US 20160223211A1

(19) United States
(12) Patent Application Publication
XUE et al.
(10) Pub. No.: US 2016/0223211 A1
(43) Pub. Date: Aug. 4, 2016

(54) **AIR CONDITIONING UNIT**

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(21) Appl. No.: **14/972,159**

(22) Filed: **Dec. 17, 2015**

(30) **Foreign Application Priority Data**

Jan. 30, 2015 (JP) 2015-017048

Publication Classification

(51) **Int. Cl.**

F24F 1/00 (2006.01)
F24F 13/24 (2006.01)

(52) **U.S. Cl.**

CPC ***F24F 1/0022*** (2013.01); ***F24F 13/24*** (2013.01); *F24F 2001/0037* (2013.01)

(57) **ABSTRACT**

The present invention provides an air conditioning unit having an indoor unit, the indoor unit including: a casing; a centrifugal fan having a hub, a shroud, and blades disposed therebetween; and an indoor heat exchanger which surrounds the centrifugal fan, the casing containing the centrifugal fan and the indoor heat exchanger. In the indoor unit, the indoor heat exchanger has a planar air inflow surface allowing an inflow of air discharged from an air outlet of the centrifugal fan, the air inflow surface is provided with a rectifying member, the rectifying member includes a support having an insertion portion fixed between fins on the air inflow surface, and a vane having a shape extending from the support toward a direction opposite a rotating direction of the centrifugal fan, the rectifying member configured to block some of the air flowing between the centrifugal fan and the air inflow surface, and an angle formed by the insertion portion and the vane in the plane orthogonal to a rotation axis of the centrifugal fan is set to become parallel to the air inflow from the air outlet to the air inflow surface at least at the hub side to increase a static pressure of the air at upstream and downstream sides of the vane.

