in Fig. 18 and of which a detailed description will be given later; the fourth embodiment is different from this embodiment in that the horizontal louver 113 is omitted. K3 indicates the fifth embodiment that is shown in Fig. 19 and of which a detailed description will be given later; the fifth embodiment is different from this embodiment in that the horizontal louver 113 is omitted and that the horizontal louvers 111 and 112 are shaped and positioned differently from those of this embodiment.

[0065] K4 indicates a comparative example shown in Fig. 7. In the comparative example, the horizontal louver 113 is omitted, and the lengths of the upper wall 6b and the lower wall 6c are $1D$ and $2.1D$, respectively, which are the typical lengths of the upper wall 6b and the lower wall 6c formed in conventional air conditioners. The horizontal louvers 111 and 112 are positioned such that flow paths separated thereby are substantially equal to each other, and smoothly guide an air flow forward and upward.

[0066] Comparison between K1 and K2 clearly shows the effect of positioning the horizontal louver 113 as shown in Fig. 5. Comparison between K2 and K3 clearly shows the effect of the shape and the position of the horizontal louvers 111 and 112. Comparison between K1 and K4 clearly shows the effect of the lengths of the upper wall 6b and the lower wall 6c.

[0067] According to the figure, in the cases of K1 to

K3, the cross flow fan 7 can be driven with lower inputs (i.e., power consumption) of the fan driving motor than in the comparative example (K4). As to the difference among the cases of K1 to K4 in level of noise produced at the same air flow rate, the level of noise in the case of K1 is smaller by approximately 2 dB than that in the case of K4, the levels of noise in the cases of K2 and K3 and the level of noise in the case of K1 are practically equal, with the former being higher than the latter only within the margin of error.

[0068] Figs. 8 to 11 are diagrams for illustrating the difference in power consumption of the cross flow fan 7 between this embodiment (K1) and the comparative example (K4). Fig. 8 is a side sectional view schematically showing a state of the inside of the indoor unit 1 of K4. Fig. 9 is a diagram schematically showing how the state of the static pressure of an air flow flowing through the indoor unit 1 changes in the state shown in Fig. 8; here, the vertical axis indicates the static pressure of the air flow and the horizontal axis indicates the direction of the air flow.

[0069] When the cross flow fan 7 is driven, air outside the indoor unit 1, whose static pressure is equal to the atmospheric pressure, is taken in, and thereby an air flow is generated. The air flow flows through the air intake port 4, the indoor heat exchanger 9, and the air flow path 6; when it flows through the indoor heat exchanger 9, it is conditioned to be conditioned air. At this time, pressure losses ΔP_a , ΔP_b , and ΔP_c occur due to the air resistances of the air intake port 4, the indoor heat exchanger 9, and the air flow path 6, respectively. Thus, the static pressure of the air flow is, when the air flow has passed through the air flow path 6, lowered down to a level equal to (Atmospheric Pressure - ΔP_a - ΔP_b - ΔP_c). Pressure losses occurring in the other sections such as the air filter 8 will not be taken into consideration in the following description.

[0070] Furthermore, when the air flow is discharged from the air discharge port 5, the air flow is disturbed just out of the air discharge port 5, which causes a pressure loss ΔP_{d1} . That is, the air flow that is discharged from the air discharge port 5 is suddenly blown out of the air flow path enclosed by the wall surfaces into the ambient air, where no wall surface exists. At this time, the viscosity of the air makes the air flow give its kinetic energy to the ambient air, and this makes the ambient air move slowly. Thus, kinetic energy of the air flow discharged from the air discharge port 5 is lost into the ambient air, and the static pressure of the air flow shortly becomes equal to the atmospheric pressure. This phenomenon, occurring in an instant the moment the air flow is discharged from the air discharge port 5, leads to a great disturbance of the air flow in the vicinity of the air discharge port 5, and this results in a pressure loss.

[0071] To cope with this, the cross flow fan 7 needs to instantly increase the static pressure by the sum of the above described static pressure losses ($\Delta P_a + \Delta P_b + \Delta P_c + \Delta P_{d1}$). Thus, a static pressure rise ΔP_0 by the cross

flow fan needs to be equal to the sum of the static pressure losses ($\Delta P_a + \Delta P_b + \Delta P_c + \Delta P_{d1}$).

[0072] The work of the cross flow fan 7 is equal to what is obtained by multiplying this static pressure rise ΔP_0 by the volume Q of passed air ($\Delta P_0 \times Q$). If the static pressure rise produced by the cross flow fan 7 is less than the sum of the static pressure losses ($\Delta P_0 < \Delta P_a + \Delta P_b + \Delta P_c + \Delta P_{d1}$), the cross flow fan cannot pass a desired volume of air through the indoor heat exchanger 9. Thus, appropriate air conditioning cannot be performed.

[0073] Figs. 10 and 11 show the case of this embodiment (K1). Fig. 10 is a side sectional view schematically showing a state of the inside of the indoor unit 1 of K1. Like Fig. 9, Fig. 11 is a diagram schematically showing how the state of the static pressure of the air flow flowing through the indoor unit 1 changes in this state; here, the vertical axis indicates the static pressure, and the horizontal axis indicates the direction of the air flow.

[0074] Like in the case described above, when the cross flow fan 7 is driven, air outside the indoor unit 1, whose static pressure is equal to the atmospheric pressure, is taken in, and thereby an air flow is generated. At this time, pressure losses ΔP_a , ΔP_b , and ΔP_c occur in the air flow attributable to air resistances of the air intake port 4, the indoor heat exchanger 9, and the air flow path 6, respectively. Thus, the static pressure of the air flow is, when it has passed through the air flow path 6, lowered down to a level equal to (Atmospheric Pressure - $\Delta P_a - \Delta P_t - \Delta P_c$).

[0075] On the other hand, a pressure loss ΔP_{d2} that the air flow discharged from the air discharge port 5 suffers is smaller than the pressure loss ΔP_{d1} of the comparative example shown in Fig. 9. Hence, the air flow passed through the forward guide section 6a flows smoothly along the tilted surface 6b5 via the bent portion 6b4. As a result, kinetic energy of the air flow is not lost into the ambient air as rapidly as in the comparative example, and the amount of kinetic energy lost into the ambient is not as large as in the comparative example.

[0076] Furthermore, the entire air flow that has passed through the forward guide section 6a flows along the tilted surface 6b5 because of the Coanda effect, and this affects the portion of the air flow flowing along the lower wall 6c of the air flow path 6. As a result, the air flow is dispersed in the ambient air not instantly but gradually in the order from the lower portion thereof, until the static pressure thereof becomes equal to the atmospheric pressure. Thus, only a slight disturbance of the air flow occurs in the vicinity of the air discharge port 5, and accordingly, the pressure loss ΔP_{d2} caused thereby is reduced.

[0077] Moreover, the flow passage area is gradually enlarged along the forward guide section 6a, and then along the tilted surface 6b5 and the horizontal louver 113. As a result, the air flow flows smoothly along the tilted surface 6b5 after the forward guide section 6a, gradually increasing its flowing area.

[0078] At this time, since the horizontal louvers 111,

112 and 113 are positioned as shown in Fig. 5 referred to above, the flow path of a portion of the air flow discharged from the air discharge port 5 that flows below the lowermost horizontal louver 113 first starts to be gradually enlarged. Then, the flow path of a portion of the air flow discharged from the air discharge port 5 that flows between the horizontal louvers 112 and 113 starts to be gradually enlarged. Then, the flow path of a portion of the air flow discharged from the air discharge port 5 that flows between the horizontal louvers 111 and 112 starts to be gradually enlarged. Then finally, the flow path of a portion of the air flow discharged from the air discharge port 5 that flows above the horizontal louver 111, i.e., the uppermost portion of the air flow, starts to be gradually enlarged. Thus, the speed of the air flow is smoothly and gradually lowered in the order from the lower portion of the air flow.

[0079] When the speed of the air flow is smoothly lowered, the static pressure of the air flow rises according to the Bernoulli's equation which is well known in the field of fluid dynamics. That is, the flowing speed of the air flow (kinetic energy) is converted into static pressure (potential energy). Thus, before kinetic energy of the air flow discharged from the air discharge port 5 is lost into the ambient air and the air flow is disturbed, a portion of the kinetic energy of the air flow is converted into static pressure, and thereby a static pressure rise ΔP_2 is produced.

[0080] Hence, the cross flow fan 7 is required to instantly increase the pressure by the value obtained by subtracting the static pressure rise ΔP_2 from the sum of the above described static pressure losses ($\Delta P_a + \Delta P_b + \Delta P_c + \Delta P_{d2}$). Accordingly, static pressure rise ΔP_1 produced by the cross flow fan 7 is equal to ($\Delta P_a + \Delta P_b + \Delta P_c + \Delta P_{d2} - \Delta P_2$).

[0081] This means that the static pressure rise ΔP_1 that the cross flow fan 7 needs to produce is smaller than the static pressure rise ΔP_0 in the comparative example (see Figs. 8 and 9) by the value equal to ($\Delta P_2 + \Delta P_{d1} - \Delta P_{d2}$). As a result, the work of the cross flow fan 7 is reduced by the value equal to ($(\Delta P_2 + \Delta P_{d1} - \Delta P_{d2}) \times Q$), and thus the input (power consumption) of the fan driving motor can be reduced accordingly, which helps to save energy.

[0082] That is, the pressure loss ΔP_{d2} occurring in the vicinity of the air discharge port 5 can be reduced, and meanwhile, the speeds of the portions of air flow flowing along the upper wall 6b and the lower wall 6c are lowered for the kinetic energy of the air flow to be converted into static pressure, and the thus produced static pressure rise ΔP_2 assists the cross flow fan 7. In other words, kinetic energy that has conventionally been lost into the ambient air can be adequately collected and converted into static pressure that can be utilized to discharge air. This helps reduce the amount of static pressure rise the cross flow fan 7 needs to produce, and thus can be realized an air conditioner having an enhanced energy-saving feature.

[0083] As describe above, since the speed of an air

flow is smoothly and gradually lowered in the order from the lower portion of the air flow to be converted into static pressure, the speed of the air flow (kinetic energy) is converted into static pressure (potential energy) with a small loss. Thus, the speed of the air flow is converted into static pressure with very high efficiency, and this makes it possible to convert a large amount of kinetic energy into static pressure.

[0084] Fig. 12 is a contour diagram showing the result of measurement where the input (power consumption, in W) of the cross flow fan 7 driving motor was measured under different lengths of the upper wall 6b and the lower wall 6c. The vertical axis indicates the length of the upper wall 6b, which is divided by the diameter D of the cross flow fan 7 to be dimensionless. The horizontal axis indicates the length of the lower wall 6c, which is divided by the diameter D of the cross flow fan 7 to be dimensionless. The air flow rate of the cross flow fan 7 is fixedly set to be 16 m³/min. K1 and K4 in this figure have the same conditions as in Fig. 6.

[0085] With respect to the case where the upper wall 6b and the lower wall 6c are shorter than 0.5D and 1.5D, respectively, that are too short for the cross flow fan 7, no measurement was performed. In addition, the number of measure points is limited in the figure which is a contour diagram, and thus it is completed by estimation through interpolation of measurement values.

[0086] The figure clearly shows that the longer the upper wall 6b and the lower wall 6c are, the smaller the power consumption of the cross flow fan 7 can be made. It is also clear that the value of the power consumption greatly changes near the line L 1 where the sum of the lengths of the upper wall 6b and the lower wall 6c is 3.5D. Hence, the power consumption can be significantly reduced by making the sum of the lengths of the upper wall 6b and the lower wall 6c 3.5D or greater; thereby the kinetic energy of the air flow continues to be converted into static pressure until the speed of the air flow is sufficiently lowered, and thus an ample portion of the kinetic energy of the air flow can be converted into static pressure to be collected.

