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

(11) EP 3 101 280 A1

(12) # EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:
07.12.2016 Bulletin 2016/49

(21) Application number: **14880164.0**

(22) Date of filing: **27.01.2014**

(51) Int Cl.:
***F04D 29/28** (2006.01)* ***F24F 1/00** (2011.01)*

(86) International application number:
PCT/JP2014/051641

(87) International publication number:
WO 2015/111210 (30.07.2015 Gazette 2015/30)

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

(71) Applicant: **Mitsubishi Electric Corporation**
Tokyo 100-8310 (JP)

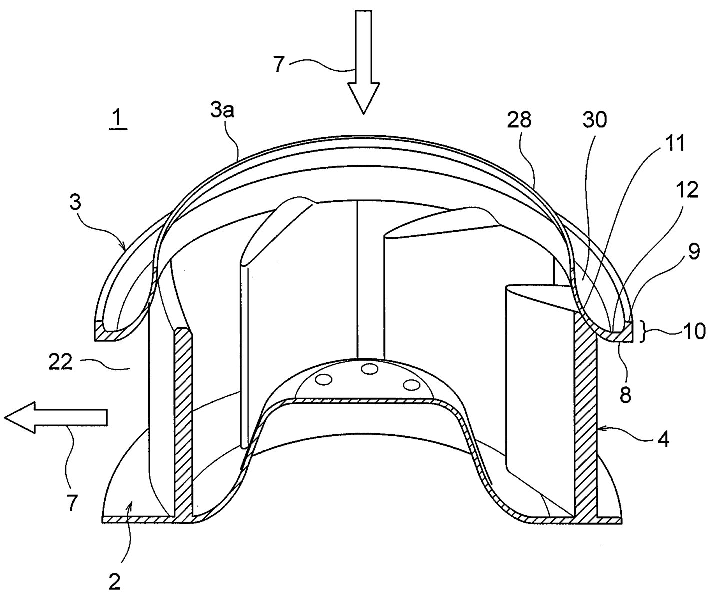
(72) Inventor: **TADOKORO, Takahide**
Tokyo 100-8310 (JP)

(74) Representative: **Moore, Graeme Patrick et al**
Mewburn Ellis LLP
City Tower
40 Basinghall Street
London EC2V 5DE (GB)

(54) **CENTRIFUGAL FAN AND AIR CONDITIONING DEVICE**

(57) Provided is a centrifugal fan including a main plate 2, a shroud 3 having a fan inlet port 3a, and a plurality of vanes 4 provided between the main plate and the shroud, wherein the shroud has a shroud main body section 11 and an extension part 9, the extension part is a portion extending from a shroud outer peripheral end section 8 of the shroud main body section to an upstream side when viewed in a direction parallel to an axis of rotation 5, a radially outside surface of the shroud main body section and a radially inside surface of the extension part constitute a concave rounded surface 30, and the direction of recess of the concave rounded surface is towards the upstream side when viewed in the direction parallel to the axis of rotation.

FIG. 2



EP 3 101 280 A1

Description

[Technical Field]

[0001] The present invention relates to a centrifugal fan and an air-conditioning device.

[Background Art]

[0002] Conventionally, modifications have been made to the shape of a centrifugal fan in order to achieve a low-noise, high-efficiency air blower. The noise and loss of a centrifugal fan increase in accordance with the disturbance and velocity of an air flow, and therefore in order to achieve low noise and high efficiency, it is necessary to reduce the disturbance of the air flow arising at the periphery of the vanes and to alleviate local high-velocity flows.

[0003] For example, PTL1 discloses a centrifugal fan which is configured in such a manner that an outer peripheral section of a shroud which is positioned on an outlet side of the centrifugal fan is inclined to an inlet side, and the flow passage area of any cross-section in the circumferential direction is greater than the cross-sectional area of the blade inlet in the circumferential direction at the position where a blade inflow section of a shroud inner peripheral section intersects with the shroud. By adopting a configuration of this kind for the centrifugal fan, it is intended that the outlet flow of the centrifugal fan is directed towards the outlet port of the air blower main body, and the velocity of the outlet flow from the centrifugal fan is reduced by the velocity of the flow at the outer peripheral section of the shroud, thereby reducing the impact on the housing side walls of the air blower.