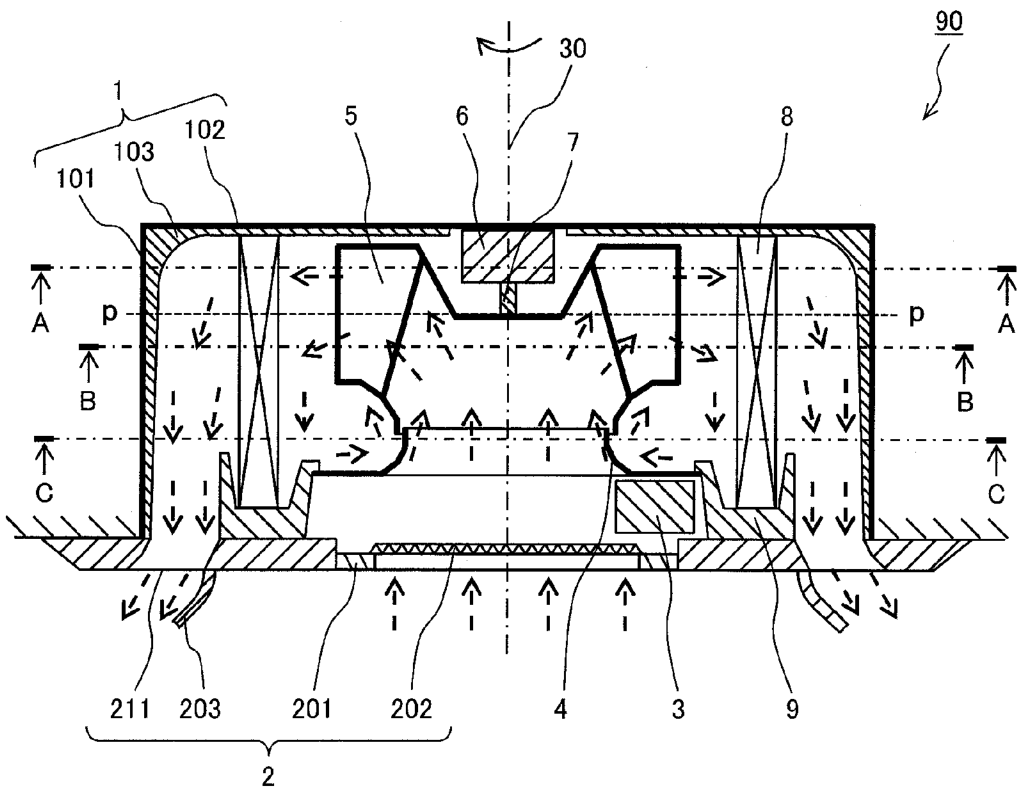


FIG. 1

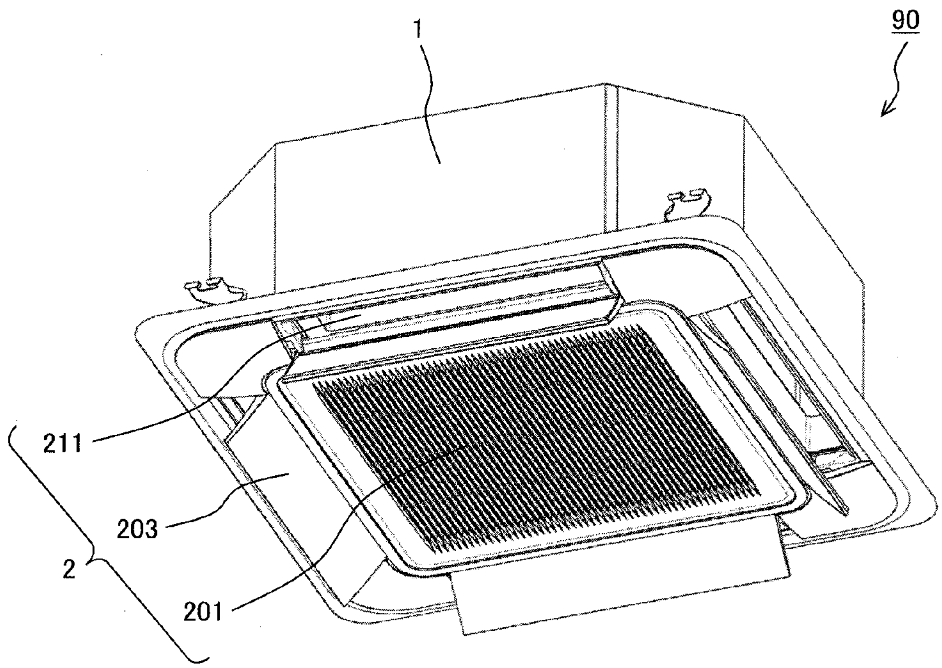


FIG. 2

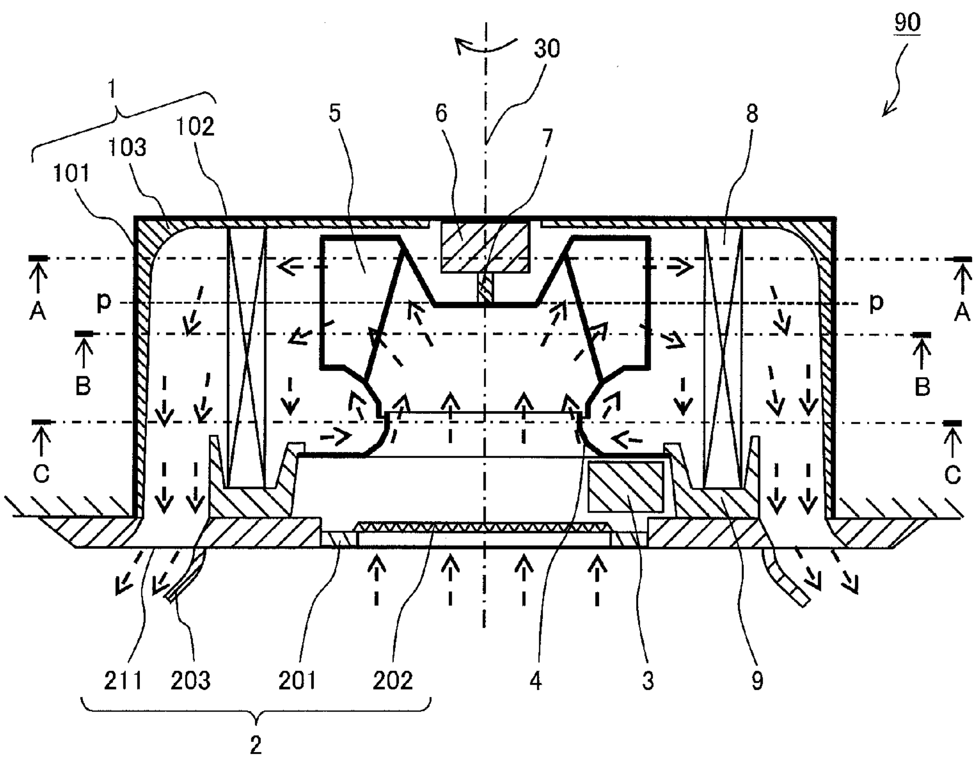


FIG. 3

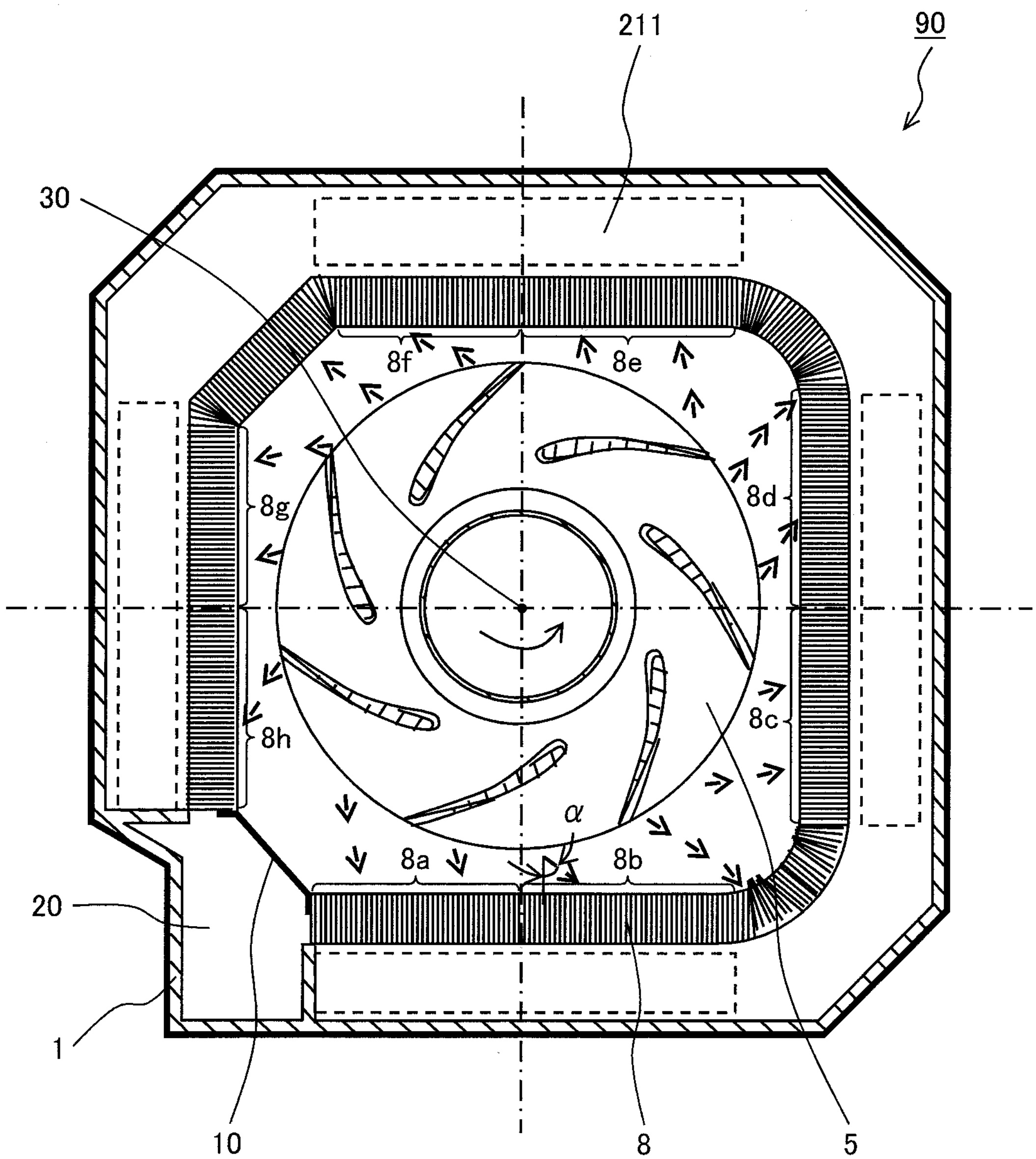


FIG. 4

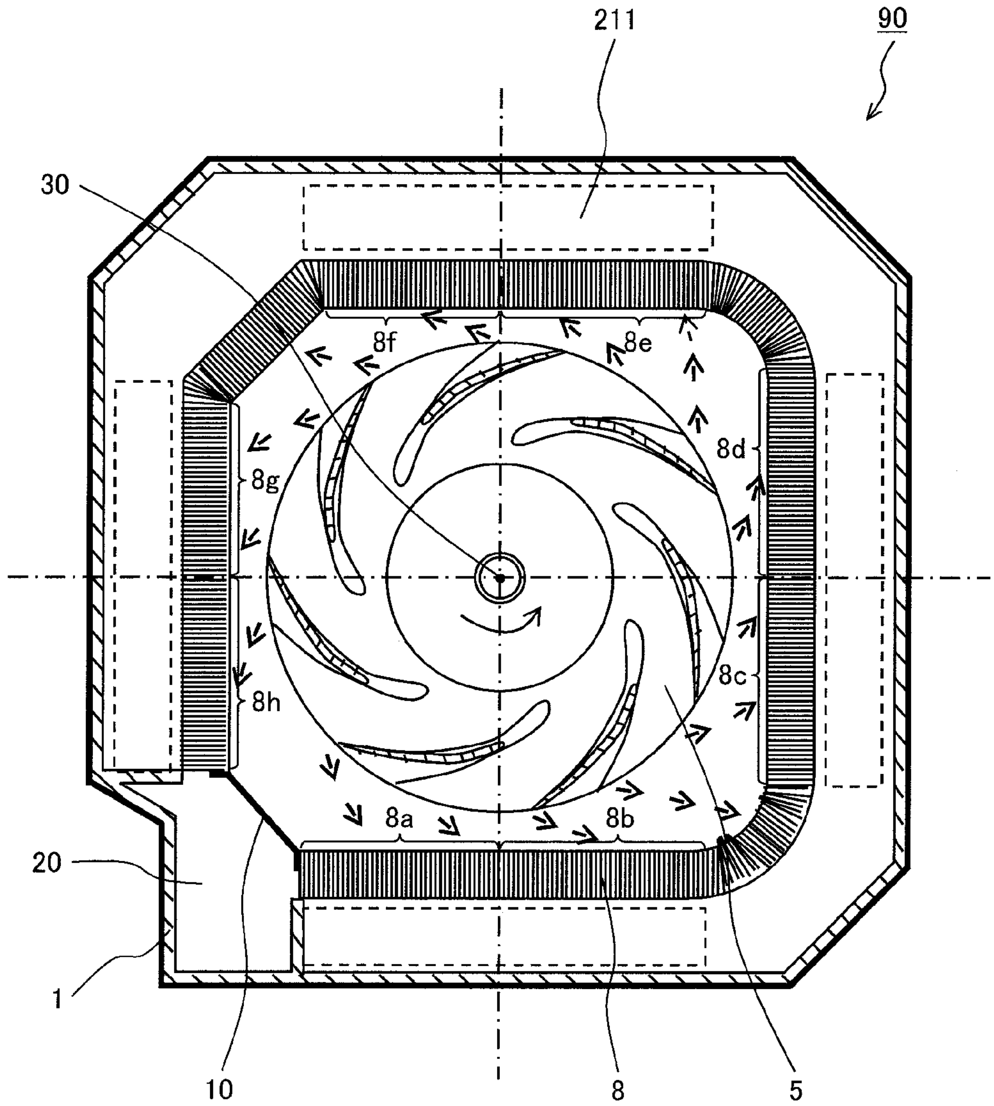


FIG. 5

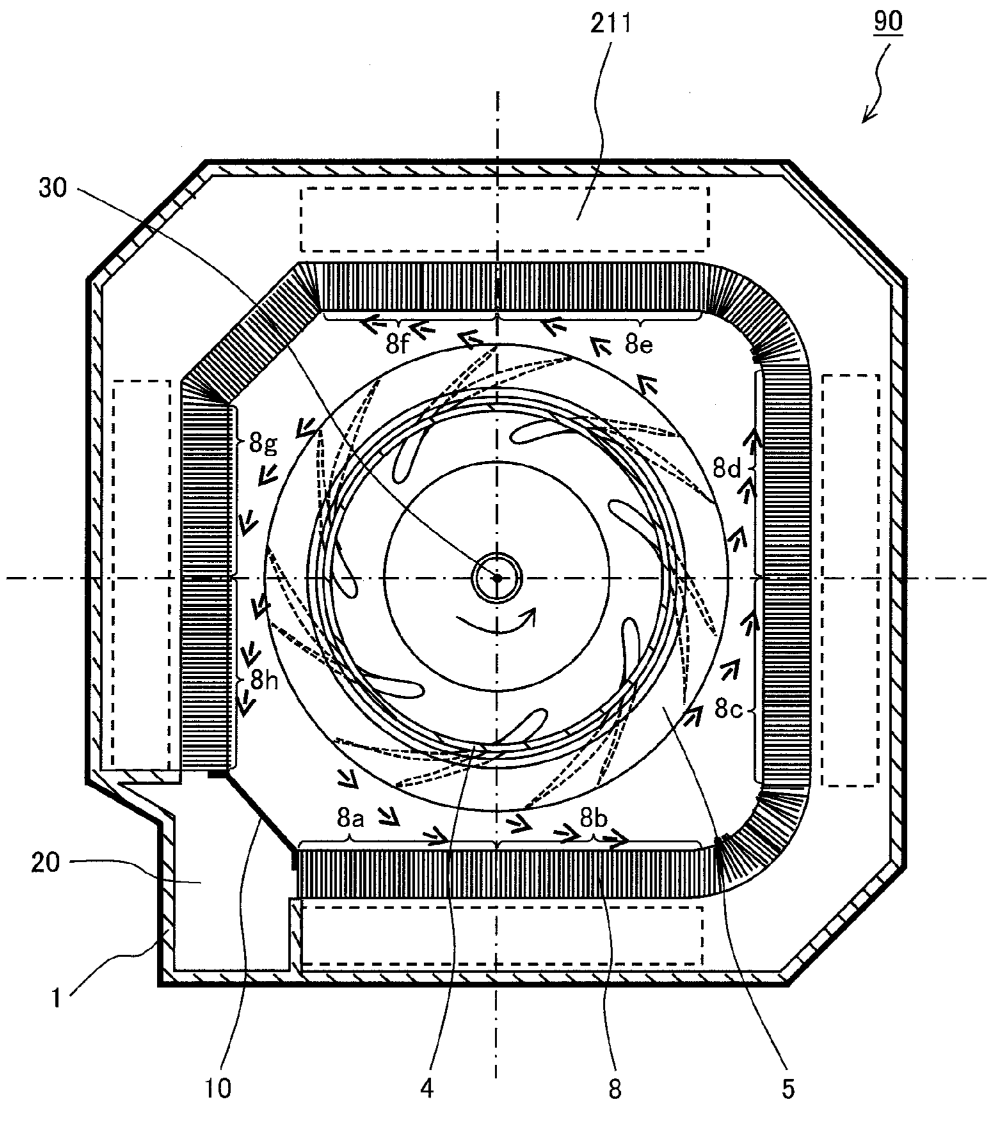


FIG. 6

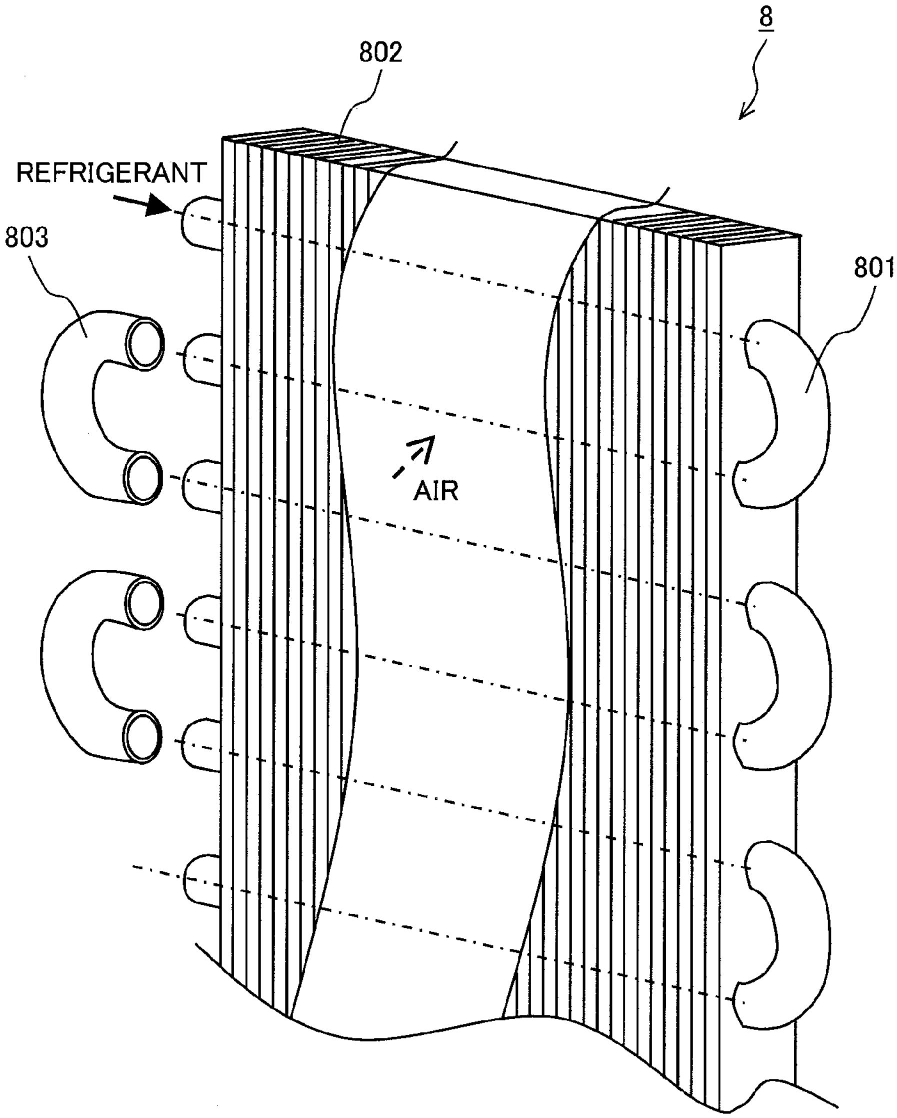


FIG. 7

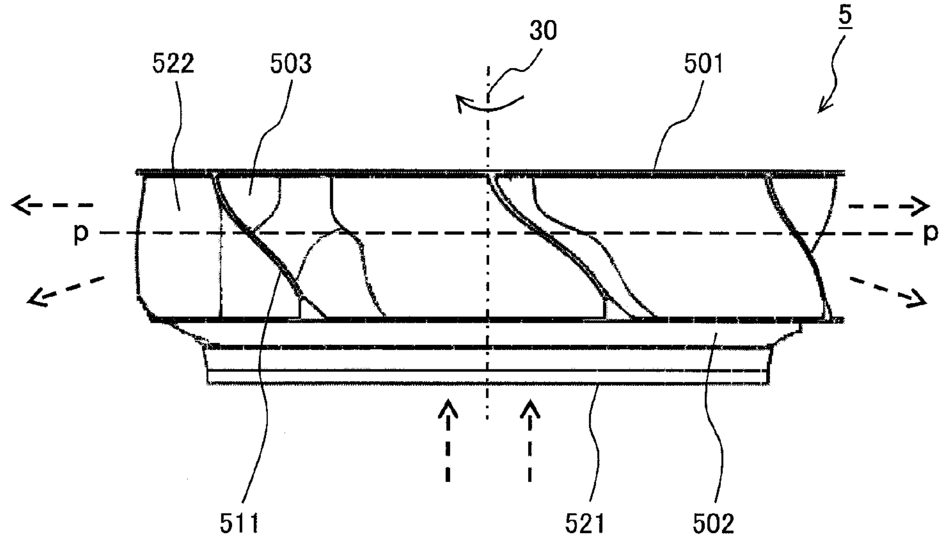
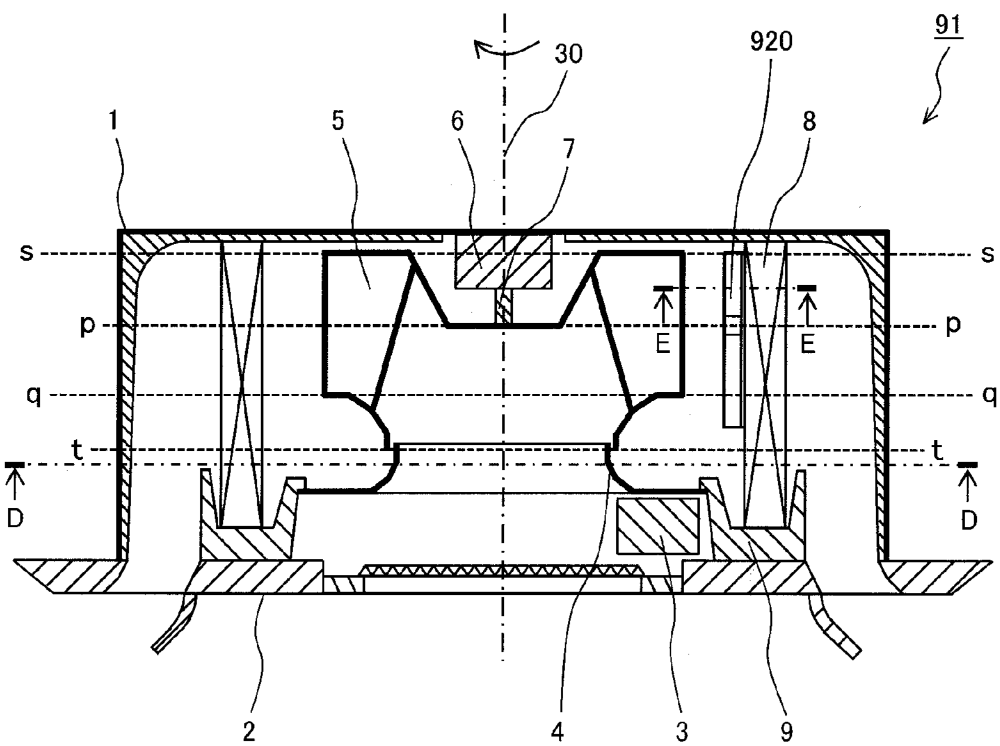

30
5
522
503
501
p
p
511
521
502

FIG. 8


30
91
920
1
5
6
7
8
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s
p
p
E
E
q
q
t
t
D
D
2
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3
9