[0087] Fig. 13 is a contour diagram showing the result of measurement in which the travel distance (in meter) that the air flow travels along a ceiling surface was measured under different lengths of the upper wall 6b and the lower wall 6c. Here, the travel distance is a distance to a position where the average speed of the air flow in 30 seconds is 0.05 m/s. As in Fig. 12, the vertical axis indicates the length of the upper wall 6b, which is divided by the diameter D of the cross flow fan 7 to be dimensionless. The horizontal axis indicates the length of the lower wall 6c, which is divided by the diameter D of the cross flow fan 7 to be dimensionless. The air flow rate of the cross flow fan 7 is fixedly set to be 16 m³/min. The conditions of K1 and K4 are the same as in Fig. 6 referred to above.

[0088] With respect to the case where the upper wall 6b and the lower wall 6c are shorter than 0.5D and 1.5D, respectively, which are too short for the cross flow fan 7,

no measurement was performed. In addition, the number of measure points is limited in the figure which is a contour diagram, and thus it is completed by estimation through interpolation of measurement values.

[0089] As is clear from the figure, the travel distance has a low dependence on the length of the lower wall 6c, while it greatly changes with the length of the upper wall 6b. That is, prevention of loss of kinetic energy of the air flow in an upward direction effectively helps extend the travel distance, which is greatly influenced by the length of the upper wall 6b.

[0090] The travel distance greatly changes near the line L2 where the length of the upper wall 6b is 1.5D. That is, the air flow causes the ambient air to move due to viscosity as soon as it is discharged from the air discharge port 5, and its kinetic energy is gradually lost into the ambient air; however, the level of the movement of the ambient air above the air flow is greatly low when the length of the upper wall 6b is 1.5D or longer, which is long enough as the length of the upper wall 6b. Accordingly, the portion of the kinetic energy of the air flow lost into the ambient air is smaller than would otherwise be, and thus the air flow travels farther. Thus, when the length of the upper wall 6b is 1.5D or longer, the air flow can securely travel far enough even after its kinetic energy has been amply collected.

[0091] When the air flow discharged from the cross flow fan 7 flows through the air flow path 6, in the vicinity of the air discharge port 5, the speed of the lower portion (in the vicinity of the lower wall 6c) of the air flow becomes lower than that of the upper portion thereof (in the vicinity of the upper wall 6b). That is, in the vicinity of the air discharge portion 5, a portion of an air flow flowing through an upper portion of the air flow path 6 has a comparatively high density of kinetic energy, while a portion of the air flow flowing through a lower portion of the air flow path 6 has a comparatively low density of kinetic energy. This phenomenon is commonly observed with respect to cross flow fans in general.

[0092] When kinetic energy is collected at a time from an air flow where energy density is not uniform, kinetic energy is collected mainly from a high-speed portion of the air flow where the density of kinetic energy is comparatively high. This makes it difficult to collect ample kinetic energy from a slowly-flowing portion of the air flow where the density of kinetic energy is comparatively low.

[0093] That is, when an air flow having non-uniform distribution of speed is passed through a flow path that is gradually enlarged to lower the speed of the air flow to convert its kinetic energy into static pressure, a high-speed portion of the air flow passes through the flow path first and the speed thereof is greatly reduced. This makes it difficult to reduce the speed of a low-speed portion of the air flow. This results in lower efficiency of kinetic energy collection from the entire air flow. To prevent this from happening, it is preferable that kinetic energy be collected separately from the high-speed portion of the air flow having a comparatively high density of kinetic

energy and from the low-speed portion having a comparatively low density of kinetic energy. This helps improve the efficiency of kinetic energy collection from the entire air flow.

[0094] The low-speed portion of the air flow having a comparatively low density of kinetic energy gradually loses its kinetic energy due to wall resistance or the like as it passes, and thus the energy density becomes increasingly low. To deal with this, it is necessary to collect kinetic energy at as early a stage as possible. A low-speed air flow having a comparatively low density of kinetic energy has a small amount of kinetic energy, and thus a comparatively short distance is enough to collect kinetic energy therefrom. In contrast, a high-speed air flow having a comparatively high density of kinetic energy has a large amount of kinetic energy, and thus a comparatively long distance is needed in order to collect an ample amount of kinetic energy therefrom.

[0095] Hence, it is preferable that the air flow path 6 be divided into a plurality of flow paths in the up/down direction and that the lowermost flow path be comparatively short, each of the other flow paths being longer than a flow path below it. This makes it possible to efficiently collect kinetic energy from an air flow having a non-uniform energy density that is specific to the cross flow fan 7. Therefore, in this embodiment, the air flow path 6 is divided into four in the vertical direction by the horizontal louvers 111, 112, and 113 when the air conditioner 1 is in operation.

[0096] That is, the air flow path is divided into four flow paths: the uppermost flow path formed by the tilted surface 6b5 and the uppermost horizontal louver 111; the second-highest flow path formed by the top horizontal louver 111 and the middle horizontal louver 112; the third-highest flow path formed by the middle horizontal louver 112 and the lowermost horizontal louver 113; and the lowermost flow path formed by the lowermost horizontal louver 113 and the lower wall 6c.

[0097] As has been already described, the end 6b6 of the upper wall 6b, the front edge of the horizontal louver 111, the front edge of the horizontal louver 112, the front edge of the horizontal louver 113, and the end 6c4 of the lower wall 6c are arranged in this order from upper front. In this way, each of the divided flow paths can be made longer than a flow path below it.

[0098] It is more preferable that the angles $\theta 1$ to $\theta 4$ (see Fig. 5) representing the enlargement ratios of the flow passage areas of the flow paths be in the range between 10° and 15° . If the angles $\theta 1$ to $\theta 4$ are larger than 15° , air flows flowing through the flow paths separate from the wall surfaces or greatly slow down, and this increases the possibility of a loss occurring in converting kinetic energy into static pressure. If the angles $\theta 1$ to $\theta 4$ are smaller than 10° , the path is unnecessarily extended, and accordingly more kinetic energy is lost due to friction between the air flows and the wall surfaces.

[0099] The amount of kinetic energy an air flow has is proportional to the square of its speed. In the case where

the cross flow fan 7 is used, the speed of the air flow flowing through the upper portion of the air flow path 6 (in the vicinity of the upper wall 6b) is several times higher than that of the air flow flowing through the lower portion of the air flow path 6 (in the vicinity of the lower wall 6c). Hence, the portion of the air flow flowing through the upper portion of the air flow path 6 (in the vicinity of the upper wall 6b) sometimes has several tens of times as much kinetic energy as the portion of the air flow flowing through the lower portion of the air flow path 6 (in the vicinity of the lower wall 6c) does. Accordingly, a very large amount of kinetic energy needs to be collected through the upper portion of the air flow path 6, and thus the upper portion of the air flow path 6 needs to be formed as an amply long flow path.

[0100] As has been mentioned above, it is preferable that the angle α (see Fig. 2) representing the enlargement ratio of the flow passage area of the forward guide section 6a of the air flow path 6 be approximately 20° . If the angle α is larger than that, the air flow flowing through the forward guide section 6a separates from the wall surfaces or suddenly slows down, and this results in a loss of energy. In this case, if the flow passage area is enlarged by a ratio represented by an angle between 10° and 15° , there can be formed only two flow paths. As a result, it becomes extremely difficult to effectively collect kinetic energy from an air flow in the case where, as described above, the amount of kinetic energy varies by up to several tens of times among different portions.

[0101] Thus, the middle horizontal louver 112 is positioned such that it faces the bent portion 6b4, its rear edge is located behind the bent portion 6b4, and it is substantially parallel to the upper surface 6b3 of the forward guide section 6a. In this way, the flow path of the forward guide section 6a is divided into two flow paths in the up/down direction. Further, the one of the two divided flow paths that is under the horizontal louver 112 can be divided into two flow paths by the horizontal louver 113 with the angles $\theta 3$ and $\theta 4$ being in the range between 10° and 15° .

[0102] Moreover, the upper wall 6b is bent upward at the bent portion 6b4 that faces the horizontal louver 112. As a result, the flow path above the horizontal louver 112 is enlarged. The flow path that is formed by the horizontal louver 112 and the tilted surface 6b5 and that is gradually enlarged is divided by the uppermost horizontal louver 111. The uppermost horizontal louver 111 is positioned such that it faces the tilted surface 6b5 and its rear edge is located before the bent portion 6b4, and thus the flow path can be divided into two flow paths above the horizontal louver 112 by the horizontal louver 111 with the angles $\theta 1$ and $\theta 2$ being in the range between 10° and 15° . Bending downward the lower surface 6c3 of the forward guide section 6a for the purpose of further enlargement is not very effective, because it results in a lower speed of the air flow.

[0103] It is further preferable that the rear edge of the lowermost horizontal louver 113 and the lower surface

6c3 of the forward guide section 6a be positioned such that they overlap each other at a position close to the end 6c4 of the lower wall 6c as viewed in the direction perpendicular to the direction in which the air flow flows. This makes it possible to efficiently collect kinetic energy from the air flow flowing through the flow path below the horizontal louver 113.

[0104] The horizontal louvers 111, 112, and 113 are each formed to rotate around a shaft (not shown), and hence they can be rotated to change their positions such that the air flow is discharged in a different direction.

[0105] According to this embodiment, since the sum of the lengths of the upper wall 6b and the lower wall 6c of the air flow path 6, which extend on the downstream side of the cross flow fan 7, is 3.5 times as great as the diameter D of the cross flow fan 7 or greater, an air flow smoothly flows a long distance along the upper wall 6b and the lower wall 6c of the air flow path 6 when the air conditioner is in operation. This reduces the disturbance of the air flow occurring in the vicinity of the air outlet port 5, and accordingly the pressure loss ΔP_{d2} caused thereby is reduced.

[0106] In addition, the speed of the portion of the air flow flowing along the upper wall 6b and that of the portion of the air flow flowing along the lower wall 6c are reduced to be sufficiently low, and thus kinetic energy is converted into static pressure to produce the static pressure rise ΔP_2 , which assists the cross flow fan 7. In other words, kinetic energy that has been conventionally lost into the ambient air is amply collected to be converted into static pressure that can be utilized for discharging air. This helps reduce the amount of static pressure rise the cross flow fan 7 needs to produce, and thus the air conditioner can be energy saving.

[0107] Furthermore, it is possible to extend the travel distance of an air flow whose kinetic energy has been collected and whose speed has been reduced. This allows the air flow discharged from the air discharge port 5 to reach the ceiling of the room, then to flow along the wall surface that faces the air conditioner, the floor, and the wall surface on which the air conditioner is mounted. Thus, a conditioned air flow reaches every corner of the room and greatly circulates in the room. As a result, a comfortable living space can be realized in the room, where the temperature distribution is uniform except in a part of the upper portion thereof and hardly any direct wind blows on the user.

[0108] The cross flow fan 7 often generates surging if a large pressure loss occurs in a flow path. This sometimes prevents a desired air flow rate from being obtained or greatly increases noise. In the case where the indoor heat exchanger 9 has a refrigerant tube bent in a plurality of stages and rows, and is bent as in this embodiment, a very large pressure loss occurs. Hence, it is necessary to considerably increase the rotation speed of the cross flow fan 7 to deal with surging. This causes the cross flow fan 7 to generate a high level of noise, and makes it less energy saving.

[0109] In view of the above inconvenience, in this embodiment, kinetic energy of an air flow is converted into static pressure for assisting the cross flow fan 7, and this prevents the cross flow fan 7 from generating surging and allows the cross flow fan 7 to generate a comparatively lower level of noise. This embodiment can be more advantageous particularly in the case where a refrigerant tube is bent, in the depth direction, in four or more rows, where pressure loss is very large.