[0004] Furthermore, PTL2 discloses a centrifugal fan which is configured in such a manner that a smallest section where the cross-sectional area is smallest is formed at an intermediate point of an air flow passage surrounded by a main plate, blades and a shroud, and the cross-sectional area of the air flow passage increases gradually from the smallest section to the outer peripheral section of the shroud. By adopting a configuration of this kind in a centrifugal fan, it is intended that the flow velocity decreases gradually from the smallest section and the occurrence of disturbance in the flow of air is suppressed in the vicinity of the outer peripheral section of an impeller.

[0005] Furthermore, PTL3 discloses a centrifugal fan in which a guide section extending to an inlet side is formed in an outside portion of a shroud in the radial direction.

[Citation List]

[Patent Literature]

[0006]

[PTL1]
Japanese Patent Application Publication No. 2000-120582 (principally, Fig. 2 and Fig. 4)
[PTL2]
Japanese Patent Application Publication No. 2012-207600 (principally, Fig. 4)
[PTL3]
W/O 98/58213 (principally, Fig. 1 and Fig. 9)

[Summary of Invention]

[Technical Problem]

[0007] Here, the air flow blown out from the centrifugal fan is a high-velocity flow and therefore an eddy occurs due to velocity differential at the periphery of the outlet port. In particular, in an air-conditioning device in which a heat exchanger is disposed immediately after the outlet, or an air blower provided with a flow passage which causes an air flow blown out in a centrifugal direction to make a U turn and be directed to the inlet side, an eddy caused by a velocity differential between the main flow and the slower air flow on the upper surface of the shroud increases the air passage resistance by closing off the outlet flow passage, thus leading to increased power consumption of the fan and increased noise due to increase in the velocity of the air flow passing through the narrow flow passage.

[0008] Furthermore, when the width and/or height of the air flow passage between the vanes is increased in the vicinity of the inlet port, as in PTL1 or PTL2, then a pressure gradient occurs due to the sudden internal expansion, and the flow on the side of the shroud where the flow velocity is slower becomes more liable to separate. The eddy caused by this separation closes off the flow passage between the vanes, and hence there is a risk of increase in the power consumption due to the increase in the air passage resistance, and deterioration in the noise due to the increased velocity of the outlet flow.

[0009] Furthermore, in the shroud disclosed in PTL3, an instable eddy is generated by the guide section, depending on the shape thereof, and there is a risk that the eddy will close off the flow passage.

[0010] The present invention was devised in view of the foregoing, an object thereof being to provide a centrifugal fan capable of suppressing increase in air passage resistance.

[Solution to Problem]

[0011] In order to achieve the object described above, the present invention is a centrifugal fan including a main plate, a shroud having a fan inlet port, and a plurality of vanes provided between the main plate and the shroud, wherein the shroud has a shroud main body section and an extension part, the extension part is a portion extending from a shroud outer peripheral end section of the shroud main body section to an upstream side when viewed in a direction parallel to an axis of rotation, a radially outside surface of the shroud main body section, and a radially inside surface of the extension part constitute a concave rounded surface, and a direction of recess of the concave rounded surface is towards the upstream side when viewed in the direction parallel to the axis of rotation.

[0012] A configuration may be disposed in which a plurality of projections extending in the radial direction are formed on the concave rounded surface.

[0013] A configuration may be adopted wherein the plurality of projections are inclined in such a manner that, in plan view, the portion of each projection on the outside in the radial direction is positioned rearwards in a direction of rotation of the centrifugal fan, with respect to the portion of the projection on the inside in the radial direction.

[0014] A configuration may be adopted wherein a front end of the extension part is positioned towards the inner side in the radial direction than a portion of the extension part on the side of the shroud outer peripheral end section. Furthermore, in order to achieve the objects, the present invention provides an air-conditioning device including a centrifugal fan relating to the present invention as described above, and a heat exchanger disposed on the outside of the centrifugal fan.