FIG. 9

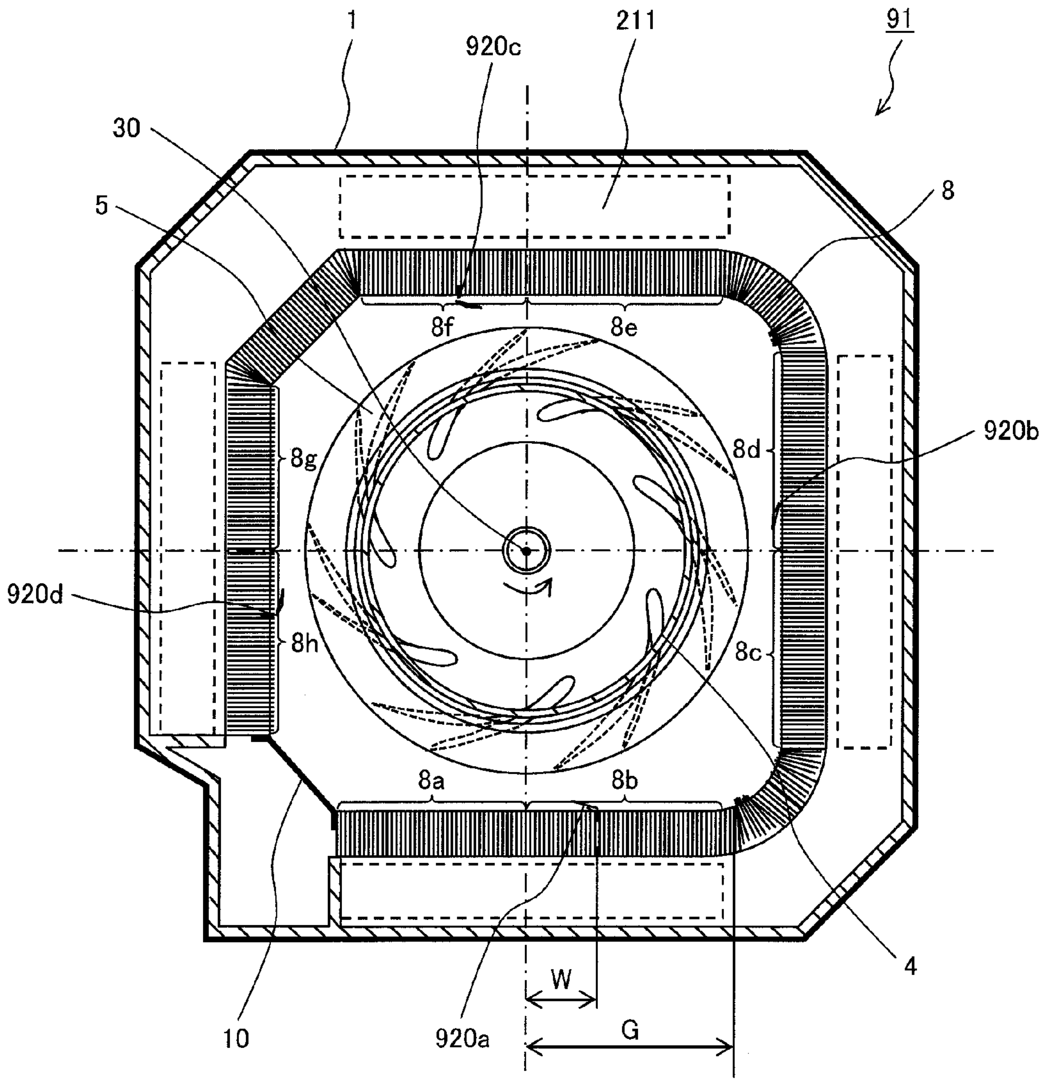


FIG. 10

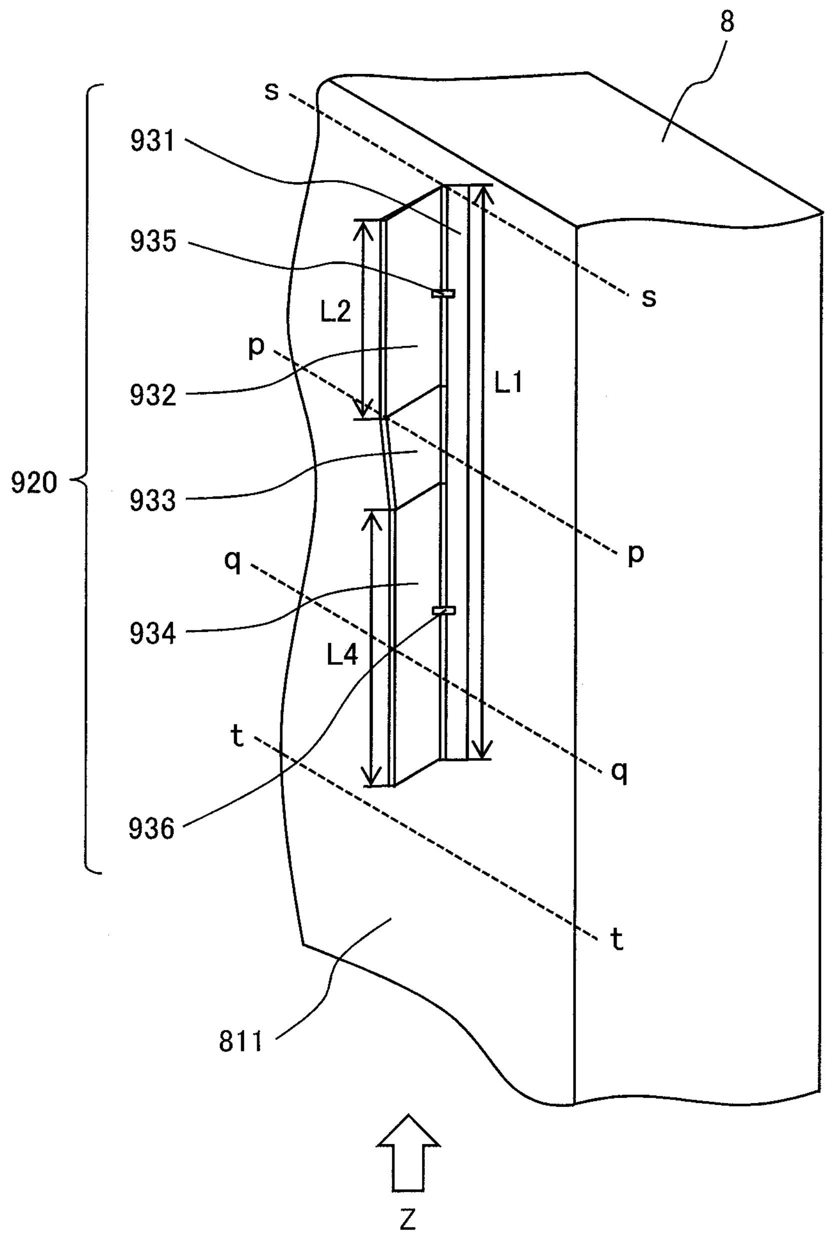


FIG. 11

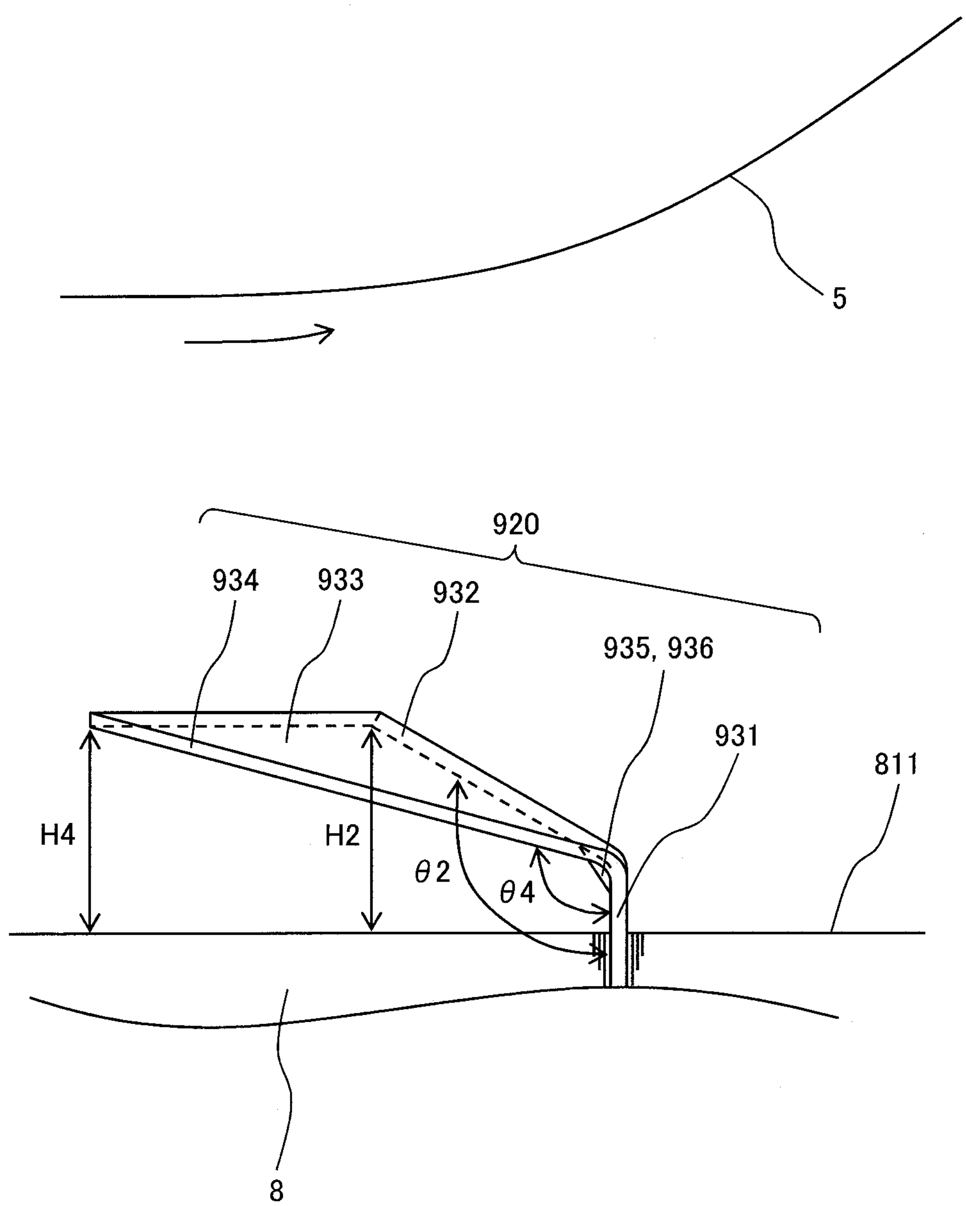


FIG. 12

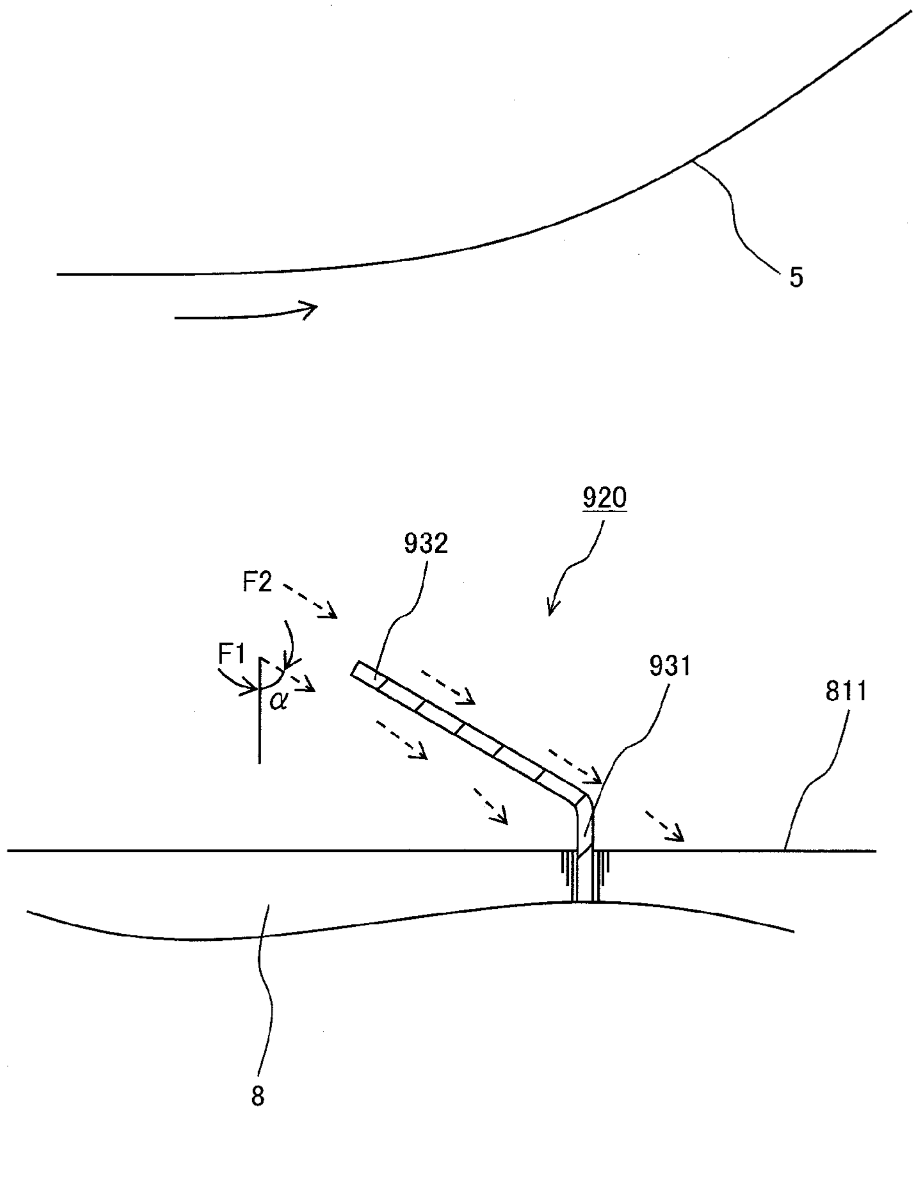


FIG. 13

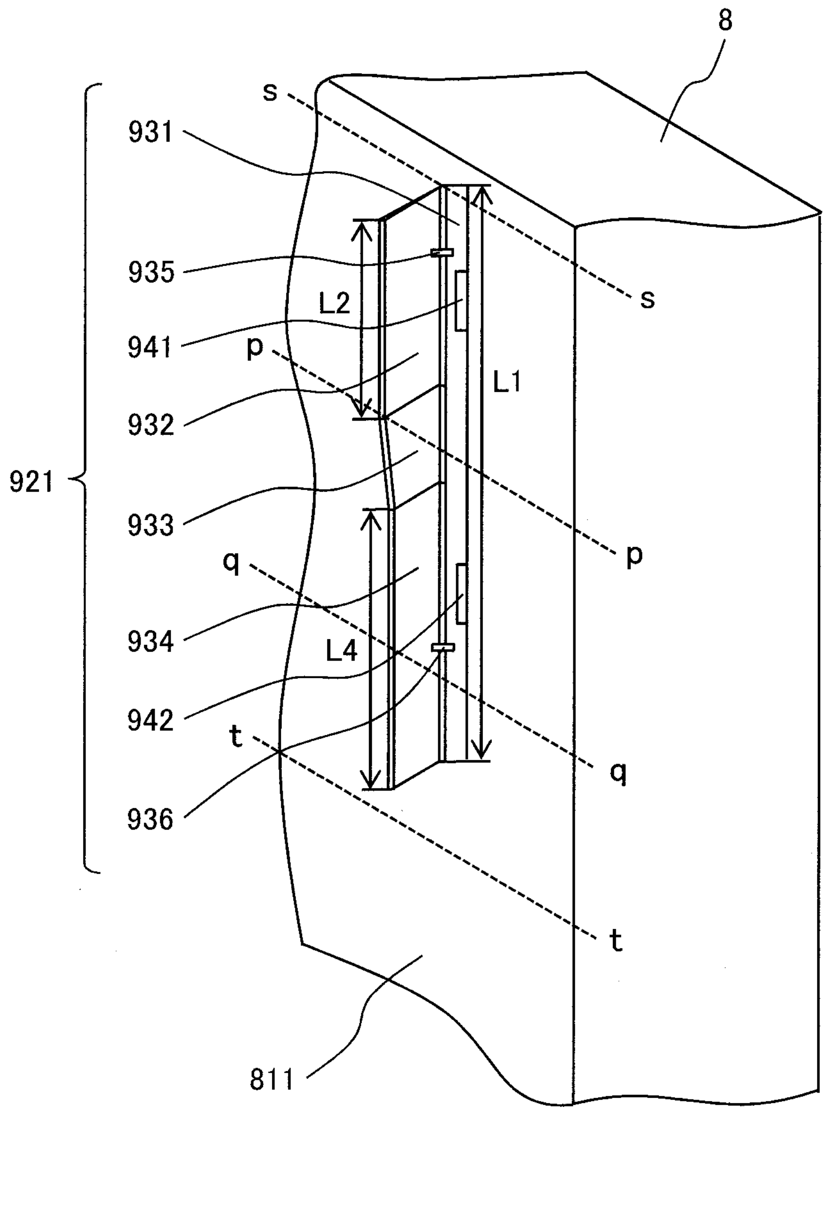


FIG. 14

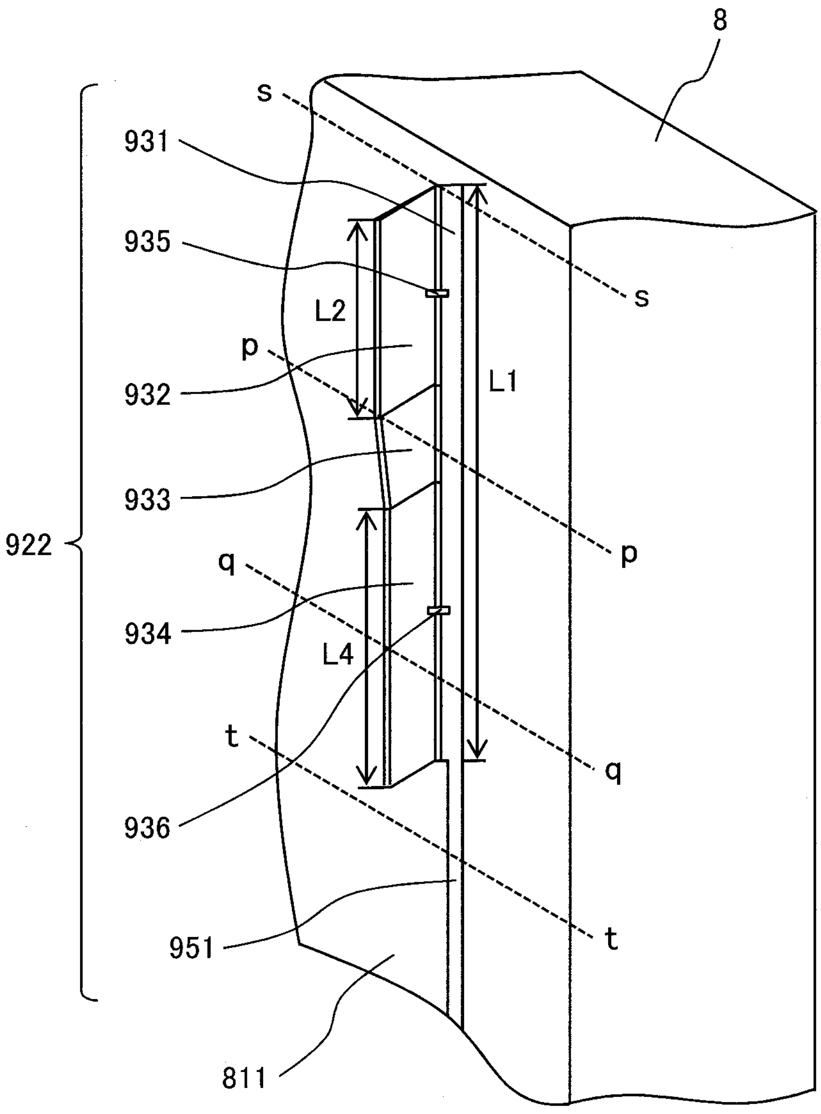


FIG. 15

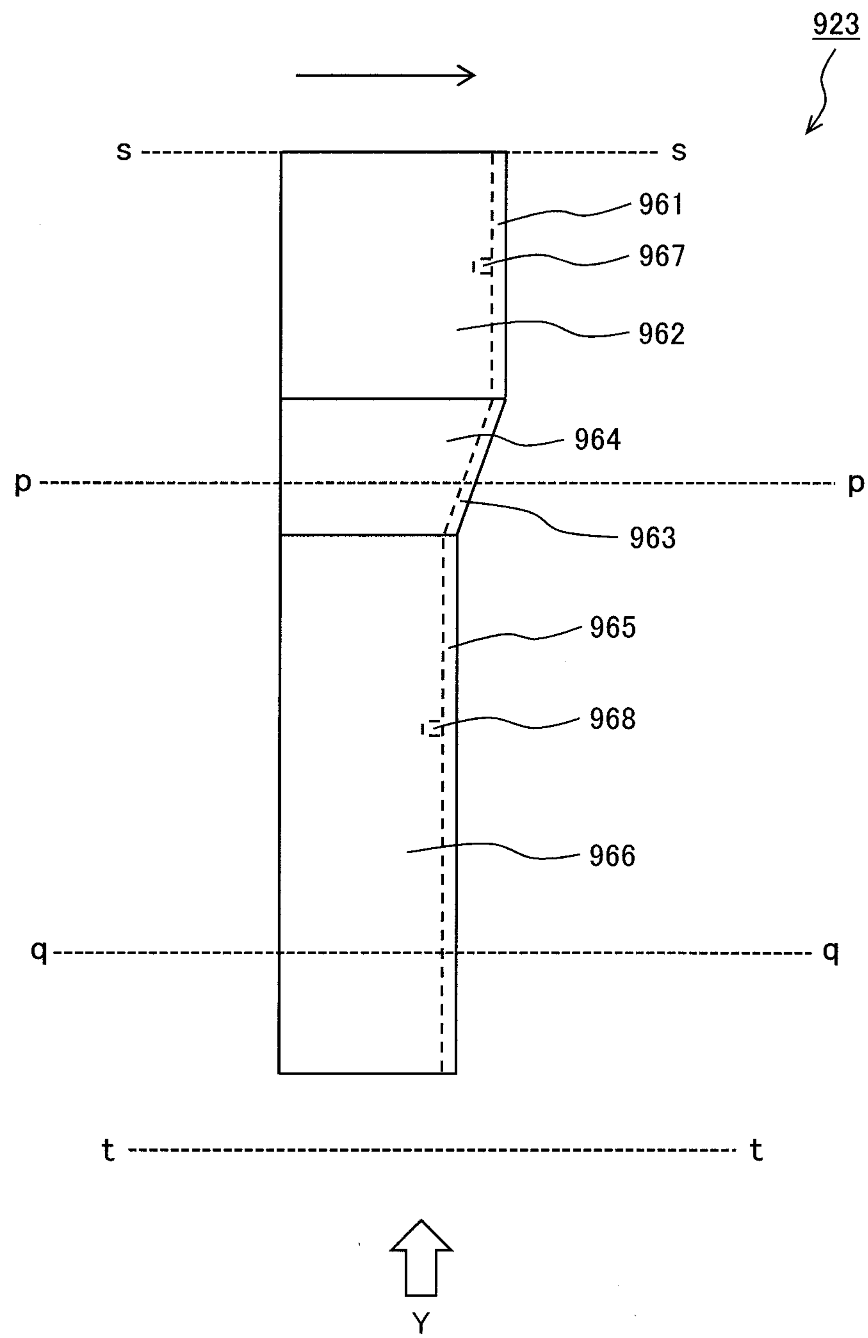


FIG. 16

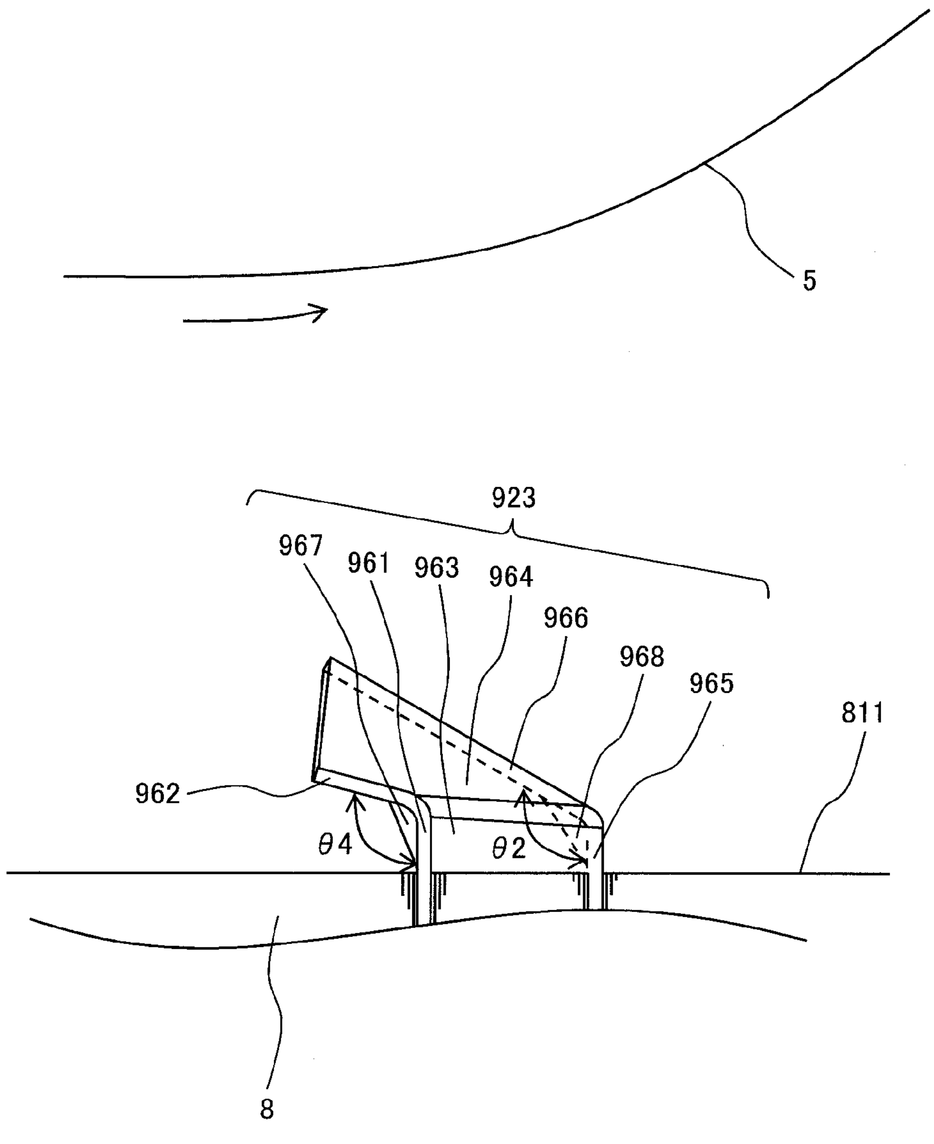


FIG. 17

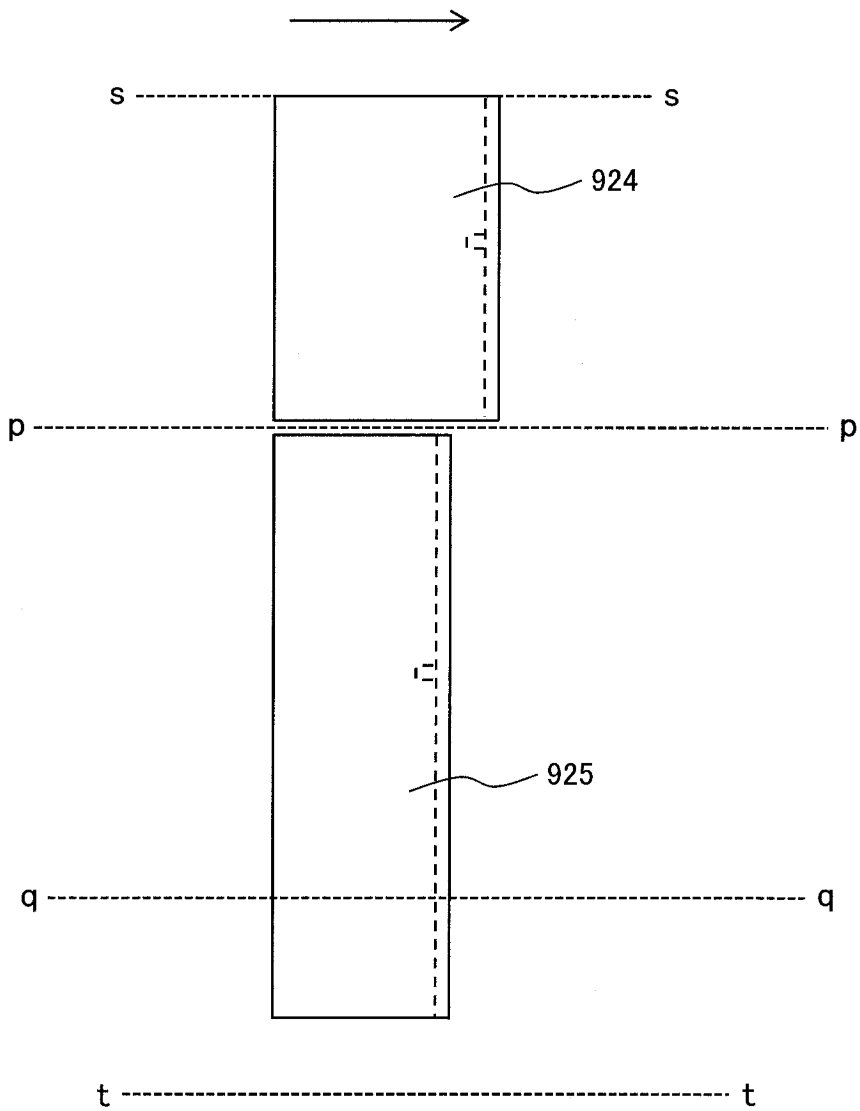


FIG. 18

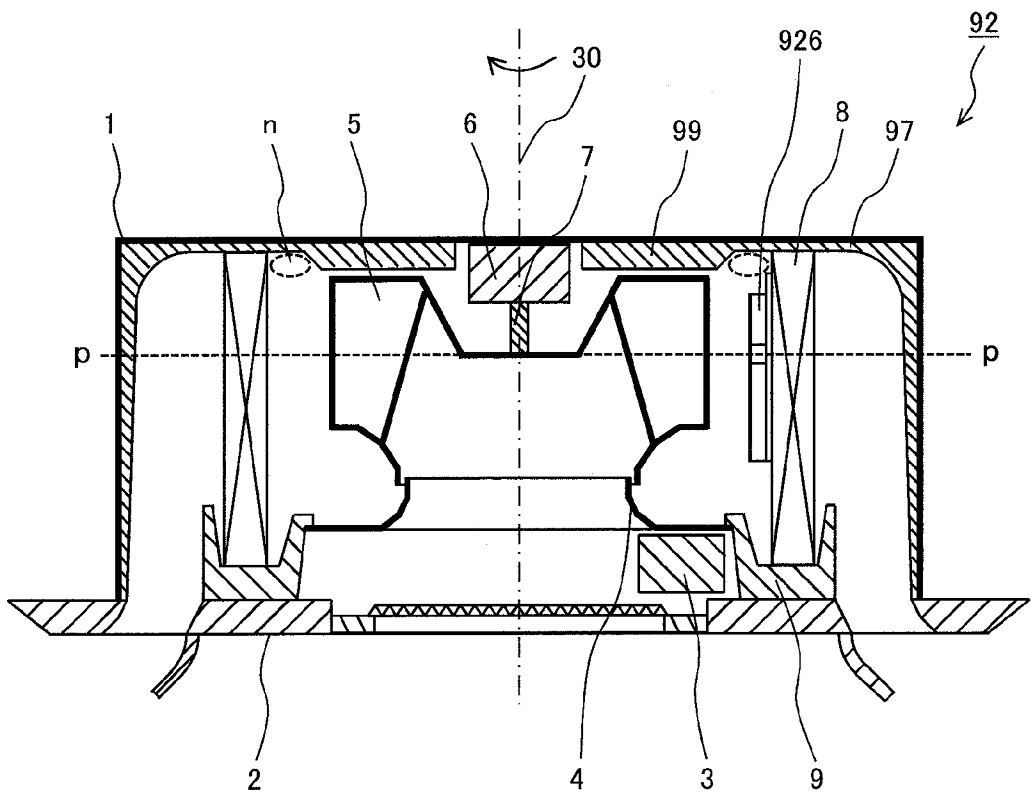