<Second Embodiment>

[0110] Fig. 14 is a side sectional view showing an indoor unit of an air conditioner of a second embodiment. For convenience of description, such components as find their counterparts in the first embodiment shown in Figs. 1 to 13 are denoted by the same reference numerals. In this embodiment, the front panel 3 is pivoted at its lower edge by a pivot shaft 22. Furthermore, the front panel 3 can be bent around a pivot shaft 23 that is disposed in the front face thereof. This embodiment is otherwise the same as the first embodiment.

[0111] When the air conditioner is not in operation, as shown in Fig. 14, the front panel 3 is positioned such that the upper edge thereof is in contact with the upper portion of the casing. Furthermore, as in the first embodiment, the horizontal louvers 111 and 112 close the air discharge port 5.

[0112] When the air conditioner is in operation, as shown in Fig. 15, the front panel 3 pivots around the pivot shafts 22 and 23, and the portion of the front panel 3 between the pivot shafts 22 and 23 forms the tilted surface 6b5 of the air flow path 6. In this way, the upper wall 6b of the air flow path 6 extending on the downstream side of the cross flow fan 7 is formed such that its length is 1.5D or longer, "D" denoting the diameter of the cross flow fan 7. The upper wall 6b and the lower wall 6c of the air flow path 6 extending on the downstream of the cross flow fan 7 are formed such that the sum of their lengths is 3.5D or greater. Thus, this embodiment can offer the same advantage as the first embodiment.

<Third Embodiment>

[0113] Fig. 16 is a side sectional view showing an indoor unit of an air conditioner of a third embodiment. For convenience of description, such components as find their counterparts in the first embodiment shown in Figs. 1 to 13 are denoted by the same reference numerals. In this embodiment, there is an opening formed at the bottom of the front panel 3, and a movable panel 21 for closing the opening is pivoted at its lower edge by the pivot shaft 22. This embodiment is otherwise the same as the first embodiment.

[0114] When the air conditioner is not in operation, as shown in Fig. 16, the movable panel 21 is positioned to close the opening formed at the bottom of the front panel 3. Furthermore, as in the first embodiment, the horizontal

louvers 111 and 112 close the air discharge port 5.

[0115] When the air conditioner is in operation, as shown in Fig. 17, the movable panel 21 pivots around the pivot shaft 22, and the movable panel 21 forms the tilted surface 6b5 of the air flow path 6. In this way, the upper wall 6b of the air flow path 6 extending on the downstream side of the cross flow fan 7 is formed such that its length is 1.5D or longer, "D" denoting the diameter of the cross flow fan 7. The upper wall 6b and the lower wall 6c of the air flow path 6 extending on the downstream of the cross flow fan 7 are formed such that the sum of their lengths is 3.5D or greater. Thus, this embodiment can offer the same advantage as the first embodiment.

<Fourth Embodiment>

[0116] Fig. 18 is a vertical section side view showing an indoor unit of an air conditioner of a fourth embodiment. Such components as find their counterparts in the first embodiment shown in Figs. 1 to 13 are denoted by the same reference numerals. In this embodiment, as has been described above, the horizontal louver 113 employed in the first embodiment is omitted. This embodiment is otherwise the same as the first embodiment, including the lengths of the upper wall 6b and the lower wall 6c of the air flow path 6.

[0117] In the air conditioner of this embodiment, since the lowermost horizontal louver 113 is omitted, kinetic energy is collected from an air flow flowing through the lower portion of the air flow path 6 with slightly less efficiency than in the air conditioner of the first embodiment. However, as shown by K2 in Fig. 6 referred to above, power consumption is less in this embodiment than in the comparative example K4 shown in Fig. 7, and thus the air conditioner of this embodiment is more energy saving than conventional air conditioners.

<Fifth Embodiment>

[0118] Fig. 19 is a side sectional view showing an indoor unit of an air conditioner of a fifth embodiment. Such components as find their counterparts in the first embodiment shown in Figs. 1 to 13 are denoted by the same reference numerals. In this embodiment, as has been described above, the horizontal louver 113 employed in the first embodiment is omitted, and the lengths and the positions of the horizontal louvers 111 and 112 are changed. This embodiment is otherwise the same as the first embodiment including the lengths of the upper wall 6b and the lower wall 6c of the air flow path 6.

[0119] The horizontal louvers 111 and 112, the former being located above the latter, are positioned such that they face the bent portion 6b4, their rear edges are located behind the bent portion 6b4, and their front edges are located in front of the bent portion 6b4 substantially at the same position in the front/rear direction. The horizontal louvers 111 and 112 divide the forward guide section 6a of the air flow path 6 flow paths having a substan-

tially equal space.

[0120] In the air conditioner of this embodiment, kinetic energy is collected from the air flow flowing through the air flow path 6 with less efficiency than in the air conditioner of the first and the second embodiments. However, as shown by K3 in Fig. 6 referred to above, power consumption is less in this embodiment than in the comparative example K4 shown in Fig. 7, and thus the air conditioner of this embodiment is more energy saving than conventional air conditioners.

[0121] Although the present invention has been described hereinabove by way of the first to the fifth embodiments thereof, the present invention is not limited to these specific embodiments, and the present invention can be practiced with alterations as necessary within the spirit thereof.

Industrial Applicability

[0122] The present invention can be applied to air conditioners for conditioning air taken in into them.

Claims

1. An air conditioner, comprising:

an air intake port through which air is taken in from inside a room into a casing of an indoor unit;
an air discharge port formed at a bottom of the casing;
an air flow path through which the air intake port and the air discharge port communicate with each other;
an indoor heat exchanger that has a refrigerant tube bent in a plurality of stages and rows, and that is disposed in the air flow path so as to face the air intake port, the indoor heat exchanger being bent along an inner surface of the casing; and
a cross flow fan that is disposed between the indoor heat exchanger and the air discharge port in the air flow path,

wherein

the air flow path has a forward guide section that guides air forward and downward, and whose flow passage area is enlarged toward a downstream side, and

a sum of lengths of an upper wall and a lower wall of the air flow path that extend on a downstream side of the cross flow fan is 3.5 times as great as a diameter of the cross flow fan or greater.

2. The air conditioner of claim 1, further comprising:

a first wind direction plate for changing up and down a wind direction in which air is discharged

- from the air discharge port,
- wherein
a front edge of the upper wall, a front edge of the first wind direction plate, and a front edge of the lower wall are arranged in this order from upper front when the air conditioner is in operation.
3. The air conditioner of claim 2, further comprising a second wind direction plate, wherein
the second wind direction plate is positioned below the first wind direction plate such that a front edge of the first wind direction plate is before a front edge of the second wind direction plate.
4. The air conditioner of claim 3, wherein
the upper wall includes:
- an upper surface of the forward guide section that is tilted forward and downward;
a bent portion that is located at an end of the upper surface of the forward guide section; and
a tilted surface that extends from the bent portion to be tilted forward and upward,
the first wind direction plate is positioned such that a rear edge thereof is located before the bent portion, and
the second wind direction plate is positioned such that a rear edge thereof is located behind the bent portion.
5. The air conditioner of claim 1, further comprising:
a first and a second wind direction plate for changing up and down a wind direction in which air is discharged from the air discharge port,
- wherein
the upper wall includes:
- an upper surface of the forward guide section;
a bent portion that is located at an end of the upper surface of the forward guide section; and
a tilted surface that extends from the bent portion to be tilted forward and upward,
the first wind direction plate is positioned such that a rear edge thereof is located before the bent portion, and
the second wind direction plate is positioned such that a rear edge thereof is located behind the bent portion.
6. The air conditioner of claim 4 or 5, wherein
an angle formed by the tilted surface and the first wind direction plate and an angle formed by the first and the second wind direction plates are between 10 ° and 15°.
7. The air conditioner of claim 6, further comprising a third wind direction plate,
wherein
the third wind direction plate is provided below the second wind direction plate, and
an angle formed by the second and the third wind direction plates is between 10 ° and 15 °.
8. The air conditioner of claim 6, wherein
an angle formed by a wind direction plate positioned lowest and a line tangent to the lower wall at an end of the lower wall is between 10 ° and 15 °.
9. The air conditioner of claim 1, wherein
the upper wall is 1.5 times as long as a diameter of the cross flow fan or longer.
10. An air conditioner, comprising:
- an air intake port through which air is taken in from inside a room into a casing of an indoor unit;
an air discharge port formed at a bottom of the casing;
an air flow path through which the air intake port and the air discharge port communicate with each other;
an indoor heat exchanger that has a refrigerant tube bent in a plurality of stages and rows, and that is disposed in the air flow path so as to face the air intake port, the indoor heat exchanger being bent along an inner surface of the casing;
a cross flow fan that is disposed between the indoor heat exchanger and the air discharge port in the air flow path; and
a first and a second wind direction plate for changing up and down a wind direction in which air is discharged from the air discharge port,
- wherein
the air flow path has a forward guide section that guides air from the cross flow fan forward and downward, and whose flow passage area is enlarged toward a downstream side,
an upper wall of the air flow path, the upper wall extending on a downstream side of the cross flow fan, is 1.5 times as long as a diameter of the cross flow fan or longer,
the upper wall includes:
- an upper surface of the forward guide section;
a bent portion that is located at an end of the upper surface of the forward guide section; and
a tilted surface that extends from the bent portion to be tilted forward and upward,
the first wind direction plate is positioned such that a rear edge thereof is located before the bent portion, and
the second wind direction plate is positioned be-

low the first wind direction plate such that a rear edge of the second wind direction plate is located behind the bent portion.

11. The air conditioner of claim 10, wherein
an angle formed by the tilted surface and the first wind direction plate and an angle formed by the first and the second wind direction plates are between 10 ° and 15 ° .
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12. The air conditioner of claim 11, further comprising a third wind direction plate,
wherein
the third wind direction plate is positioned below the second wind direction plate, and
an angle formed by the second and the third wind direction plates is between 10 ° and 15 ° .
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13. The air conditioner of claim 11, wherein
an angle formed by a wind direction plate located lowest and a line tangent to a lower wall of the forward guide section at an end of the lower wall is between 10 ° and 15 ° .
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14. The air conditioner of claim 10, wherein
a front edge of the upper wall, a front edge of the first wind direction plate, a front edge of the second wind direction plate, and a front edge of the lower wall are arranged in this order from upper front when the air conditioner is in operation.
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15. An air conditioner, comprising:

an air intake port through which air is taken in from inside a room into a casing of an indoor unit;
an air discharge port formed at a bottom of the casing;
an air flow path through which the air intake port and the air discharge port communicate with each other;
an indoor heat exchanger that is disposed in the air flow path so as to face the air intake port; and
a cross flow fan that is disposed between the indoor heat exchanger and the air discharge port in the air flow path,
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40
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wherein
an upper wall of the air flow path, the upper wall extending on a downstream side of the cross flow fan, is 1.5 times as long as a diameter of the cross flow fan or longer.
50
16. An air conditioner, comprising:

an air intake port through which air is taken in from inside a room into a casing of an indoor unit;
an air discharge port formed at a bottom of the casing;
55

an air flow path through which the air intake port and the air discharge port communicate with each other;

an indoor heat exchanger that is disposed in the air flow path so as to face the air intake port; and
a cross flow fan that is disposed between the indoor heat exchanger and the air discharge port in the air flow path,

wherein

a sum of lengths of an upper wall and a lower wall of the air flow path that extend on a downstream side of the cross flow fan is 3.5 times as great as a diameter of the cross flow fan or greater.