[0015] A configuration may be adopted, wherein an end section of the heat exchanger on the side of an air-conditioning device outlet port is closer to the air-conditioning device outlet port than an inlet-side end section of the centrifugal fan is, when viewed in a direction parallel to an axis of rotation.

[Advantageous Effects of Invention]

[0016] According to the present invention, it is possible to suppress increase in the air passage resistance.

[Brief Description of Drawings]

[0017]

[Fig. 1]
Fig. 1 is a perspective diagram of a centrifugal fan according to a first embodiment of the present invention.
[Fig. 2]
Fig. 2 is a cross-sectional diagram of the centrifugal fan in Fig. 1.
[Fig. 3]
Fig. 3 is a drawing showing the internal structure of an air-conditioning device relating to a first embodiment of the present invention.
[Fig. 4]
Fig. 4 is a diagram showing the internal structure of the air-conditioning device in Fig. 3, viewed in the direction of arrow IV in Fig. 3.
[Fig. 5]
Fig. 5 is a diagram showing a view of the flow relating to the centrifugal fan according to the first embodiment.
[Fig. 6]
Fig. 6 is a diagram showing a view of the flow relating to the centrifugal fan according to a first illustrative example.
[Fig. 7]
Fig. 7 is a diagram showing a view of the flow relating to the centrifugal fan according to a second illustrative example.
[Fig. 8]
Fig. 8 is a diagram of a similar mode to Fig. 2, relating to the portion near the extension part of a first modification of the first embodiment.
[Fig. 9]
Fig. 9 is a diagram of a similar mode to Fig. 5, relating to the first modification of the first embodiment.
[Fig. 10]
Fig. 10 is a diagram of a similar mode to Fig. 5, relating to the second modification of the first embodiment.
[Fig. 11]
Fig. 11 is a diagram of a similar mode to Fig. 1, relating to a second embodiment of the present invention.
[Fig. 12]
Fig. 12 is a plan diagram illustrating a flow on the side of a concave rounded surface, relating to the second embodiment.
[Fig. 13]
Fig. 13 is a perspective diagram of a centrifugal fan according to a third embodiment of the present invention.
[Fig. 14]
Fig. 14 is a plan diagram of the centrifugal fan in Fig. 13.
[Fig. 15]
Fig. 15 is a diagram illustrating a flow in a case where productions on the concave rounded surface extend along a radial direction.
[Fig. 16]
Fig. 16 is a diagram of a similar mode to Fig. 15, relating to a third embodiment of the present invention.
[Fig. 17]
Fig. 17 is a diagram of a similar mode to Fig. 5, relating to a fourth embodiment of the present invention.

[Description of Embodiments]

[0018] Embodiments of a centrifugal fan and an air-conditioning device according to the present invention are described below with reference to the accompanying drawings. Parts which are the same or corresponding below are labelled with the same reference numerals.

First Embodiment

[0019] Fig. 1 is a perspective diagram showing a centrifugal fan relating to a first embodiment of the present invention, and Fig. 2 is a cross-sectional diagram of the centrifugal fan in Fig. 1. Fig. 3 is a diagram showing an internal structure of an air-conditioning device relating to a first embodiment, and Fig. 4 is a diagram showing an internal structure of the air-conditioning device in Fig. 3, viewed in the direction of the arrow IV in Fig. 3.

[0020] The centrifugal fan 1 is provided with a main plate 2, a shroud 3 and a plurality of vanes 4. The main plate 2 and the shroud 3 face each other in the direction of extension of an axis of rotation 5, and are disposed at an interval apart in the direction of extension of the axis of rotation 5. A plurality of vanes 4 extend in the direction of extension of the axis of rotation 5, between the main plate 2 and the shroud 3, and couple together the main plate 2 and the shroud 3. The vanes may have a hollow internal structure in order to reduce the weight thereof.