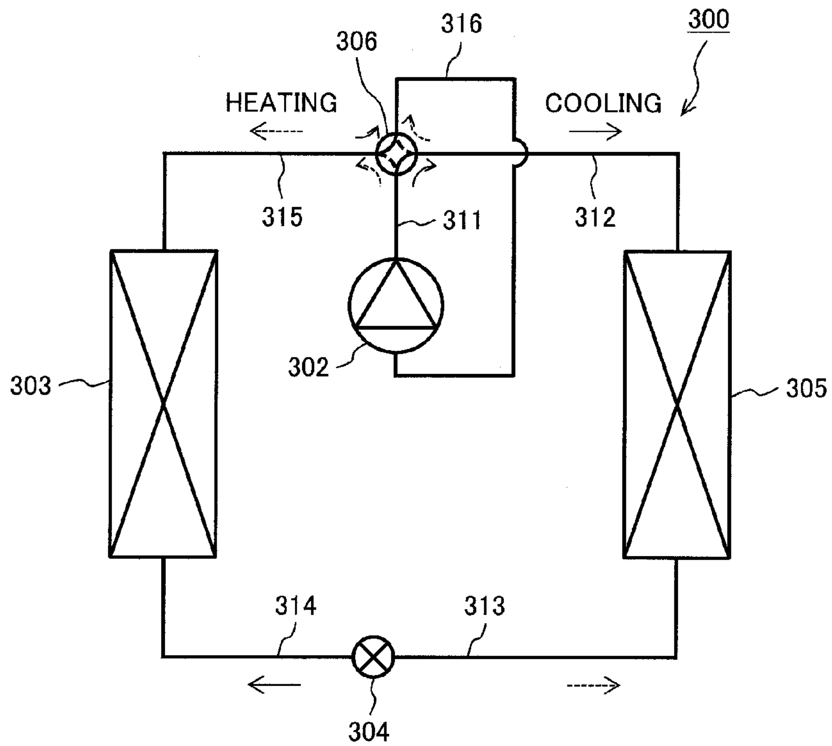


FIG. 19


300
316
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HEATING
COOLING
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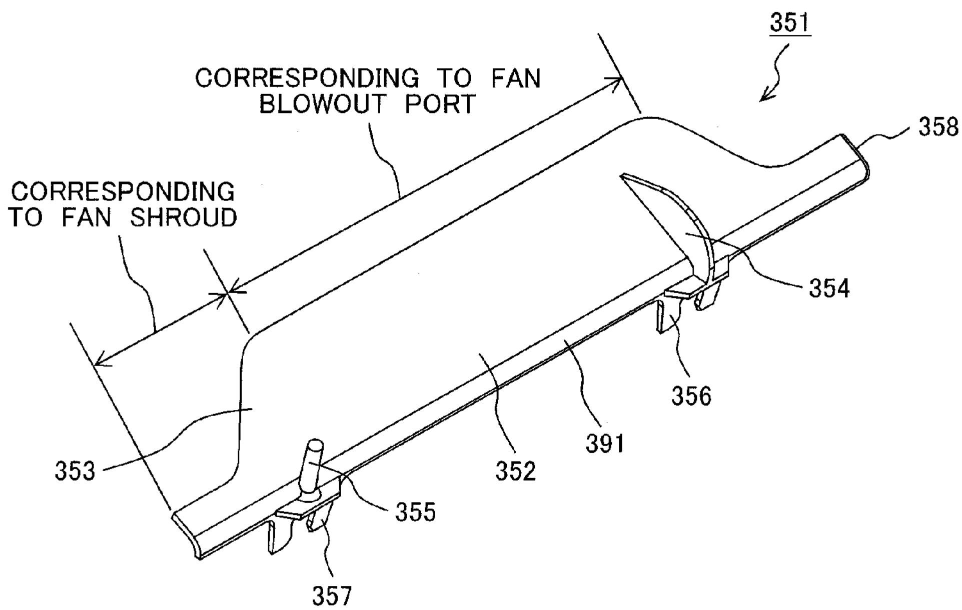
FIG. 20


351
CORRESPONDING TO FAN BLOWOUT PORT
358
CORRESPONDING TO FAN SHROUD
354
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391
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357

FIG. 21

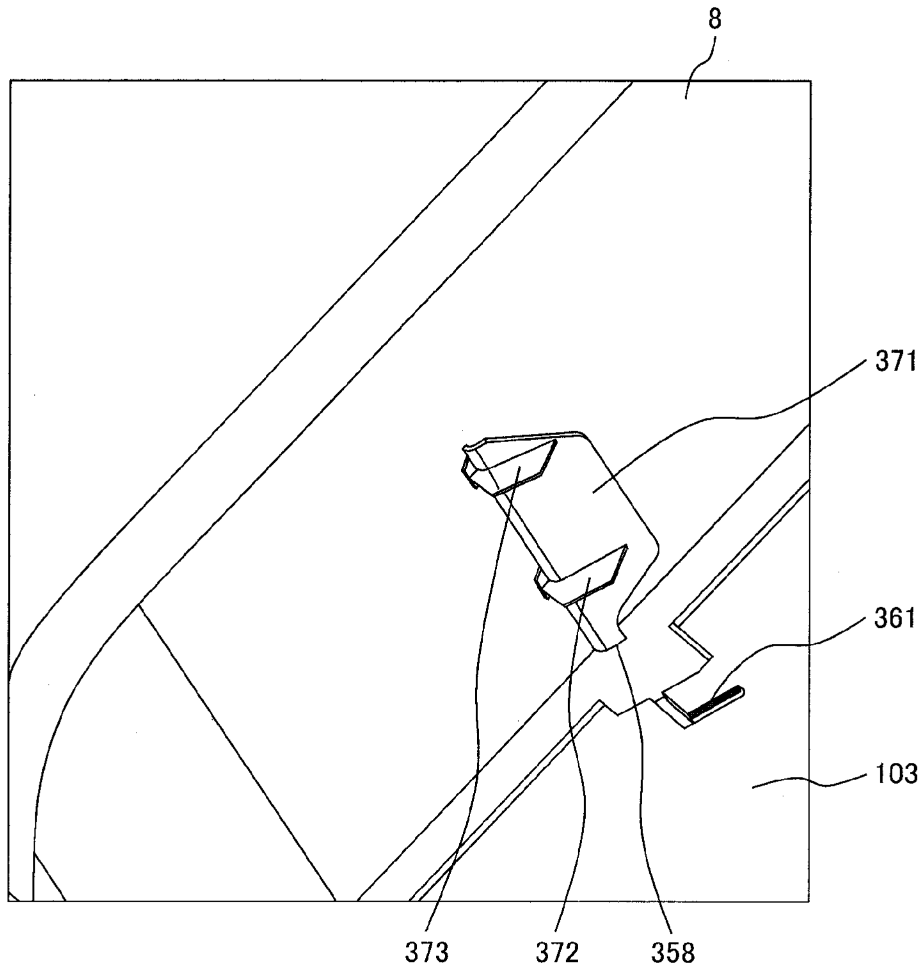

FIG. 22

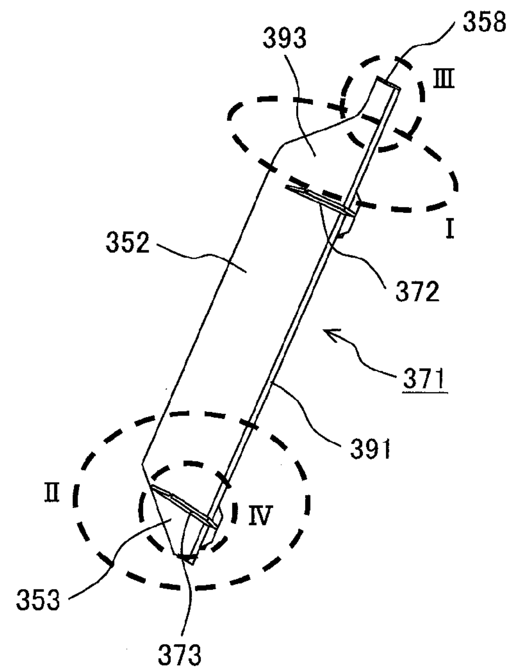