FIG.1

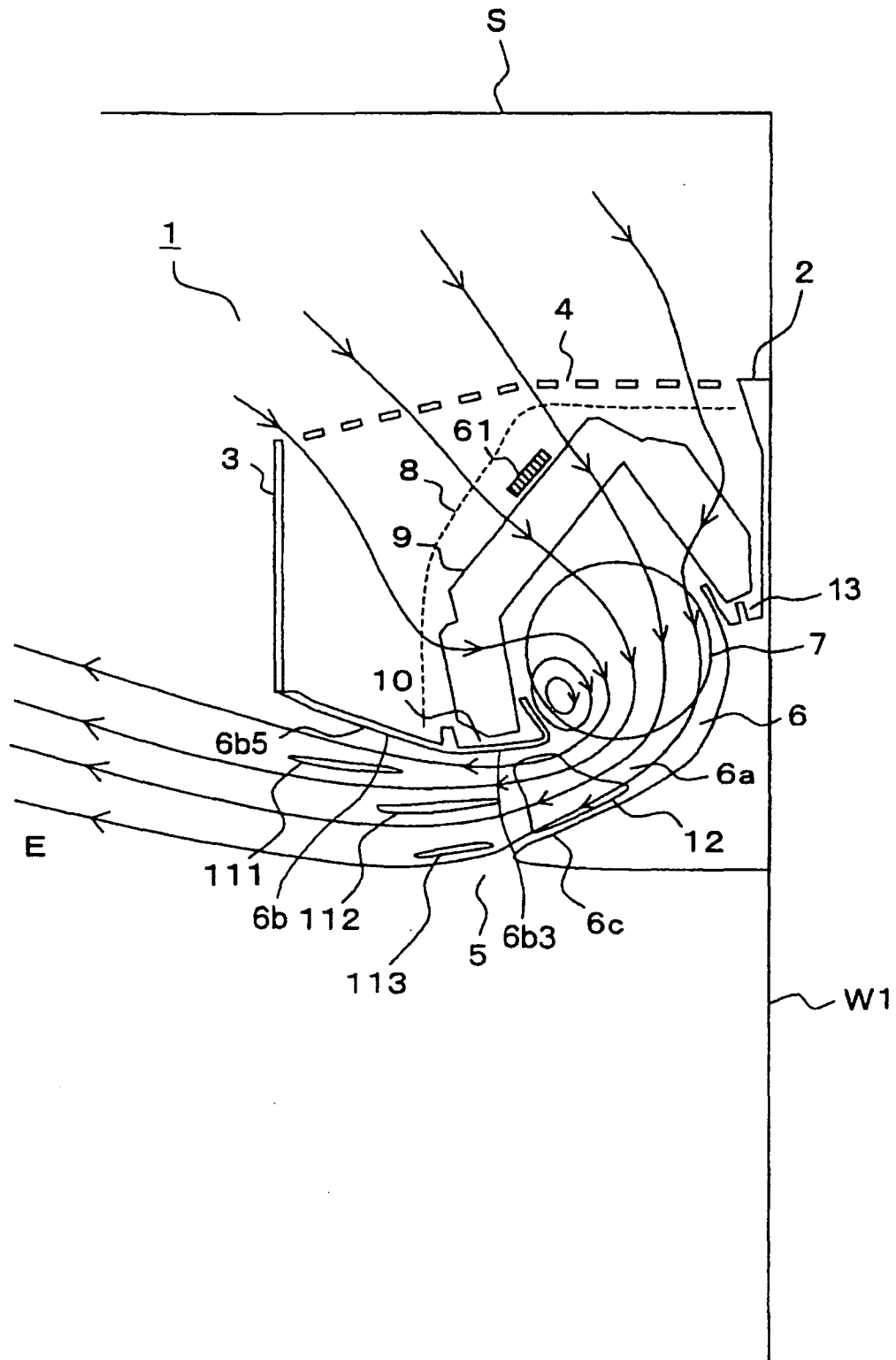


FIG.2

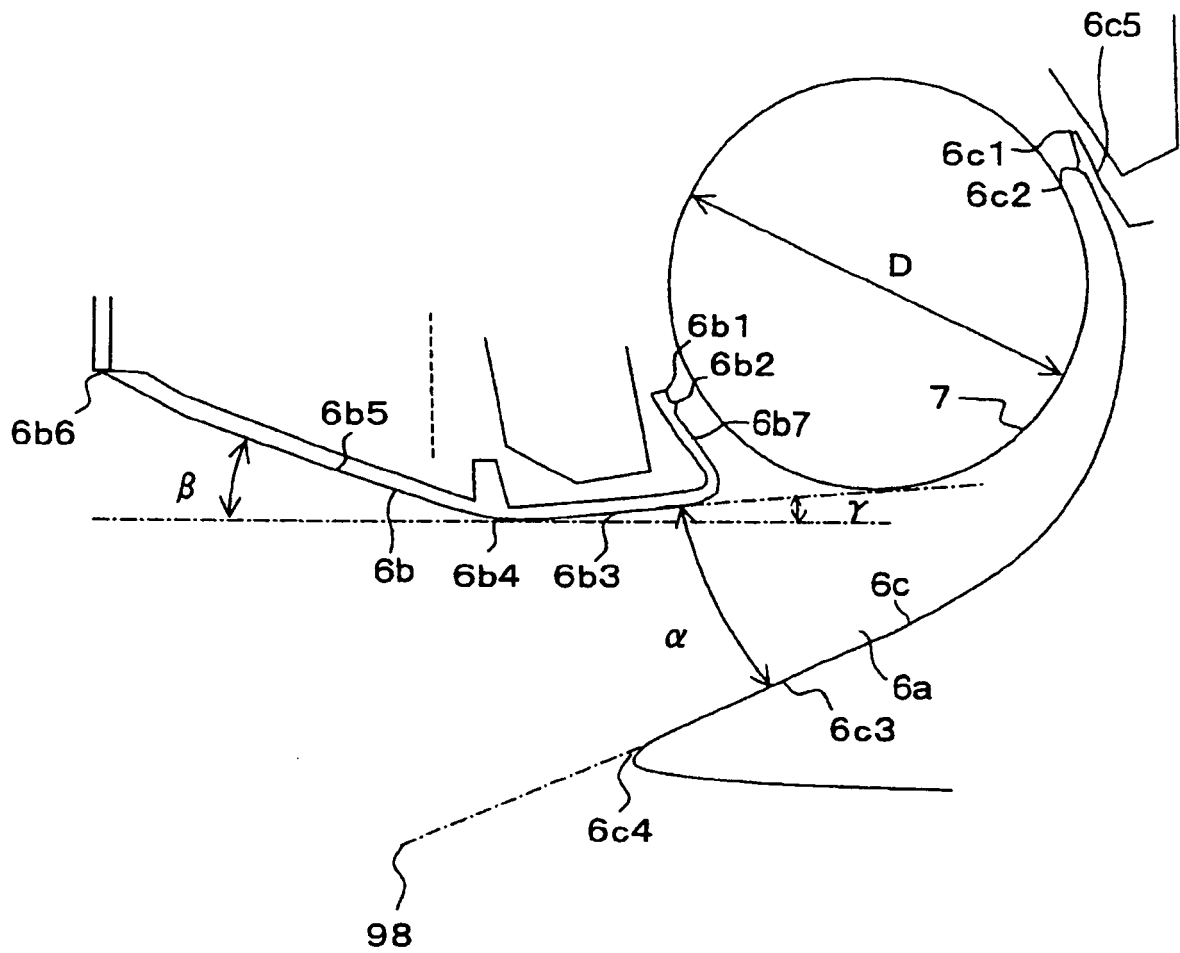


FIG.3

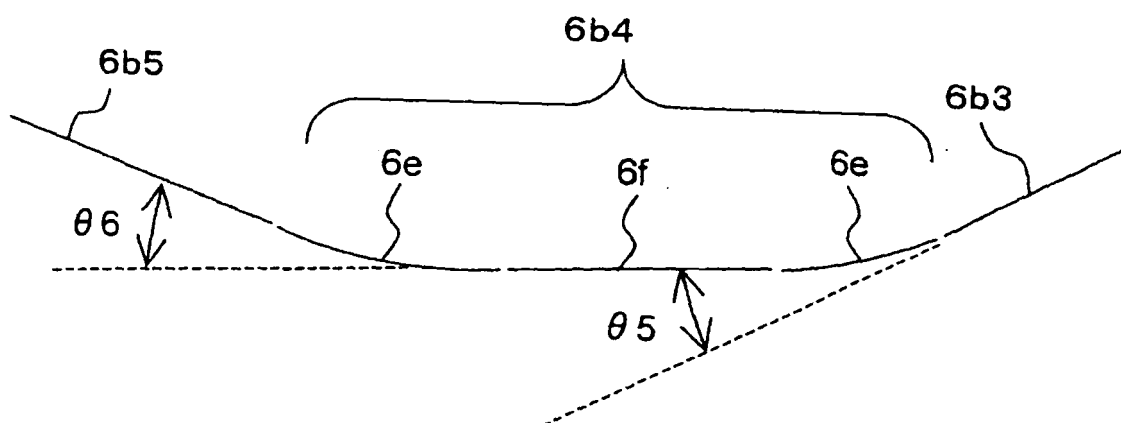


FIG.4

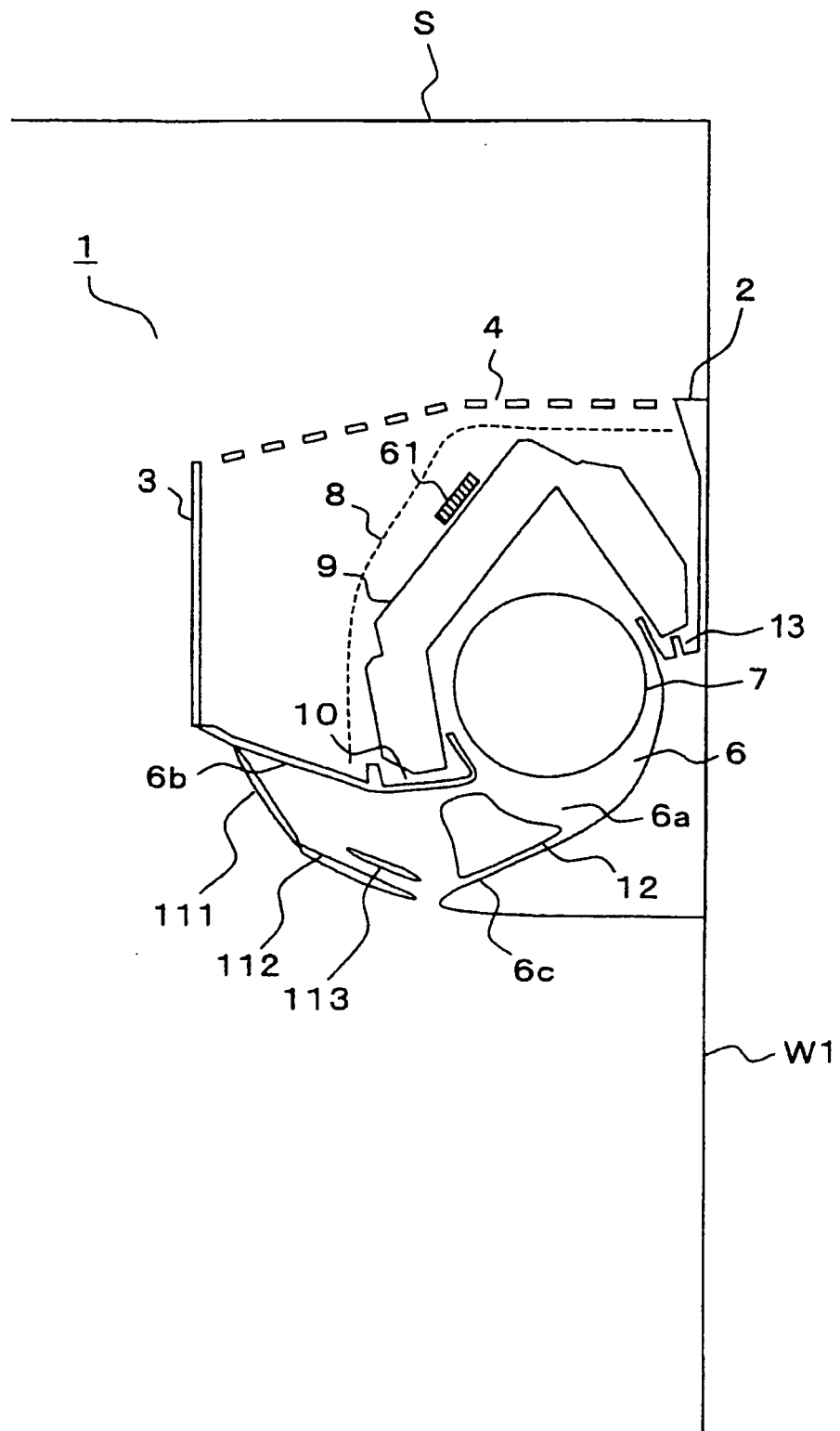


FIG.5

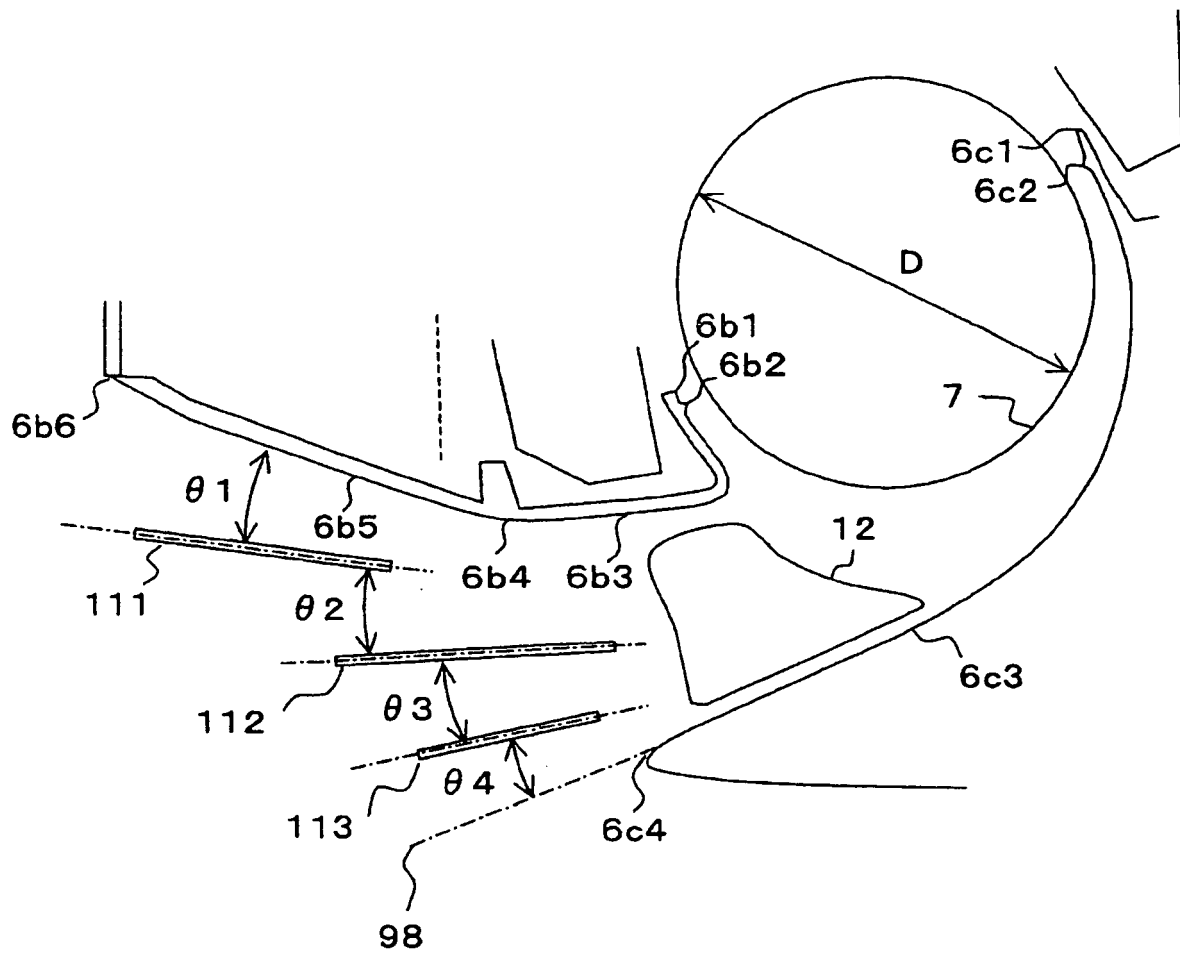


FIG.6

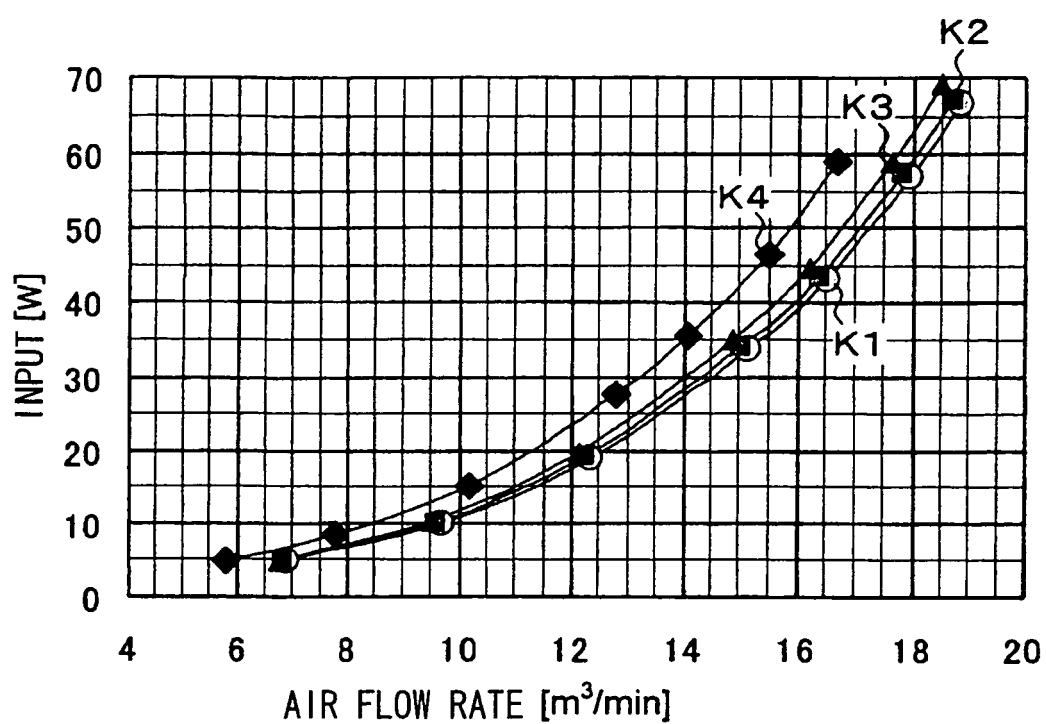


FIG.7

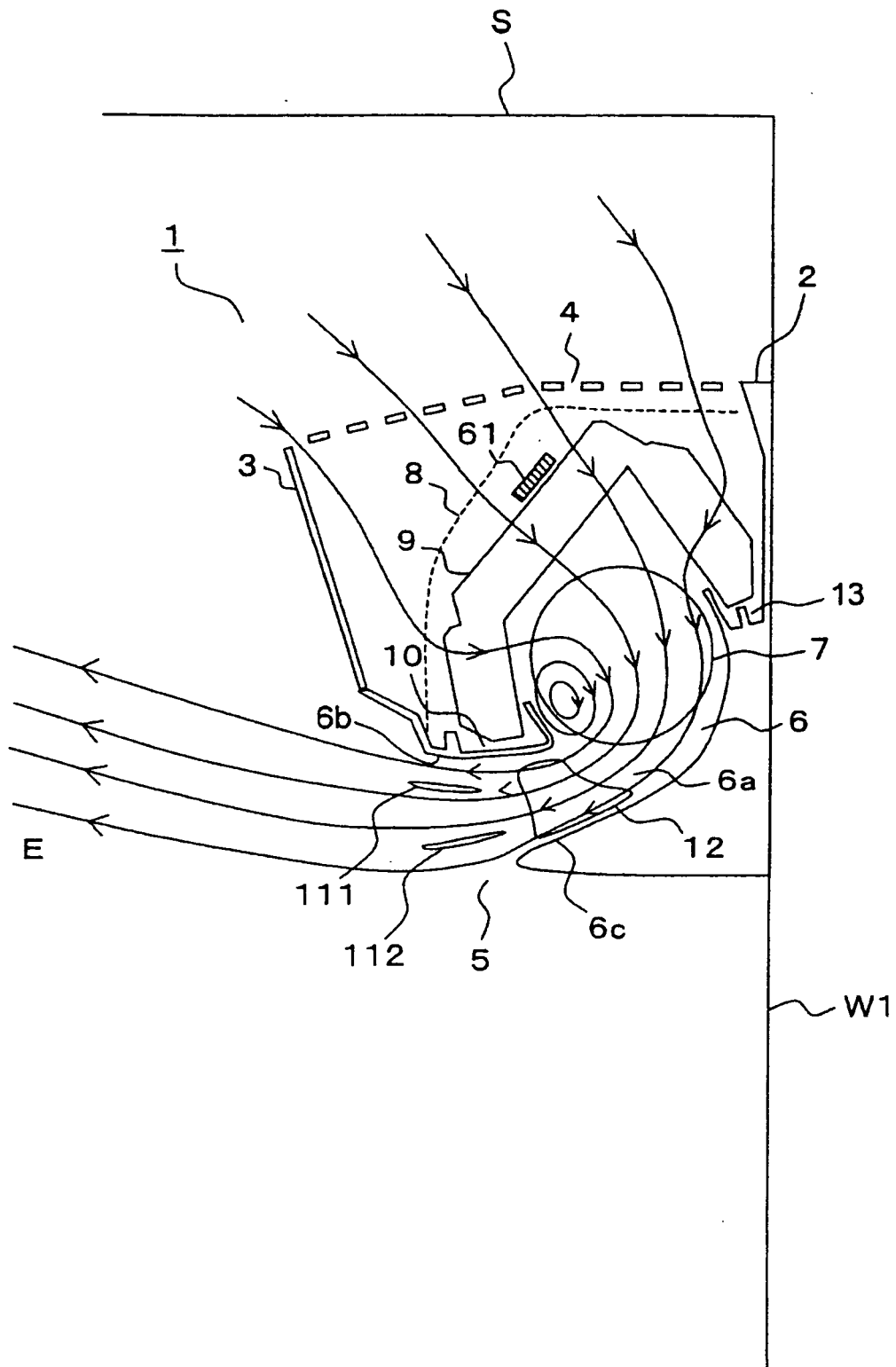


FIG.8

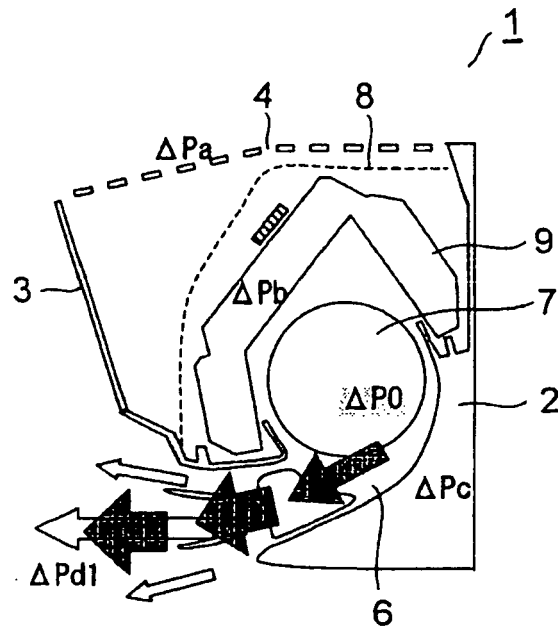


FIG.9

PRIOR ART

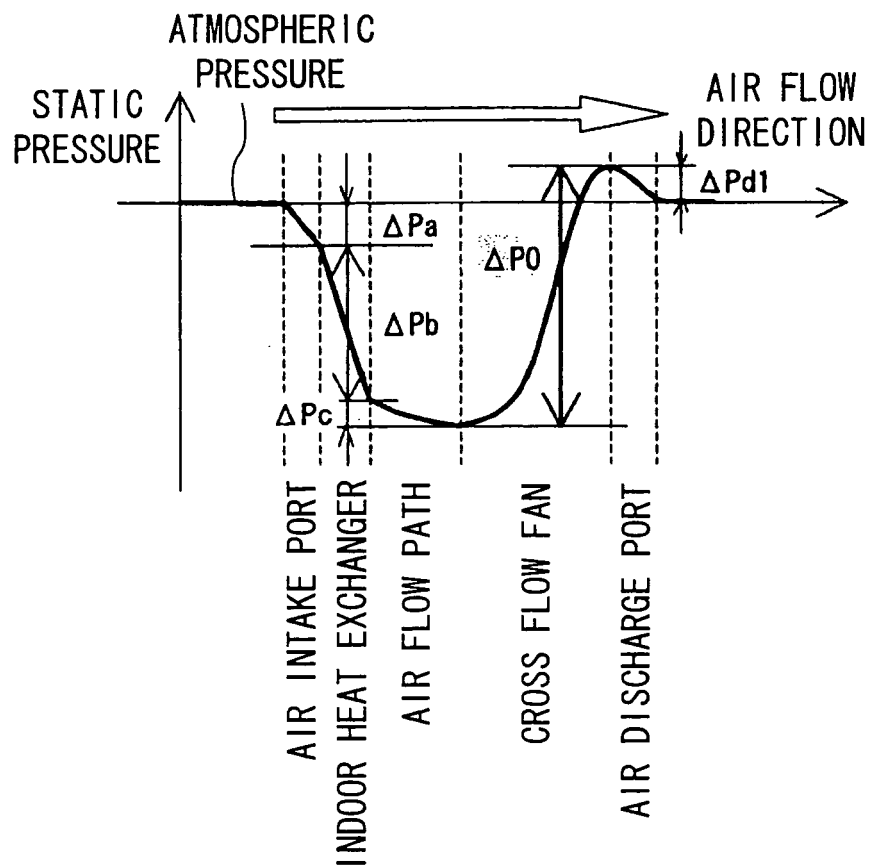