[0021] The centrifugal fan 1 is supported rotatably, and the main plate 2, the shroud 3 and the plurality of vanes 4 rotate in a unified fashion. A fan inlet port 3a for taking in air is formed in a central portion of the shroud 3. When the centrifugal fan 1 rotates in the direction of rotation 6 due to driving by the motor 15 (see Fig. 3), then air on the side of the shroud 3 is sucked into the region between the shroud 3 and the main plate 2, via the fan inlet port 3a, as indicated by the air flow 7, the pressure of the air is raised as the air passes between the plurality of vanes 4, and the air passes through the fan outlet port 22 and is blown out to the outside of the centrifugal fan 1.

[0022] As shown in Fig. 2, the shroud 3 is configured such that an end section of a shroud main body section 11 which constitutes the fan outlet port 22 in conjunction with the main plate 2 (in other words, the shroud outer peripheral end section 8) is positioned towards the outer side in the radial direction and closer to the main plate 2, than an end section of the shroud main body section 11 which constitutes the fan inlet port 3a (in other words, the inlet-side end section 28) is.

[0023] The shroud 3 also has a ring-shaped extension part 10. This extension part 10 is a portion which extends from the shroud outer peripheral end section 8, which is the outermost end portion of the shroud main body section 11, to the upstream side (to the side of the fan inlet port 3a), in a direction parallel to the axis of rotation 5. When viewed in plan view from the direction of the axis of rotation 5, the ring-shaped extension part 10 surrounds the shroud main body section 11.

[0024] Furthermore, the radially outside surface of the shroud main body section 11 and the radially inside surface of the extension part 10 constitute a concave rounded surface. This concave rounded surface 30 is configured by a single circular arc, or by a combination of a plurality of circular arcs, when viewed in a longitudinal cross-section including the axis of rotation 5 (as seen in Fig. 5 which is one cross-section of a longitudinal cross-section of this kind). The direction of the recess in the concave rounded surface 30 is towards the upstream side (the side of the fan inlet port 3a) in a direction parallel to the axis of rotation 5.

[0025] Moreover, an air-conditioning device 100 provided with the centrifugal fan 1 is also described here. As shown in Fig. 3 and Fig. 4, the air-conditioning device 100 has the abovementioned centrifugal fan 1, and a motor 15 which causes the centrifugal fan 1 to rotate, in the center of the interior of a unit which is configured by a ceiling plate 13 and side plate 14. Fig. 4 is a perspective view which prioritizes a view of the internal configuration of the unit.

[0026] Furthermore, in the unit, a heat exchanger 16 which carries out heat exchange with the air flowing out from the centrifugal fan 1 is provided on the outside (downstream side) of the centrifugal fan 1. The heat exchanger 16 is disposed so as to surround the centrifugal fan 1. Furthermore, the heat exchanger 16 is disposed so as to follow the main four surfaces of the side plates 14, and extends so as to form substantially a quadrilateral shape.

[0027] In the case of embedded installation in the ceiling 103, a cosmetic plate 17 facing into the room 102 is provided on the lower side of the unit. An air-conditioning device inlet port 18 and a plurality of air-conditioning device outlet ports 19 are provided in the center of the cosmetic plate 17. The air-conditioning device inlet port 18 occupies the central region of the axis of rotation 5 and the periphery thereof, and the air-conditioning device outlet port 19 occupies the region peripheral to the air-conditioning device inlet port 18. An air flow directing vane 20 is provided on the air-conditioning device outlet port 19 to control the direction of the discharged air flow.

[0028] Fig. 3 illustrates the flow of air 21 as viewed in the whole of the air-conditioning device 100 which is configured in this way. The air in the room 102 is sucked inside the unit from the air-conditioning device inlet port 18, by the rotation of the centrifugal fan 1. The air flow that flows in from the fan inlet port 3a of the centrifugal fan 1, while flowing between the vanes, receives energy from the vanes 4 and the pressure thereof is thereby raised, while the orientation of the air flow is changed from the fan axis direction towards the outside in the radial direction, and the air is blown out from the fan outlet port 22. Upon passing through the heat exchanger 16, the air flow blown out in a rotating fashion by the centrifugal fan 1 is regulated in temperature, principally, and is blown out from the air-conditioning device outlet port 19 to the room 102.