358
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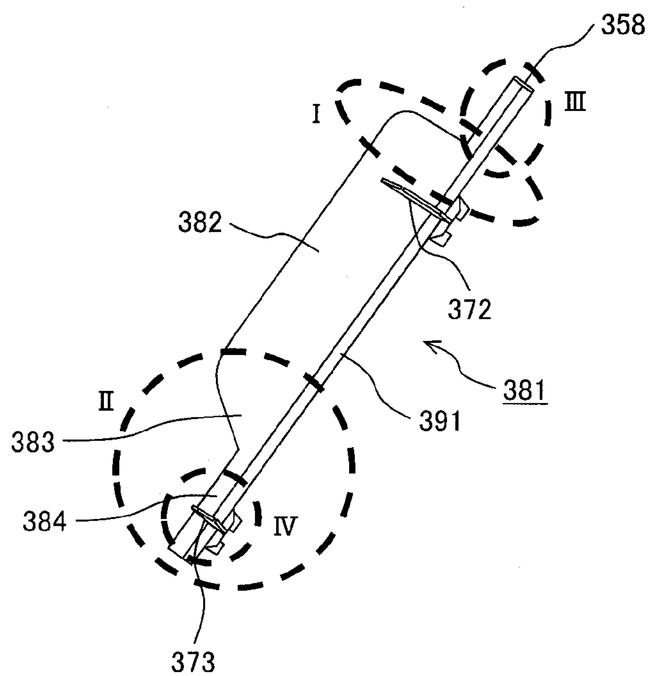
FIG. 23


358
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AIR CONDITIONING UNIT

CLAIM OF PRIORITY

[0001] The present application claims priority from Japanese Patent application serial No. 2015-017048, filed on Jan. 30, 2015, the content of which is hereby incorporated by reference into this application.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to an air conditioning unit.