FIG.10

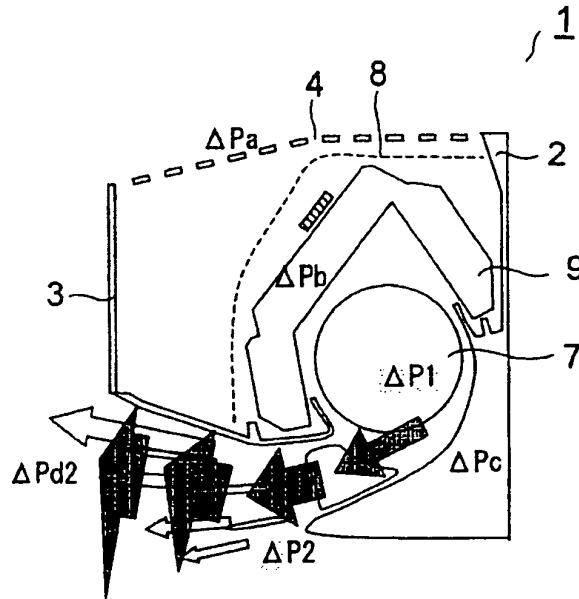


FIG.11

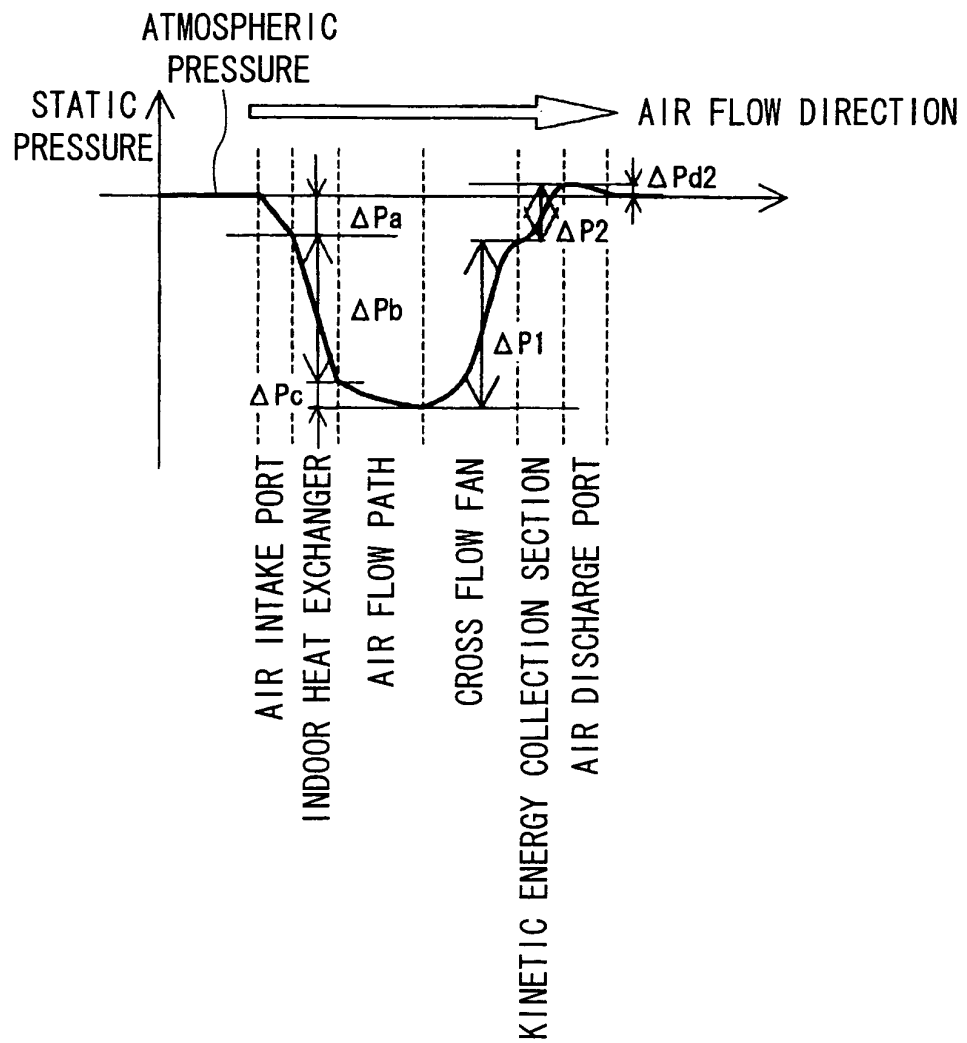


FIG.12

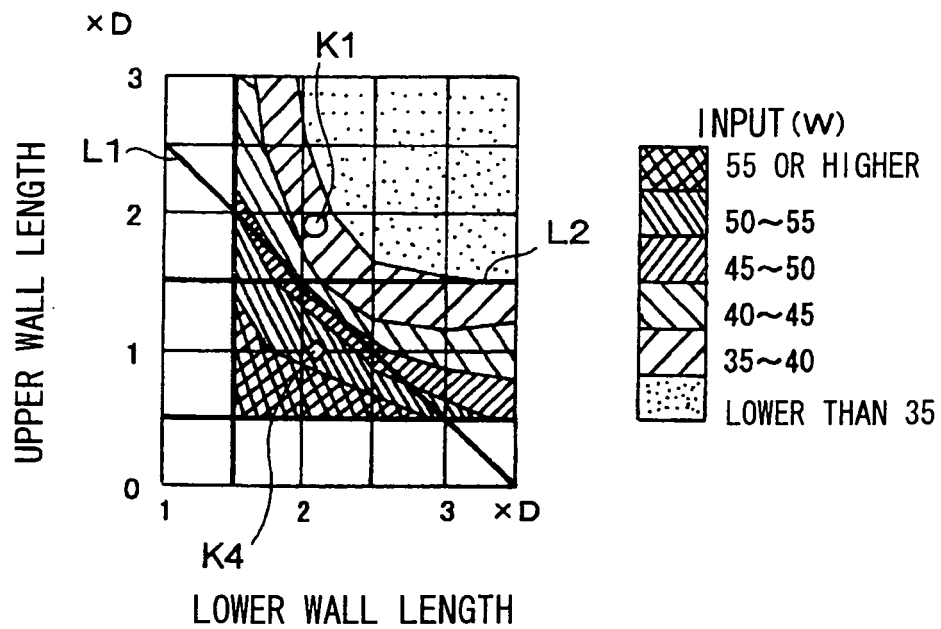


FIG.13

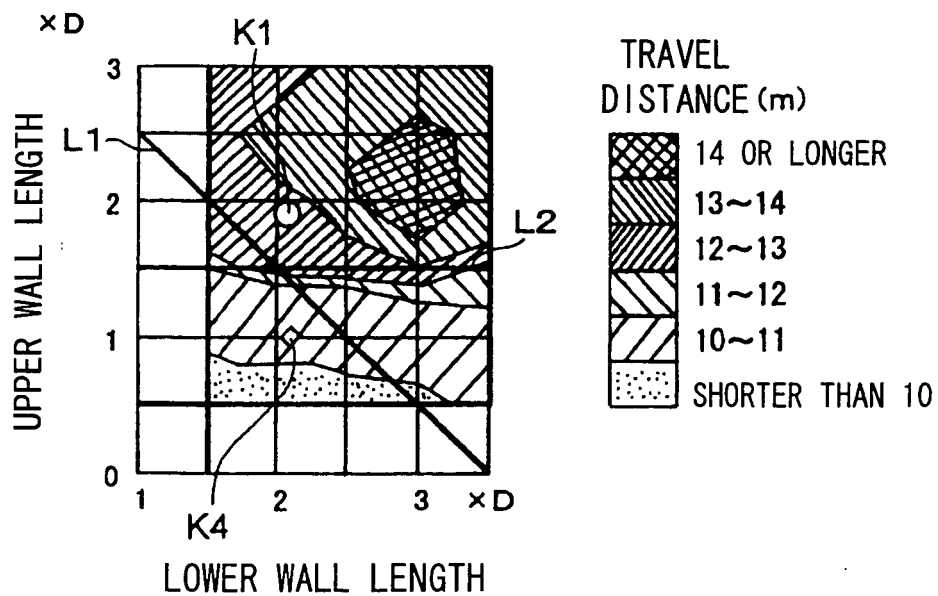


FIG.14

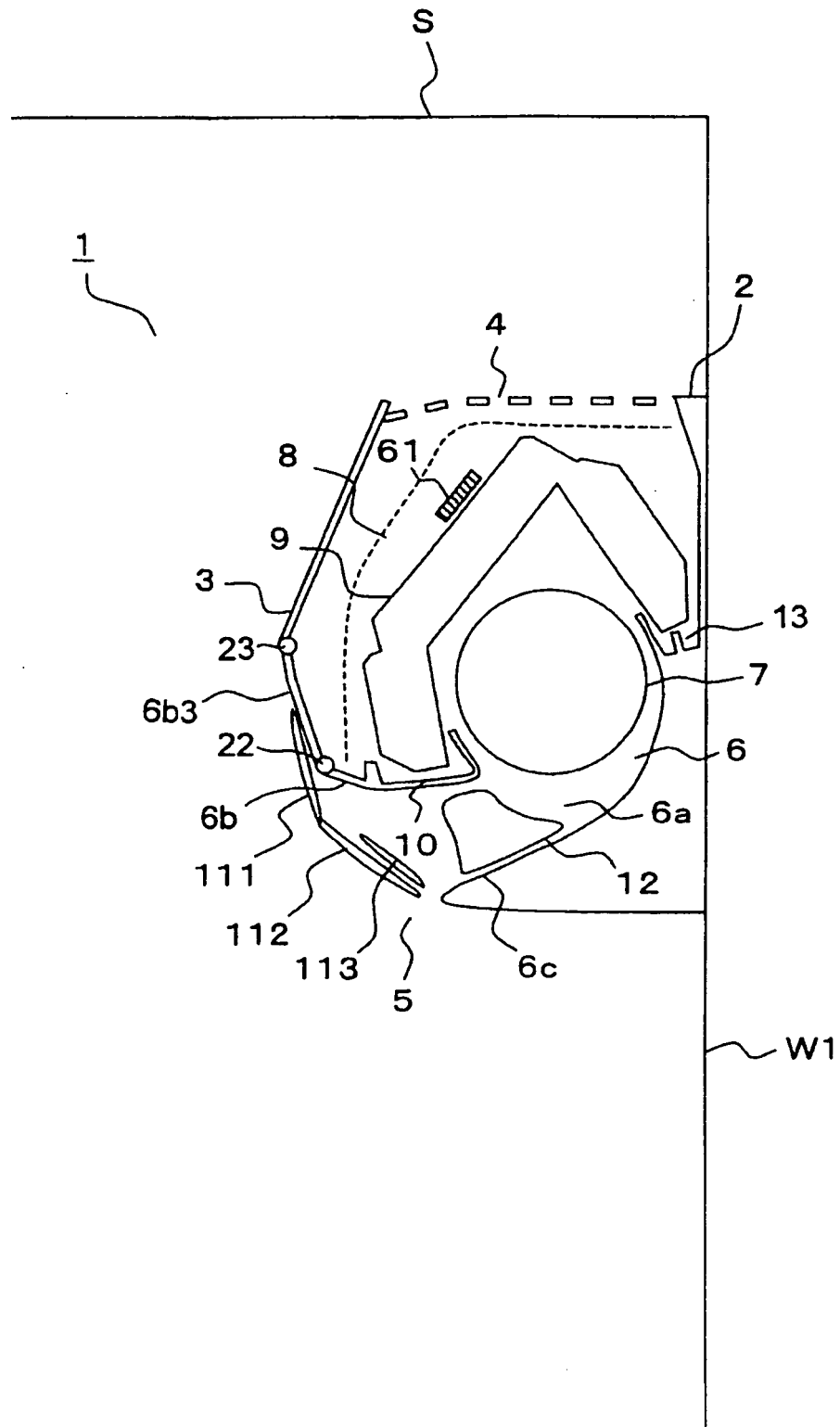


FIG.15

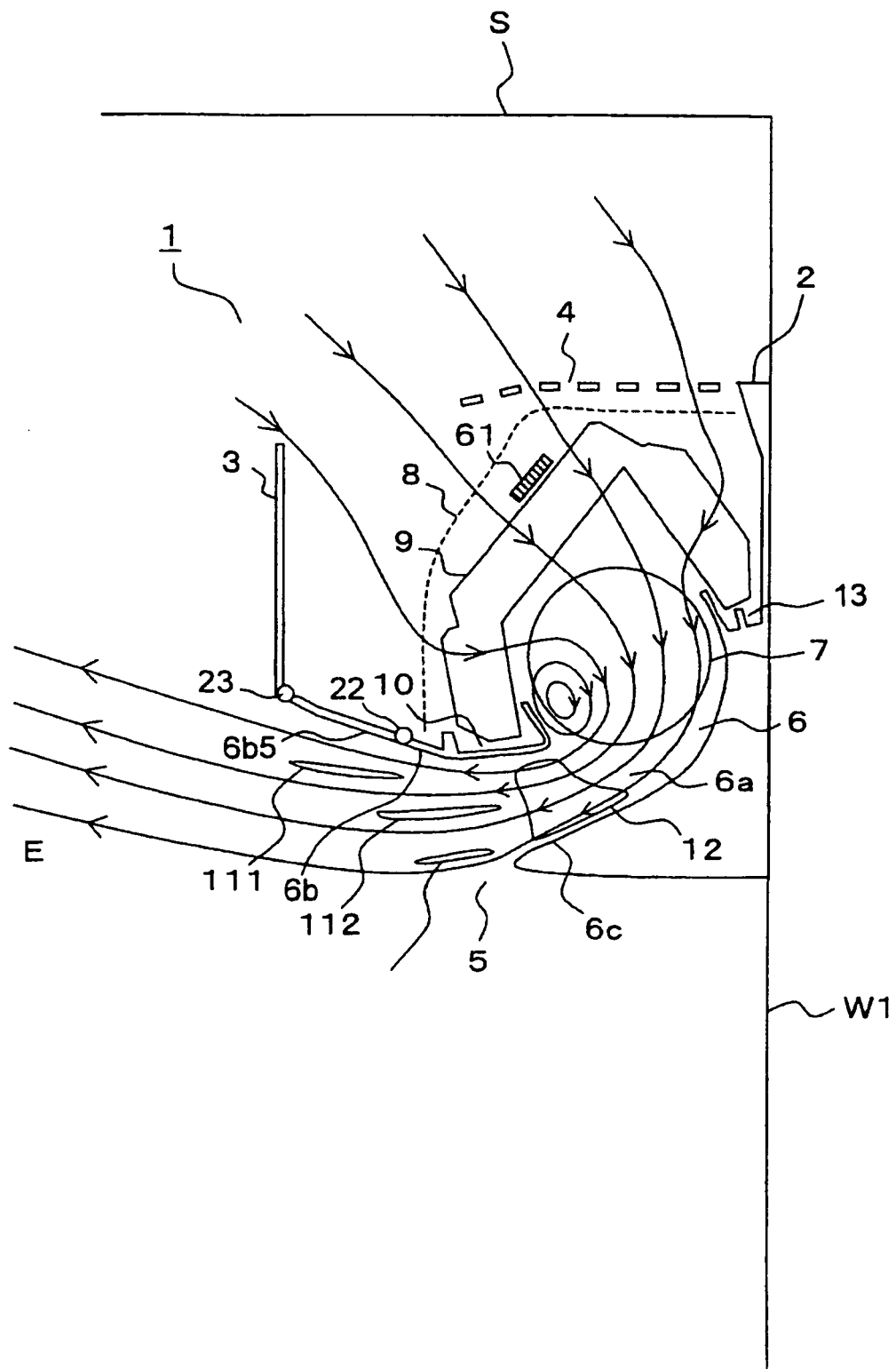


FIG.16

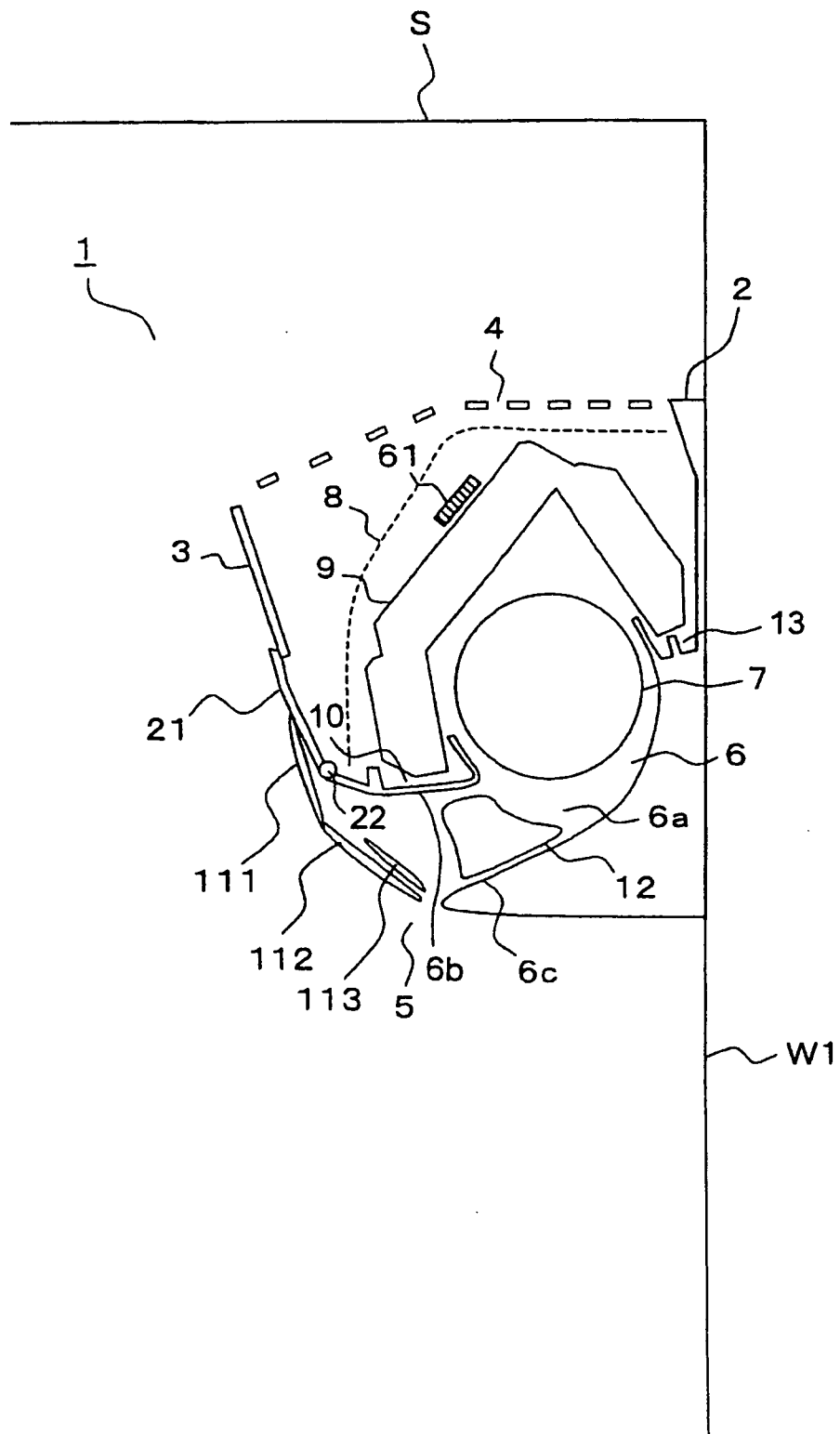


FIG.17

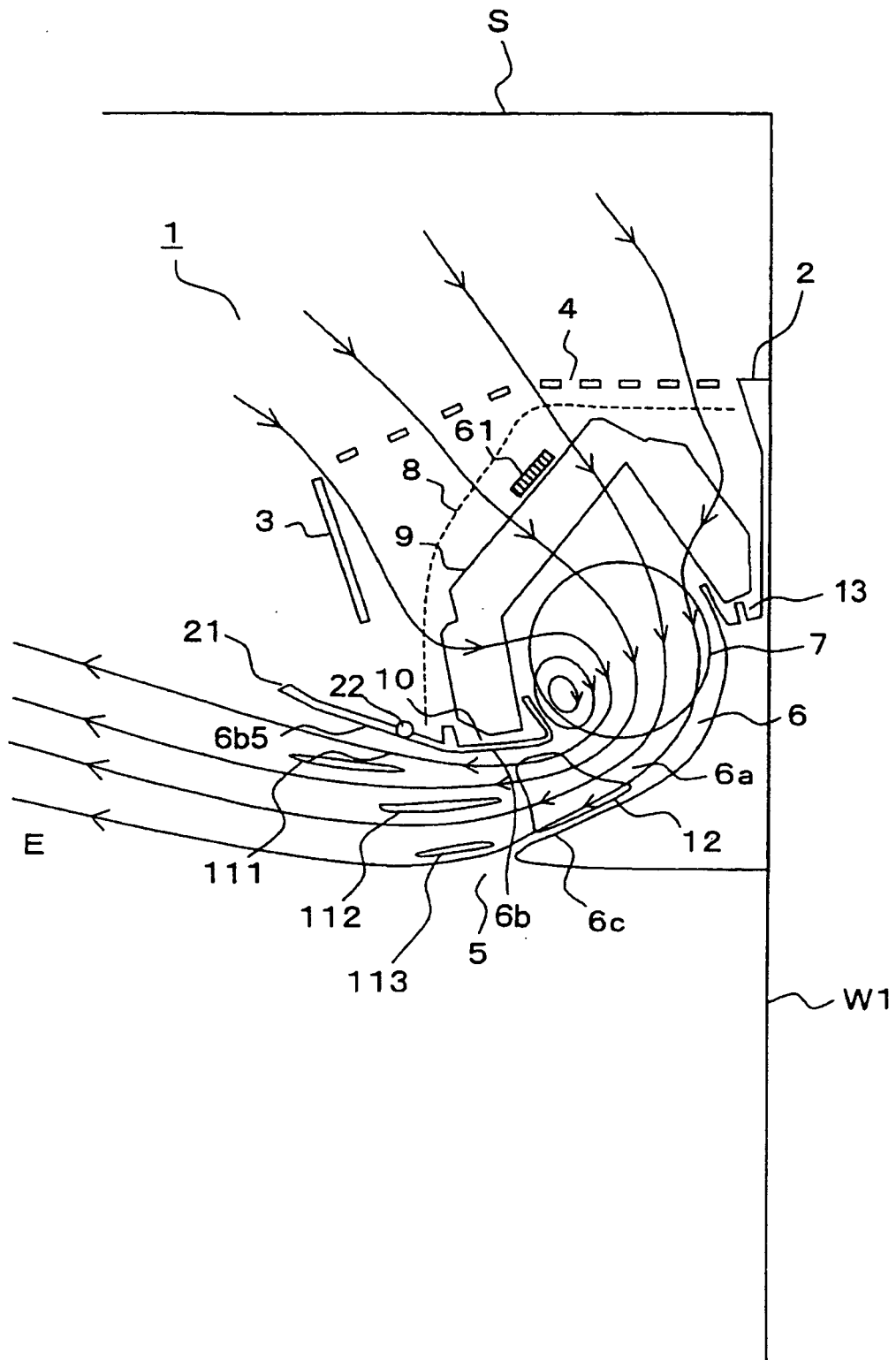


FIG.18

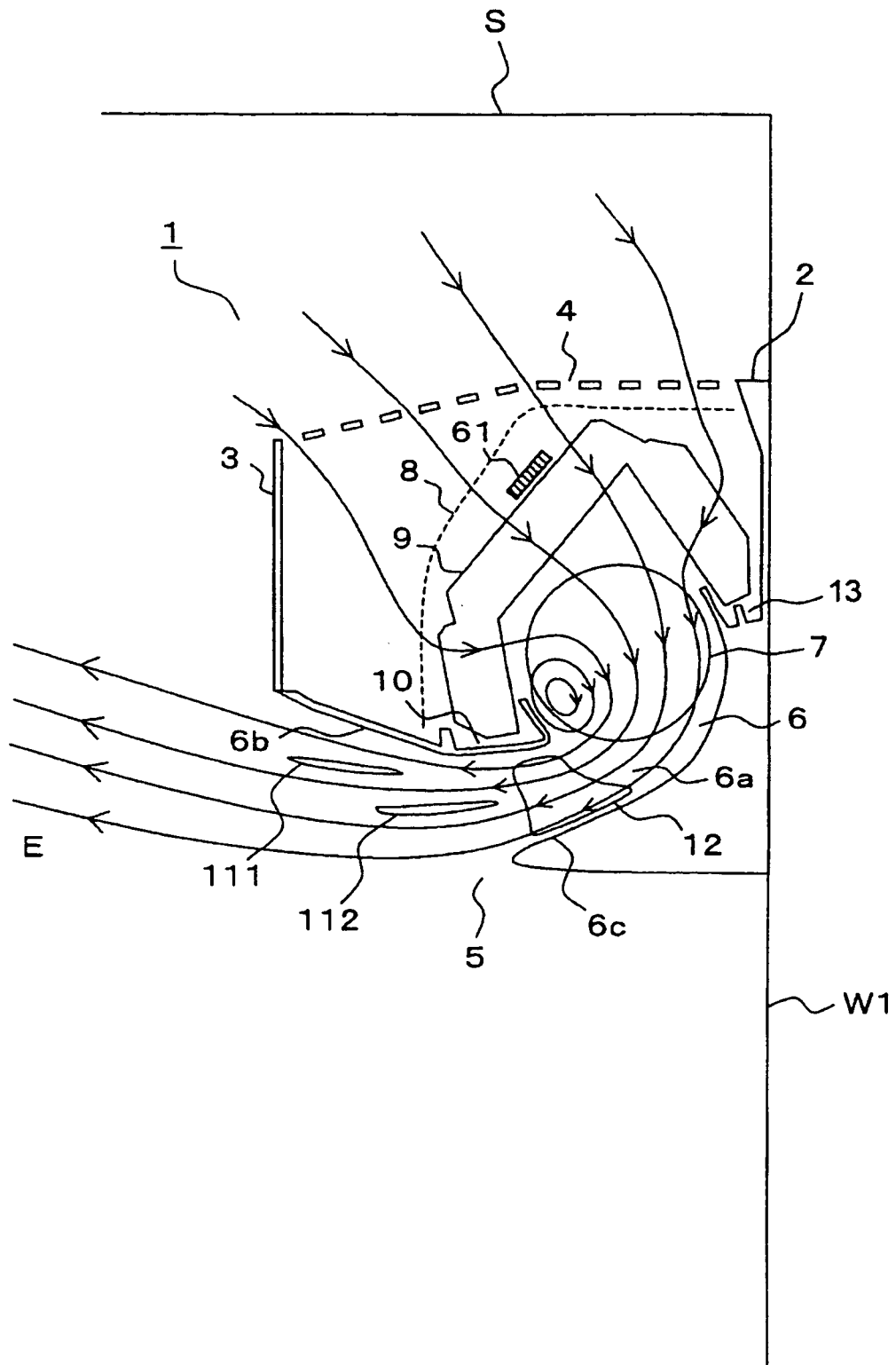