[0029] The first embodiment and embodiments indicated below describe an air-conditioning device as one example of an air blower in which a flow of air sucked in from a device inlet port (fan inlet port) is made to perform a U turn in the centrifugal fan and the air flows to the device outlet port (in the present embodiment, the air-conditioning device outlet port) in the same direction as on the upstream side of the device inlet port (fan inlet port).

[0030] Moreover, the action of the centrifugal fan 1 is described here with reference to Fig. 5, Fig. 6 and Fig. 7. Fig. 5 is a diagram showing a view of the flow relating to the centrifugal fan according to the first embodiment. Fig. 6 is a diagram showing a view of the flow relating to a centrifugal fan according to a first illustrative example, and Fig. 7 is a diagram showing a view of the flow relating to a centrifugal fan according to a second illustrative example. Fig. 5, Fig. 6 and Fig. 7 all show only the centrifugal fan, the bell mouth 41 and the heat exchanger 16, and omit the interior of the unit, in order to aid understanding.

[0031] Firstly, as shown in Fig. 6, in the centrifugal fan 51 according to the first illustrative example which does not have an extension part in the outer peripheral end section of the shroud that configures the fan outlet port 22, an eddy 23 generated by the flow 7 which exits from the fan outlet port 22 towards the air-conditioning device outlet port 19 expands further to the outer side in the radial direction, beyond the outer diameter of the centrifugal fan 1. Therefore, a flow passage width 24 in the region sandwiched between the eddy 23 and the heat exchanger 16, which is the effective air flow path, is narrow and consequently, the air passage resistance when the flow 7 passes is increased.

[0032] Furthermore, as shown in Fig. 7, in a virtual centrifugal fan 61 according to a second illustrative example in which a peripheral wall section 61a that is simply folded back on the fan inlet port 3a side is formed on the outer peripheral end section of the shroud, the flow 7 blown out from the fan outlet port 22 subsequently flows along the peripheral wall section 61a due to the Coanda effect, and furthermore, a flow that has separated from the peripheral wall section 61a generates an eddy 23 due to a velocity differential with respect to the air on the inner side in the radial direction, between the shroud and the bell mouth. Due to the eddy 23 which is generated in this way, it is difficult to obtain a flow that reaches to the surface of the main body section of the shroud and to the vicinity of the corner section 61b of the base portion of the peripheral wall section 61a, as indicated by reference numeral 23a. Therefore, the eddy 23 is not readily contained on the inner side of the peripheral wall section 61a in the radial direction, and expands towards the outer side in the radial direction, beyond the outer diameter of the centrifugal fan 1. Therefore, similarly to the case of the first illustrative example in Fig. 6, there is a problem in that the flow passage width 24 is narrow, and consequently, the air passage resistance upon passing of the flow 7 is large.

[0033] On the other hand, in the first embodiment, as described above, an extension part 10 is provided which extends to the fan inlet port 3a side when viewed in the direction parallel to the axis of rotation 5, on the outer peripheral end section 8 of the shroud which constitutes the fan outlet port, and the shroud constituting surface 12 from the front end 9 of the extension part 10 to the shroud main body section 11 is formed by a concave rounded surface 30 which is recessed towards the side of the fan inlet port 3a as viewed in the direction parallel to the axis of rotation 5. Consequently, although, initially, the flow 7 which is blown out from the fan outlet port 22 generates an eddy 23, similarly to the case in Fig. 7 described above, the eddy 23 thus generated flows along the shroud constituting surface 12 which is the concave rounded surface 30, and is readily contained to the inside of the extension part 10 in the radial direction. Consequently, the flow passage width 24 can be kept large in the region sandwiched between the eddy 23 and the heat exchanger 16, and increase in the air passage resistance of the flow 7 can be suppressed. Furthermore, since the eddy can be contained in the concave region, then it is possible to reduce the size of the eddy and disturbance can be reduced.

[0034] As described above, according to the centrifugal fan and air-conditioning device according to the first embodiment, it is possible to achieve reduced noise by suppressing disturbance and reducing the outlet air flow velocity, as well as reducing the power consumption of the motor by reducing the air passage resistance.