[0004] 2. Description of Related Art

[0005] An air conditioning unit includes an indoor unit, an outdoor unit, and a piping for connecting the indoor unit and the outdoor unit. There are various types of indoor units including a ceiling embedded cassette type.

[0006] The ceiling embedded cassette type indoor unit generally includes a centrifugal fan which takes in air from a rotation axial direction and discharges the air from an outer periphery portion, and a heat exchanger with a polygonal shape for externally surrounding the centrifugal fan.

[0007] The above-described structure is configured that the air discharged from the centrifugal fan is obliquely directed with respect to an inner side surface or an air inflow surface of the heat exchanger, thus generating a wind noise. Generally, it has been known that the structure includes several rectifying members that protrude from the heat exchanger side toward the centrifugal fan for reducing the wind noise.

[0008] For example, Japanese Unexamined Patent Application Publication No. Hei 11-325497 (Patent Document 1) discloses the structure in which a rectifying member disposed around a position where a centrifugal fan is brought closest to a heat exchanger, which allows its primary side surface to block the air discharged from the centrifugal fan, and its secondary side surface with a smooth curved shape to guide the aforementioned air to the heat exchanger using Coanda effect.

[0009] Japanese Unexamined Patent Application Publication No. 2003-269738 (Patent Document 2) discloses an air conditioning unit configured such that any one of upper and lower ends of a rectifying plate disposed on an indoor unit body having a centrifugal fan is located at an anterior position of the other end in a fan rotating direction, and an intermediate section is inclined to a rotation axis.

[0010] Japanese Unexamined Patent Application Publication No. 2014-129994 (Patent Document 3) discloses an indoor unit of an air conditioning unit configured to have a slope or a stepped shaped rectifying plate so that a distance between a heat exchanger and a rectifying plate at a top panel side becomes larger than the one at a lower side.

SUMMARY OF THE INVENTION

[0011] The generally employed structure disclosed in Patent Document 1 has the rectifying plate extending toward a rotating direction.

[0012] The generally employed structure disclosed in Patent Document 2 discloses the rectifying plate as a planar plate perpendicular to the air inflow surface. In any of the aforementioned cases, the rectifying plate serves to block a part of the flow to reduce the wind noise. However, the aforementioned structure may generate a region behind the rectifying plate where an air flow velocity is significantly decreased, leading to a deteriorated heat exchanging performance and an increased blower power.

[0013] In the generally employed structure disclosed in Patent Document 3, an angle formed by the rectifying plate and the air inflow surface continuously varies in a fan rotation axial direction. However, an air flow direction exhibits a steep change in the fan rotation axial direction in accordance with a shape of a centrifugal fan blade, and a positional relationship with an air outlet. In this case, a part of the rectifying plate may have its direction largely deviated from the air flow direction. As a result, the flow separates from a surface of the rectifying plate, resulting in a lessened improvement effect. Meanwhile, the rectifying plate with the stepped shape causes a steep change in a distance between the rectifying plate and the air inflow surface around a stepped section. This may easily cause turbulence in the flow.

[0014] An object of the present invention provides an air conditioning unit which has an indoor unit including a centrifugal fan, the indoor unit being configured to increase a static pressure of air both at an upstream side and a downstream side of a vane of a rectifying member (a rectifying plate) so as to realize a reduction in a blower power and an improvement in a heat exchanging performance.

[0015] The present invention provides an air conditioning unit having an indoor unit, the indoor unit including: a casing; a centrifugal fan having a hub, a shroud, and blades disposed therebetween; and an indoor heat exchanger which surrounds the centrifugal fan, the casing containing the centrifugal fan and the indoor heat exchanger. In the indoor unit, the indoor heat exchanger has a planar air inflow surface allowing an inflow of air discharged from an air outlet of the centrifugal fan, the air inflow surface is provided with a rectifying member, the rectifying member includes a support having an insertion portion fixed between fins on the air inflow surface, and a vane having a shape extending from the support toward a direction opposite a rotating direction of the centrifugal fan, the rectifying member configured to block some of the air flowing between the centrifugal fan and the air inflow surface, and an angle formed by the insertion portion and the vane in the plane orthogonal to a rotation axis of the centrifugal fan is set to become parallel to the air inflow from the air outlet to the air inflow surface at least at the hub side to increase a static pressure of the air at upstream and downstream sides of the vane.

[0016] According to the present invention, in the indoor unit including the centrifugal fan for the air conditioning unit, it is possible to increase an air static pressure both at the upstream and downstream sides of the vane of the rectifying member (rectifying plate). This makes it possible to realize a reduced blower power and an improved heat exchanging performance, resulting in a highly efficient air conditioning unit.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] FIG. **1** is an external perspective view of a ceiling embedded cassette type indoor unit;

[0018] FIG. **2** is a longitudinal section of a ceiling embedded cassette type indoor unit employed generally;

[0019] FIG. **3** is a transverse section of the indoor unit taken along line A-A of FIG. **2**;

[0020] FIG. **4** is a transverse section of the indoor unit taken along line B-B of FIG. **2**;

[0021] FIG. **5** is a transverse section of the indoor unit taken along line C-C of FIG. **2**;

[0022] FIG. **6** is a partial perspective view schematically illustrating a heat exchanger;

[0023] FIG. **7** is a side view schematically illustrating a centrifugal fan according to the present invention;

[0024] FIG. **8** is a longitudinal section of an indoor unit according to a first embodiment;

[0025] FIG. **9** is a transverse section of the indoor unit taken along line D-D of FIG. **8**;

[0026] FIG. **10** is a partial perspective view of a rectifying member according to the first embodiment;

[0027] FIG. **11** is a bottom view of the rectifying member according to the first embodiment;

[0028] FIG. **12** is a partial sectional view of a flow field around the rectifying member according to the first embodiment, taken along line E-E of FIG. **8**;

[0029] FIG. **13** is a partial perspective view of a rectifying member according to a second embodiment;

[0030] FIG. **14** is a partial perspective view of a rectifying member according to a third embodiment;

[0031] FIG. **15** is a side view of a rectifying member according to a fourth embodiment;

[0032] FIG. **16** is a bottom view of the rectifying member according to the fourth embodiment;

[0033] FIG. **17** is a side view of a modified example of the rectifying member according to the fourth embodiment;

[0034] FIG. **18** is a longitudinal section of an indoor unit according to a fifth embodiment;

[0035] FIG. **19** is a schematic block diagram of an air conditioning unit according to the present invention;

[0036] FIG. **20** is a perspective view of a rectifying member according to a sixth embodiment;

[0037] FIG. **21** is a perspective view representing a state where the rectifying member (a modified example of the sixth embodiment) according to the present invention is disposed on the indoor unit;

[0038] FIG. **22** is a perspective view of the modified example of the rectifying member according to the sixth embodiment; and

[0039] FIG. **23** is a perspective view of another modified example of the rectifying member according to the sixth embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0040] An indoor unit according to the present invention will be described in detail referring to the drawings.

[0041] FIGS. **1** to **5** illustrate an example of a generally employed indoor unit **90** of a ceiling embedded cassette type to which the present invention has not been applied. FIG. **1** is an external perspective view. FIG. **2** is a longitudinal section of the unit including a fan rotation axis. FIGS. **3** to **5** are transverse sections taken along lines A-A, B-B, and C-C of FIG. **2**, respectively.

[0042] The drawings show a casing **1**, a panel **2**, an electrical component box **3**, a bell mouth **4**, a centrifugal fan **5**, a motor **6**, a shaft **7**, a heat exchanger (an indoor heat exchanger) **8**, a drain pan **9**, a partition **10**, a blowout port **211**, and a rotation axis **30** of the centrifugal fan **5**. Referring to the drawings, a solid arrow represents a rotating direction of the centrifugal fan **5**, and a dashed arrow represents an air flow direction. Furthermore, referring to FIGS. **3** to **5**, each rectangle drawn by a dashed line represents a position of the blowout port **211**.

[0043] The casing **1** includes a side plate **101** that constitutes a side surface, a top plate **102** for covering a top surface, and a heat insulating material **103** for covering inner sides of the side plate **101** and the top plate **102**. The casing **1** is embedded in a ceiling so that a surface of the panel **2** is directed downward to a room interior.

[0044] A grill **201** for air intake from indoor is provided at a center of the panel **2** arranged at a bottom of the casing **1**. A filter **202** is disposed on the grill **201** for removing dust in the air. The blowout ports **211** as four thin rectangular openings are provided each at an outer periphery of the grill **201**, through which air at a temperature conditioned by the air conditioning unit **90** is fed into the room. Each of the blowout ports **211** is provided with a louver **203** for adjusting an air blowing direction.

[0045] Inside the casing **1**, there are provided the electric component box **3** for storing an indoor control board (not shown), the bell mouth **4** for guiding an intake air from the grill **201** to the centrifugal fan **5**, the centrifugal fan **5** for discharging the intake air from the rotation axial direction to an outer periphery portion, the motor **6** for driving the centrifugal fan **5**, the shaft **7** for connecting the centrifugal fan **5** and the motor **6**, the heat exchanger **8** for exchanging heat between the air discharged from the centrifugal fan **5** and the refrigerant, and the drain pan **9** disposed below the heat exchanger **8** for receiving dew condensation water generated in the heat exchanger **8** during a cooling operation.

[0046] The heat exchanger **8** of cross fin tube type as illustrated in FIG. **6**, for example, includes a plurality of U-shape heat transfer pipes **801** which are arranged in parallel with one another, a large number of thin plate fins **802** arranged at substantially uniform intervals along the axial direction of the heat transfer pipe **801**, and a plurality of return bends **803** for connecting the heat transfer pipes **801** with one another. The heat transfer pipes **801** that pierce through the fins **802** are expanded so as to be brought into close contact with the fins **802**. This makes it possible to exchange heat between the refrigerant flowing through the heat transfer pipes **801** and air flowing through the gap between the fins **802** via the wall surfaces of the heat transfer pipes **801** and the fins **802**.

[0047] Referring to FIG. **3**, the heat exchanger **8** of the indoor unit **90** is bent into substantially a pentagonal shape to surround the centrifugal fan **5**. Both ends of the heat exchanger **8** are connected with the partition **10**. A machine chamber **20** for storing an expansion valve (not shown) and the like is defined by the partition **10** and the casing **1**.

[0048] FIG. **7** represents an example of the centrifugal fan **5** including a hub **501**, a shroud **502** opposite the hub **501** in the fan rotation axial direction, and blades **503** which are arranged at uniform intervals between the hub **501** and the shroud **502** in the circumferential direction.

[0049] The hub **501** has a boss (not shown) at a center for fixing the centrifugal fan **5** to the shaft **7**. Meanwhile, the shroud **502** has a circular opening, that is, an air inlet **521** at a center for air intake from the fan rotation axial direction.

[0050] The blade **503** is twisted (S-shape), and inclined in a direction opposite the fan rotating direction. A blade rear edge **511** (a rear edge of the blade **503**) seen from an outer peripheral side has an inflection point at which the shape changes from convex to concave along the fan rotation axial direction. Referring to the drawing, a height of the inflection point of the blade rear edge is indicated by a line p-p. An air outlet **522** for discharging the air is formed at the outer periphery portion between the two adjacent blades **503**.

[0051] The air flow will be described using dashed arrows.

[0052] Upon rotation of the centrifugal fan **5** driven by the motor **6**, the indoor air is taken into the indoor unit **90** through the grille **201** as shown in FIG. **2**, and is drawn into the centrifugal fan **5** after passing through the filter **202** and the bell mouth **4**. The air boosted by the centrifugal fan **5** is discharged from the outer periphery portion of the centrifugal fan **5**, and flows into the heat exchanger **8**. The heat exchanger **8** is configured to exchange heat between the air flowing through the fins **802** and the refrigerant flowing in the heat transfer pipes **801** for heating or cooling operation. The air is then fed indoor from the blowout port **211** after passing through the section defined by the casing **1** and the drain pan **9**.

[0053] FIGS. **3** to **5** are transverse sections perpendicular to the fan rotation axis, each showing the air flow from the centrifugal fan **5** to the heat exchanger **8**. The respective sections represent the phases between the hub of the centrifugal fan **5** and the inflection point of the blade rear edge (corresponding to FIG. **3**), between the inflection point of the blade rear edge and the shroud of the centrifugal fan **5** (corresponding to FIG. **4**), and below the shroud (corresponding to FIG. **5**).