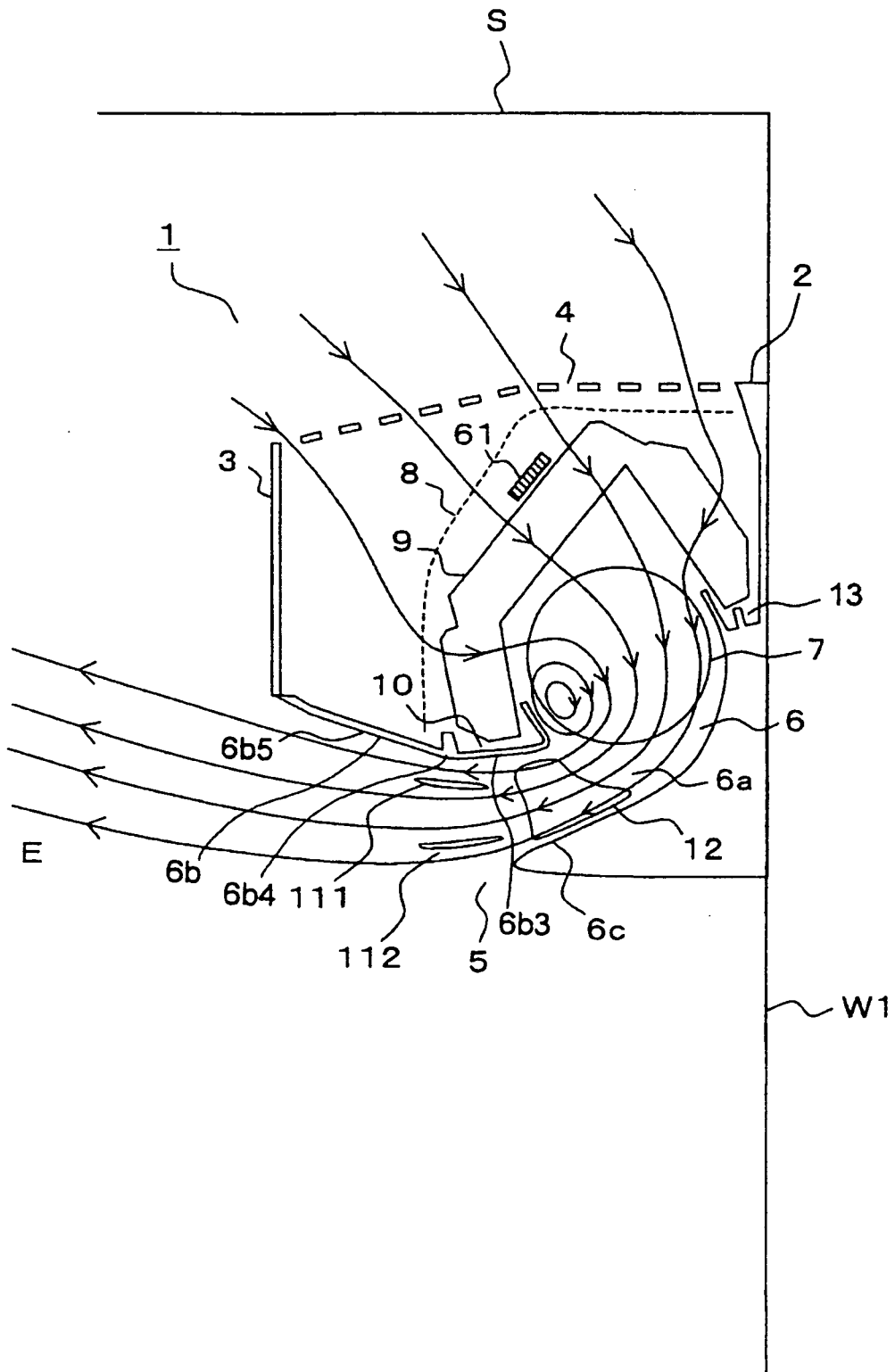


FIG.19



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2006/326032

A. CLASSIFICATION OF SUBJECT MATTER

F24F1/00(2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F24F1/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2007
Kokai Jitsuyo Shinan Koho	1971-2007	Toroku Jitsuyo Shinan Koho	1994-2007

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2005-164068 A (Sharp Corp.), 23 June, 2005 (23.06.05), Par. No. [0053]; Fig. 5 (Family: none)	1-9, 16
Y	JP 2004-69127 A (Sharp Corp.), 04 March, 2004 (04.03.04), Par. Nos. [0055], [0070], [0073]; Fig. 11 (Family: none)	1-16

☒ Further documents are listed in the continuation of Box C.☐ See patent family annex.

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
01 February, 2007 (01.02.07)Date of mailing of the international search report
13 February, 2007 (13.02.07)Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2006/326032

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 201776/1984 (Laid-open No. 116918/1986) (Daikin Industries, Ltd.), 23 July, 1986 (23.07.86), Fig. 4 (Family: none)	1-9, 16
Y	JP 2004-101128 A (Sharp Corp.), 02 April, 2004 (02.04.04), Par. No. [0070]; Fig. 12 (Family: none)	10-15

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2003028089 A [0002]
- JP 2000111082 A [0002]