[0035] Next, Fig. 8 and Fig. 9 illustrate a first modification of the first embodiment. Fig. 8 is a diagram of a similar mode to Fig. 2, relating to the portion near the extension part of the first modification. Fig. 9 is a diagram of a similar mode to Fig. 5, relating to the first modification.

[0036] As disclosed in PTL3 described above, when there is a sharp angle between the guide section and the main body of the shroud, then the eddy becomes instable on the inside of the guide section in the radial direction, becomes more liable to leak out from the shroud, and may possibly close off the flow passage.

[0037] On the other hand, in the first modification shown in Fig. 8 and Fig. 9, if the curvature of the concave rounded surface, which is constituted by the radially outside surface of the shroud main body section 11 and the radially inside surface of the extension part 10, is represented as ρa, and the curvature of the curved surface, which is constituted by the shroud outer peripheral end section 8 on the fan outlet port side of the shroud main body section 11 and the radially outside surface of the extension part 10, is represented as ρb, then a configuration is adopted in which ρa is smaller than ρb. In other words, the concave rounded surface has a more gentle curve than the curved surface which is constituted by the shroud outer peripheral end section on the outlet port side, and the extension part (a corner-shaped surface is included as one mode of the curved surface). Therefore, the eddy 23 generated flows smoothly along the constituting surfaces, and the eddy can be stabilized without leaking to the outside of the shroud. More specifically, the air flow which is blown out after passing between the vanes flows in a tight spiral from the shroud main body section to the extension part due to the Coanda effect, does not readily expand to the outside in the radial direction and therefore is not liable to close off the flow passage between the fan and the heat exchanger.

[0038] Moreover, a second embodiment of the first embodiment is shown in Fig. 10. Fig. 10 is a diagram of a similar mode to Fig. 5, relating to the second modification. This second modification is characterized in that the outer diameter Rsh of the shroud outer peripheral end section 8 is made larger than the outer diameter RO of the main plate 2, in the configuration shown in Fig. 1 to Fig. 7 described above, or the configuration shown in Fig. 8 and Fig. 9. Therefore, the concave region constituted by the radially outside surface of the shroud main body section 11 and the radially inside surface of the extension part 10 becomes wider, the eddy generated between the fan and the heat exchanger is retained readily within the concave region, and a broad flow passage can easily be guaranteed.

[0039] The first modification and the second modification are both similar to the configuration of the first embodiment illustrated in Fig. 1 to Fig. 7, apart from the portion described above.

Second Embodiment

[0040] Next, a second embodiment of the present invention will be described. Fig. 11 is a diagram of a similar mode to Fig. 1, relating to a second embodiment of the present invention. The second embodiment is similar to the first embodiment described above, with the exception of the part described below.

[0041] In the centrifugal fan 101 of the second embodiment, a plurality of projections 125 are formed in the shroud 3 on the concave rounded surface 30 which is constituted by the radially outside surface of the shroud main body section 11 and the radially inside surface of the extension part 10. These projections 125 extend from the front end 9 of the extension part 10 to the vicinity of the fan inlet port 3a of the shroud main body section 11. Furthermore, the plurality of projections 125 extend from the inside to the outside in the radial direction, and in particular, in the specific example shown in Fig. 11, the projections 125 extend in a radiating fashion following the radial direction, when viewed in plan view from the direction of the axis of rotation 5.

[0042] In this way, in the second embodiment, similarly to the first embodiment, it is possible to reduce the blowing air flow velocity, and it is possible to achieve a centrifugal fan which reduces the power consumption by reduction of the air passage resistance, and which reduces noise through reduction of the disturbance and the flow velocity.