[0054] In either case, the air flow direction is inclined with respect to the fin of the heat exchanger **8** toward the fan rotating direction. This phenomenon will be frequently observed at an anterior position of a point at which the centrifugal fan **5** is brought closest to the heat exchanger **8** in the fan rotating direction. The planar air inflow surfaces **8***b*, **8***d*, **8***f*, **8***h* of the heat exchanger are likely to generate a turbulence between the fins compared with surfaces **8***a*, **8***c*, **8***e*, **8***g*. This may interfere with air inflow, resulting in small amount of passing air. As a result, the flow velocity distribution becomes uneven in a circumferential direction of the heat exchanger **8** to increase the air flow loss and the blower power, resulting in a deteriorated heat exchanging performance.

[0055] The air flow direction influenced by the blade shape of the centrifugal fan **5** significantly changes at the position near the height of the inflection point of the blade rear edge. Specifically, the air flow direction indicated by the longitudinal section including the fan rotation axis becomes substantially horizontal above the inflection point indicated by the line p-p as shown in FIG. **2**. Meanwhile, it is directed obliquely downward in the region below the inflection point. As clearly shown in the transverse section perpendicular to the fan rotation axis, that is, FIGS. **3** and **4**, the velocity component parallel to the air inflow surface of the heat exchanger **8** becomes large when it is below the inflection point. This may increase an inclination angle α with respect to the fin as shown in FIG. **3**.

[0056] The air flow direction slightly changes as well between the hub of the centrifugal fan **5** and the inflection point of the blade rear edge, or between the inflection point of the blade rear edge and the shroud of the centrifugal fan **5**. Such change, however, is far smaller than the change which occurs around the inflection point of the blade rear edge.

[0057] The air flow direction largely changes around a height position where the shroud is disposed depending on a positional relationship with the centrifugal fan **5**. In the area below the shroud, the direction is strongly influenced by a swirl generated between the shroud and the bell mouth **4**. The resultant inclination angle with respect to the fin is further increased as shown in FIG. **5** so that the air flow direction becomes substantially parallel to the air inflow surface therearound.

[0058] As described above, the air flow direction largely changes around the height of the inflection point of the blade rear edge, and the height of the shroud. As a result, the flow velocity distribution in the fan rotation axial direction is uneven, causing increase in the blower power and deterioration in the heat exchanging performance.

[0059] In the present invention, the rectifying member is formed into the shape adaptable to change in the air flow direction for the purpose of reducing the blower power and improving the heat exchanging performance. Preferred embodiments of the present invention will be described in detail hereinafter referring to the drawings.

First Embodiment

[0060] A first embodiment of the present invention will be described referring to FIGS. **8** to **11**. FIG. **8** is a longitudinal section of an indoor unit **91** including the fan rotation axis. FIG. **9** is a transverse section of the indoor unit **91** taken along line D-D of FIG. **8**. FIG. **10** is an enlarged perspective view of a rectifying member **920**. FIG. **11** is a bottom view of the rectifying member **920** seen from a direction indicated by arrow Z of FIG. **10**. In the drawings, the lines s-s, p-p, q-q, and t-t indicate a position of the hub of the centrifugal fan **5**, the inflection point position at which the blade rear edge changes its shape from convex to concave, an upper end position of the shroud, and a lower end position of the shroud, respectively. Numeral **811** denotes an air inflow surface of the heat exchanger **8**.

[0061] The rectifying member **920** includes a thin plate support **931**, a thin plate vane **932** which extends from one end of the support **931** toward a direction opposite a fan rotating direction and is inclined at an angle θ**2** with respect to the support **931**, a thin plate vane **934** which extends from one end of the support **931** toward the direction opposite the fan rotating direction and is inclined at an angle θ**4** with respect to the support **931**, a vane **933** which extends from one end of the support **931** for connecting the vanes **932** and **934**, a rib **935** disposed between inner surfaces of the support **931** and the vane **932**, and a rib **936** disposed between inner surfaces of the support **931** and the vane **934**.

[0062] The support **931** is made thinner than the gap between the fins, which is inserted therethrough from the air inflow surface **811**, and fixed to the heat exchanger **8** by fitting with the heat transfer pipe or by bonding to the fin. A part of the support **931** protrudes from the air inflow surface **811** to the centrifugal fan **5**, serving to block the inflow air between the vanes **932**, **933**, **934** and the air inflow surface **811**. The longitudinal dimension L1 along the fan rotation axial direction is smaller than the height of the centrifugal fan **5**, that is, the distance between the lines s-s and t-t.

[0063] The space between the vane **932** and the air inflow surface **811** is gradually narrowed toward the support **931**. The end of the vane **932** at the fan side is apart from the air inflow surface **811** by the distance H2. The longitudinal dimension L2 of the vane **932** along the fan rotation axial direction is slightly smaller than the height defined by the hub of the centrifugal fan **5** and the inflection point of the blade rear edge, that is, the distance between the lines s-s and p-p.

[0064] A space between the vane **934** and the air inflow surface **811** is gradually narrowed toward the support **931**. The end of the vane **934** at the fan side is apart from the air inflow surface **811** by the distance H**4**. The vane **934** is disposed between the height of the inflection point of the blade rear edge indicated by the line p-p and the lower end of the shroud indicated by the line t-t. Therefore, the longitudinal dimension L**4** of the vane **934** along the fan rotation axial direction is smaller than the distance between the lines p-p and t-t.

[0065] The vane **933** is disposed between the lower end of the vane **932** and the upper end of the vane **934** at the angle with respect to the support **931** gradually reduced from θ**2** to θ**4**.

[0066] The rib **935** is disposed between the inner surfaces of the support **931** and the vane **932** to secure the angle θ**2**.

[0067] The rib **936** is disposed between the inner surfaces of the support **931** and the vane **934** to secure the angle θ**4**.

[0068] Referring to FIG. **9**, each one of the rectifying members **920***a*, **920***b*, **920***c* and **920***d* is disposed on the corresponding one of the planar air inflow surfaces **8***b*, **8***d*, **8***f* and **8***h* of the heat exchanger, which is apart from the position where the centrifugal fan **5** is brought closest to the heat exchanger **8** by a predetermined distance, respectively. As FIG. **8** shows, the support **931** is substantially in parallel with the fan rotation axial direction, having the upper end substantially as high as the hub of the centrifugal fan **5**. The lower end of the vane **932** is above the height of the inflection point of the blade rear edge indicated by the line p-p, and the upper end of the vane **934** is below the height of the inflection point of the blade rear edge. The lower end of the vane **934** is positioned between the upper end of the shroud indicated by the line q-q and the lower end of the shroud indicated by the line t-t.

[0069] Operations of the rectifying member **920** will be described hereinafter.

[0070] FIG. **12** represents a flow field around the rectifying member **920** on the partial sectional view taken along line E-E of FIG. **8**. The air discharged from the centrifugal fan **5** is divided into two flows, that is, a flow F**1** passing along the path defined by the vane **932** and the air flow surface **811** of the heat exchanger **8**, and a flow F**2** passing over the vane **932** to the rear of the rectifying member **920**.

[0071] The flow F**1** is decelerated under the influence of the vane **932** while changing the flowing direction, and blocked by the support **931**. Therefore, kinetic energy of the flow F**1** is partially converted into static pressure, which increases the static pressure difference between the air outflow surface (not shown) and a part of the air inflow surface **811** of the heat exchanger **8** disposed on an upstream side of a position where the support **931** is disposed, thus increasing amount of air passing through the heat exchanger **8**. In addition, the air flow direction is changed by the vane **932** to reduce the inclination angle α with respect to the fin, which suppresses the turbulence generated among the fins, thus lessening the flow loss.

[0072] Unlike the case where the rectifying member **920** is not disposed, the air flow velocity around the air flow surface **811** is retarded in a region disposed on a downstream side of a position where the support **931** is disposed. The resultant static pressure becomes high, promoting the air inflow to the heat exchanger.

[0073] Each amount of air passing through the air inflow surfaces **8***a*, **8***c*, **8***e*, **8***g* of the heat exchanger will be decreased as increase in each amount of air passing through the air inflow surfaces **8***b*, **8***d*, **8***f*, **8***h*. The flow velocity distribution in the circumferential direction of the heat exchanger is then improved, which makes it possible to reduce the blower power and improve the heat exchanging performance.

[0074] The present invention has characteristics as described below so as to maximize the effect derived from the rectifying member **920**.

[0075] (1) The rectifying member **920** has the angle θ**2** formed by the vane **932** and the support **931** larger than the angle θ**4** formed by the vane **934** and the support **931**.

[0076] Upon separation of the air flow from the vane surface, turbulence occurs in the flow, generating the region at significantly low flow velocity behind the rectifying member. Such region may cause increase in the blower power and deterioration in the heat exchanging performance. Therefore, it is necessary to coincide the vane direction with the air flow direction in order to cope with the aforementioned problems.

[0077] Meanwhile, the air flow direction under strong influence of the vane shape of the centrifugal fan **5** is remarkably changed around the inflection point of the blade rear edge. The inclination angle of the flow with respect to the fin in the region below the inflection point of the blade rear edge is larger than the one in the region above the inflection point. Accordingly, the angle formed by the vane and the support is varied at the position around the height of the inflection point of the blade rear edge so as to coincide the vane direction with the air flow direction.

[0078] (2) The vane **933** disposed between the vanes **932** and **934** gradually changes the angle formed with the support **931** from θ**2** to θ**4**.

[0079] Steep change in the angle formed by the vane and the support will generate the stepped portion on the vane surface, around which turbulence is likely to occur. The vane **933** allows smooth surface of the vane, serving to induce the air with velocity component in the fan rotation axial direction. This makes it possible to suppress generation of the turbulence.

[0080] (3) The lower end of the vane **934** is above the lower end of the shroud of the centrifugal fan **5**.

[0081] In the region below the shroud, the velocity component parallel to the air inflow surface of the heat exchanger is significantly intensified as FIG. **5** shows, and the advancing direction of the air flowing around the air inflow surface is substantially in parallel therewith. As the direction of the vane **934** disposed in the aforementioned region is greatly different from the air flow direction, the flow will separate from the vane surface, resulting in adverse effects.

[0082] (4) The ribs **935** and **936** are provided to secure angles θ**2** and θ**4**, which are formed by the vane **932** and the support **931**, and by the vane **934** and the support **931**, respectively.

[0083] Generally, resin is used for forming the rectifying member **920** with small thickness, which may cause the risk of easy deformation during a fitting work etc. Provision of the rib enhances strength of the rectifying member **920** so as to secure the angle formed by the vane and the support.

[0084] (5) The rectifying member **920** is disposed at an anterior position (a downstream side) of the position at which the centrifugal fan **5** is brought closest to the heat exchanger **8** in the fan rotating direction so that a fitted position of the support **931** satisfies the relationship of $0.2\,G<W<0.5\,G$. Reference letter W denotes a distance between the insertion portion of the support **931** and the position at which the distance between the centrifugal fan **5** and the heat exchanger **8** (indoor heat exchanger) becomes the shortest on the air inflow surface **811**. Reference letter G denotes a distance between the end of the air inflow surface **811** at an anterior position of the position at which the distance between the centrifugal fan **5** and the heat exchanger **8** (indoor heat exchanger) becomes the shortest in the rotating direction of the centrifugal fan **5**, and the position at which the distance becomes the shortest (a horizontal direction of the air inflow surface **811**). The angle θ2 formed by the vane **932** and the support **931** is equal to or smaller than 135°, and the angle θ**4** formed by the vane **934** and the support **931** is equal to or smaller than 115°.

[0085] Provision of the support **931** around the position at which the static pressure on the air inflow surface is the lowest will provide higher effect of improving the rectifying member **920**. According to results of the analysis carried out in the present invention, the static pressure distribution on the air inflow surface is influenced by various factors. The static pressure is the lowest in the region at an anterior position of the position at which the centrifugal fan **5** is brought closest to the heat exchanger **8** in the fan rotating direction by the distance ranging from 0.2 G to 0.5 G.

[0086] The inclination angle α of the flow with respect to the fin is equal to or larger than 45° in the region above the inflection point of the blade rear edge, and in the region therebelow, is equal to or larger than 65°. The vane may be directed to be coincided with the air flow by setting the angle θ**2** formed by the vane **932** and the support **931** to be equal to or smaller than 135°, and the angle θ**4** formed by the vane **934** and the support **931** to be equal to or smaller than 115°.

[0087] In this embodiment, each of the planar air inflow surfaces **8*b***, **8*d***, **8*f***, **8*h*** of the heat exchanger is provided with a single rectifying member. It is possible to adjust the number of rectifying members in consideration of improvement effects, manufacturing costs and the like. Each shape of the rectifying members, and the fitted position of the support do not have to be the same, which may be set separately. The gaps H2 and H4 between the fan side end of the vane and the air inflow surface may be equally set. However, they may be made different so that the improvement effect of the rectifying member is maximized.

Second Embodiment

[0088] In this embodiment, the same components as those described in the first embodiment will be designated with the same numerals, and explanations thereof, thus will be omitted so that the difference from the first embodiment will be explained mainly hereinafter.

[0089] FIG. **13** represents the second embodiment according to the present invention. The support **931** of a rectifying member **921** has rectangular openings **941**, **942** through which the inflow air between the vane and the air inflow surface **811** of the heat exchanger partially flows to the rear of the support **931**. Therefore, even if the vane direction is deviated from the given direction owing to a fitting error, it is possible to suppress the region where the flow velocity is significantly lowered. Adjustment of the number of openings, size and position thereof allows control of the static pressure improvement effect in the fan rotation axial direction.

Third Embodiment

[0090] FIG. **14** represents a third embodiment according to the present invention. This embodiment is different from the first embodiment in that the support **931** has an extended thin plate section **951** at the lower end. Some of the flowing air around the air inflow surface **811** is blocked in the region below the centrifugal fan **5** so that the amount of air passing through the part of the heat exchanger at an anterior position of a fitted position of the thin plate section **951** increases together with the static pressure. Meanwhile, the part of the thin plate section **951** protruding from the air inflow surface **811** is very low in height. This makes it possible to suppress reduction in the flow velocity behind the part. As a result, the improvement effect of the rectifying member may further be enhanced.

Fourth Embodiment

[0091] FIGS. **15** and **16** represent a fourth embodiment according to the present invention. FIG. **15** is a side view of a rectifying member **923** seen from the fan side, and FIG. **16** is a bottom view of the rectifying member **923** seen from the direction indicated by arrow Y of FIG. **15**. The air inflow surface **811** of the heat exchanger **8** is shown in FIG. **16**. Referring to FIG. **15**, the line s-s denotes the position of the hub of the centrifugal fan **5**, the line p-p denotes the inflection point at which the blade rear edge varies its shape from convex to concave, the line q-q denotes the upper end of the shroud, and the line t-t denotes the lower end of the shroud. The solid arrow of the drawing denotes the rotating direction of the centrifugal fan **5**.

[0092] The rectifying member **923** includes thin plate supports **961**, **963**, **965** protruding from the air inflow surface **811** toward the centrifugal fan **5**, a thin plate vane **962** extending from one end of the support **961** in the direction opposite the fan rotating direction while inclining at the angle θ**4** with respect to the support **961**, a thin plate vane **966** extending from one end of the support **965** in the direction opposite the fan rotating direction while inclining at the angle θ**2** with respect to the support **965**, a vane **964** extending from one end of the support **963** to connect the vanes **962** and **966**, a rib **967** disposed between inner surfaces of the support **961** and the vane **962**, and a rib **968** disposed between inner surfaces of the support **965** and the vane **966**.

[0093] The embodiment is different from the first embodiment primarily in that the support **965** of the rectifying member **923** is substantially in parallel with the support **961**, and located forward in the fan rotating direction. The support **963** is inclined with respect to the supports **961** and **965** while connecting the lower end of the support **961** to the upper end of the support **965**.

[0094] In the indoor unit, the air flow direction steeply changes around the height of the inflection point of the blade rear edge, which makes the inclination angle of the flow larger with respect to the fin in a lower region. Accordingly, the static pressure distribution on the air inflow surface **811** changes around the height of the inflection point of the blade rear edge so that the distance between the location at the lowest static pressure and the position where the centrifugal fan **5** becomes closest to the heat exchanger **8** is shorter in the lower region. On the other hand, as the improvement effect derived from the rectifying member depends on the fitted position of the support, the higher improvement effect may be obtained by using the rectifying member **923** which allows the support to be fitted on the point at the lowest static pressure in the fan rotation axial direction.

[0095] A modified example of the embodiment is configured by separately producing a rectifying member **924** to be disposed in the region above the inflection point of the blade rear edge, and a rectifying member **925** to be disposed in the region below the inflection point, and fitting those rectifying members, as shown in FIG. **17**. Since those two respective rectifying members **924**, **925** do not have complicated configurations, they may be easily produced. Each support does not have a complicated shape so as to allow easy provision of the rectifying members **924**, **925**.

Fifth Embodiment

[0096] FIG. **18** is a longitudinal section representing a fifth embodiment according to the present invention. This embodiment is different from the first embodiment primarily in the upper end position of the vane. In other words, the upper end of the vane of the rectifying member **926** is positioned at the level lower than the hub of the centrifugal fan **5**.

[0097] In the indoor unit **92**, a heat insulating material **97** at the top panel side is provided with a protruding portion **99** (a thick part of the heat insulating material). A vortex will be generated in a space n formed between an outer surface of the protruding portion **99** and the air inflow surface of the heat exchanger **8**. In this case, like the first embodiment, if the upper end of the vane is positioned at the same level as the hub, the vortex will be interfered with the separated flow generated at the upper end of the vane, thus interrupting the flow into the part of the heat exchanger, which faces the space n. This may increase the blower power and deteriorate the heat exchanging performance. In order to avoid the aforementioned disadvantages, the upper end of the vane is positioned apart from the space n by a predetermined distance.

Sixth Embodiment

[0098] FIG. **20** is a perspective view representing the rectifying member of a sixth embodiment according to the present invention.

[0099] A rectifying member **351** shown in the drawing is configured simpler than the one described in the first to the fifth embodiments.

[0100] The rectifying member **351** includes a vane **352** corresponding to the blowout port of the fan, and a vane **353** corresponding to the fan shroud. The rectifying member **351** includes a support **391**, insertion portions **356**, **357**, and grips **354**, **355**. The support **391** is curved so that direction of the vane **352** is adapted to the inclination angle α of the flow with respect to the fin. The insertion portions **356**, **357** are inserted between the fins, and fixed. The grips **354**, **355** are configured to be gripped by the operator to assist in easy provision of the rectifying member **351**. As the drawing shows, the grip **354** has a plate-like shape easy to hold, and the grip **355** has a bar-like shape.

[0101] A top end **358** of the support **391** is configured to be fit with a recessed portion formed in the heat insulating material of the casing for the indoor unit.

[0102] The vane **352** is configured to be adapted to the inclination angle α of the flow with respect to the fin for the purpose of corresponding to the fan blowout port at high air flow velocity. The vane **353** located in the region at relatively lower air flow velocity which is small in width allows loose limitation of the angle. It is therefore possible to be configured adaptable to the inclination angle α like the vane **352**.

[0103] FIG. **21** is a perspective view representing that the rectifying member according to the present invention is disposed in the indoor unit. This drawing represents the inner side of the heat exchanger **8** seen from below.

[0104] A rectifying member **371** is slightly different in its shape from the rectifying member **351** as shown in FIG. **20**, but substantially the same in terms of the function. Configurations of grips **372**, **373** are different from those shown in FIG. **20**.

[0105] The top end **358** of the rectifying member **371** will be fitted with a recessed portion **361** formed in the heat insulating material **103** of the casing for the indoor unit.

[0106] FIG. **22** is an enlarged view of the rectifying member **371** shown in FIG. **21**.

[0107] The rectifying member **371** has the vanes **352**, **353**, **393** fixed to the support **391**.

[0108] The vane **352** may be described in the similar way to the one referring to FIG. **20** as described above, which corresponds to the region at the higher air flow velocity.

[0109] Each of sections I to IV surrounded by dashed lines will be described referring to the drawings.

[0110] The section I is positioned above the fan blowout port in the region near the heat insulating material as the inner wall of the casing for the indoor unit. In this section, the air flow velocity is decreased. Therefore, the vane **393** is configured to reduce its width toward the top portion.

[0111] The section II is positioned in the region at the relatively low air flow velocity, and configured to reduce its width downward.

[0112] The section III serves to reduce the vane width because of the need to prevent air flow parallel to the air inflow surface of the heat exchanger from hindering the air inflow to the heat exchanger at a downstream side of the vane.

[0113] In the section IV corresponding to the fan shroud, the air flow velocity is low. There is less necessity to increase width of the vane **353**, and accordingly, the vane width is made small.

[0114] FIG. **23** is a perspective view of another modified example of the rectifying member.

[0115] A rectifying member **381** has vanes **382**, **383**, **384** fixed to the support **391**.

[0116] The vane **382** may be described in the similar way to the one referring to FIG. **20** as described above, which corresponds to the region at the higher air flow velocity.

[0117] The section I shown in the drawing has the width of the vane at the upper part of the rectifying member **381** kept small uniformly rather than gradually reducing the width.

[0118] Referring to the section II, the vane **383** has its width steeply reduced downward, and the vane **384** has the width uniformly kept small.

[0119] The section III has a long part with the vane width kept uniformly smaller compared with the section shown in FIG. **22**.

[0120] The section IV has a part with the vane width kept uniformly smaller, which is not provided in the member shown in FIG. **22**.

[0121] The cross fin tube type heat exchanger has been described in the first to the sixth embodiments. However, the heat exchanger of any other type, for example, parallel flow type heat exchanger is also applicable. Any type of the indoor unit is available so long as the air flow is inclined with respect to the air inflow surface of the heat exchanger without being limited to the indoor unit of ceiling embedded cassette type.

[0122] The structure and operation of the air conditioning unit will be described below.

[0123] FIG. **19** is a schematic diagram representing structure of the air conditioning unit according to the present invention.

[0124] Referring to the drawing, an air conditioning unit **300** includes a compressor **302** for compressing the refrigerant, an indoor heat exchanger **303**, an expansion valve **304**, an outdoor heat exchanger **305**, and a four-way valve **306**, which are connected via refrigerant pipings **311**, **312**, **313**, **314**, **315**, **316**. The air conditioning operation may be selected from cooling and heating by switching the four-way valve **306**.

[0125] In the cooling operation, the refrigerant discharged from the compressor **302** passes through the refrigerant piping **311**, the four-way valve **306**, and the refrigerant piping **312** as indicated by solid arrow so as to release heat to outdoor air by the outdoor heat exchanger **305**. Then, it further passes through the refrigerant piping **313**, the expansion valve **304** and the refrigerant piping **314** so as to absorb heat from indoor air by the indoor heat exchanger **303**. The refrigerant passes through the refrigerant piping **315**, the four-way valve **306**, and the refrigerant piping **316**, and returns to the compressor **302**.

[0126] Meanwhile, in the heating operation, the refrigerant discharged from the compressor **302** passes through the refrigerant piping **311**, the four-way valve **306**, and the refrigerant piping **315** as indicated by dashed arrow so as to release heat to indoor air by the indoor heat exchanger **303**. It further passes through the refrigerant piping **314**, the expansion valve **304** and the refrigerant piping **313** so as to absorb heat from outdoor air by the outdoor heat exchanger **305**. The refrigerant passes through the refrigerant piping **312**, the four-way valve **306**, and the refrigerant piping **316**, and returns to the compressor **302**.

[0127] The specification explains the air conditioning unit using the heat pump function as a result of compression and expansion of the refrigerant as described referring to FIG. **19**. However, the present invention is not limited to the aforementioned description. It is also applicable to the indoor cooling and heating operation by supplying cold or hot water to the indoor heat exchanger.

What is claimed is:

1. An air conditioning unit having an indoor unit,

the indoor unit comprising:

a casing;

a centrifugal fan having a hub, a shroud, and blades disposed therebetween; and

an indoor heat exchanger which surrounds the centrifugal fan,

the casing containing the centrifugal fan and the indoor heat exchanger,

wherein the indoor heat exchanger has a planar air inflow surface allowing an inflow of air discharged from an air outlet of the centrifugal fan,

the air inflow surface is provided with a rectifying member,

the rectifying member includes a support having an insertion portion fixed between fins on the air inflow surface, and a vane having a shape extending from the support toward a direction opposite a rotating direction of the centrifugal fan, the rectifying member configured to block some of the air flowing between the centrifugal fan and the air inflow surface, and

an angle formed by the insertion portion and the vane in the plane orthogonal to a rotation axis of the centrifugal fan is set to become parallel to the air inflow from the air outlet to the air inflow surface at least at the hub side to increase a static pressure of the air at upstream and downstream sides of the vane.

2. The air conditioning unit according to claim **1**,

wherein the support and the vane at the shroud side are configured to increase the static pressure of the air flowing in a direction parallel to the air inflow surface.

3. The air conditioning unit according to claim **1**,

wherein a curve of a rear edge of the blade seen from an outer peripheral side of the centrifugal fan has an inflection point, having a convex part at the hub side, and a concave part at the shroud side in the rotating direction of the centrifugal fan.

4. The air conditioning unit according to claim **1**,

wherein the angle at the hub side is different from the angle at the shroud side with respect to a height of the inflection point as a boundary.

5. The air conditioning unit according to claim **1**,

wherein the indoor heat exchanger has a polygonal shape.

6. The air conditioning unit according to claim **5**,

wherein each of the air inflow surfaces constituting the polygonal shape is provided with each one of the rectifying members, respectively.

7. The air conditioning unit according to claim **1**,

wherein the support has an opening for flowing some of the air inflow between the vane and the air inflow surface downstream.

8. The air conditioning unit according to claim **1**,

wherein the end of the vane at the shroud side is positioned closer to the hub side than an air inlet of the shroud.

9. The air conditioning unit according to claim **1**,

wherein the insertion portion of the support is disposed at an anterior position of a position where a distance between the centrifugal fan and the indoor heat exchanger becomes the shortest in the rotating direction of the centrifugal fan.

10. The air conditioning unit according to claim **1**,

wherein each of the rectifying members includes a plurality of the insertion portions having the same coordinates in the rotating direction of the centrifugal fan.

11. The air conditioning unit according to claim **9**,

satisfying a relationship of $0.2\ G \leq W \leq 0.5\ G$, where W denotes a distance between the insertion portion of the support and the position at which the distance between the centrifugal fan and the heat exchanger becomes the shortest on the air inflow surface, and G denotes a distance between an end of the air inflow surface at an anterior position of the position at which the distance between the centrifugal fan and the heat exchanger becomes the shortest in the rotating direction of the centrifugal fan, and the position at which the distance between the centrifugal fan and the heat exchanger becomes the shortest.

12. The air conditioning unit according to claim **1**,

wherein an angle formed by the insertion portion and the vane at the hub side is different from the angle at the shroud side; and

a vane is disposed between those two vanes at different angles so as to be connected.

13. The air conditioning unit according to claim **1**,

wherein the angle formed by the insertion portion and the vane at the hub side is equal to or smaller than 135°.

14. The air conditioning unit according to claim **13**,

wherein the angle formed by the insertion portion and the vane at the shroud side is equal to or smaller than 115°.

15. The air conditioning unit according to claim **1**, wherein the support is longer than the vane in the rotation axial direction of the centrifugal fan.

* * * * *