[0043] Moreover, in the second embodiment, the following advantages are obtained. As shown in Fig. 4, the air blower and air-conditioning device are surrounded by a square-shaped heat exchanger, and since the mode of the air passage is not axially symmetrical, then the air passage resistance varies depending on the location, the flow volume and velocity of the air flowing between the vanes varies, and therefore variations occur in the outlet flow. As shown in Fig. 12, firstly, in the area 131 where the centrifugal fan 101 and the heat exchanger 16 are separated, the outlet flow velocity is fast, and the rotating flow which constitutes the generated eddy 23 is fast, and therefore a stable eddy is formed, and the eddy 23 is essentially easy to contain within the concave rounded surface 30. On the other hand, in the area 132 where the centrifugal fan 101 and the heat exchanger 16 are in close proximity, the outlet flow velocity becomes slower, the velocity differential between the upper portion of the shroud and the outlet flow velocity becomes smaller, the rotational flow constituting the generated eddy 23 becomes slower, and the eddy may not be stable. In this respect, in the second embodiment, by providing a plurality of projections 125 on the concave rounded surface 30, the rotating flow constituting the eddy is regulated to flow along the projections 125, the eddy becomes less liable to twist, and in particular, in the area 132 where the centrifugal fan 101 and the heat exchanger 16 are in close proximity, a high effect in containing the eddy 23 within the concave rounded surface 30 is obtained.

Third Embodiment

[0044] Next, a third embodiment of the present invention will be described. Fig. 13 and Fig. 14 are a perspective diagram and a plan diagram of a centrifugal fan relating to the third embodiment of the present invention. The third embodiment is similar to the second embodiment described above, with the exception of the part described below.

[0045] In the centrifugal fan 201 of the third embodiment, a plurality of projections 225 are formed in the shroud 3 on the concave rounded surface 30 which is constituted by the radially outside surface of the shroud main body section 11 and the radially inside surface of the extension part 10. These projections 225 extend from the front end 9 of the extension part 10 to the vicinity of the fan inlet port 3a of the shroud main body section 11. Furthermore, the plurality of projections 225 extend from the inside towards the outside in the radial direction and furthermore, extend at an inclination with respect to the radial direction, in plan view. In other words, the plurality of projections 225 are inclined in such a manner that, in plan view, the portions of the projections 225 on the outside in the radial direction are positioned to a greater extent towards the opposite side to the direction of rotation 6 (rearwards in the direction of rotation) of the centrifugal fan 201, compared to the portions thereof on the inside in the radial direction.

[0046] In the third embodiment of this kind, similarly to the first embodiment, it is possible to achieve reduced noise by suppressing disturbance and reducing the outlet air flow velocity, as well as reducing the power consumption of the motor by reducing the air passage resistance.

[0047] Moreover, in the third embodiment, the following advantages are obtained. Since the centrifugal fan 201 blows out an air flow while rotating, then the rotating flow generated by the concave rounded surface 30 is constituted as an eddy which has an axis in the circumferential direction of the fan. In other words, the rotating flow has a component which advances in the direction of rotation of the fan, due to friction with the concave rounded surface 30. Here, if the plurality of projections extend in the radial direction in plan view, then as shown in Fig. 15, the flow 227b when the flow 227a originating on the inner side of the shroud in the radial direction reaches the vicinity of the extension part on the outer side in the radial direction is in an advanced position in the direction of rotation 6, and the rotating flow constituting the eddy is twisted obliquely. Therefore, the flow assumes a longitudinal eddy state 223A wherein the flow advances while rotating in the central axis direction of the eddy. The air flow 228 peripheral to the eddy becomes wrapped in the direction of rotation, and hence there is a risk of decrease in the outlet of air to the heat exchanger side.

[0048] On the other hand, by inclining the plurality of projections 225 as in the third embodiment, then as shown in Fig. 16, the flow 227b when the flow 227a originating on the inner side of the shroud in the radial direction reaches the vicinity of the extension part on the outer side in the radial direction advances to the opposite side from the direction of rotation of the fan. In other words, due to the combination of the direction of rotation of the fan and the direction of travel of the flow, the rotating flow constituting the eddy 223B becomes less liable to twist and the longitudinal eddy state is alleviated. Consequently, the air flow peripheral to the eddy is restricted from becoming wrapped up in the direction of rotation, and it is possible to ensure a suitable flow rate of air to the heat exchanger.

Fourth Embodiment

[0049] Next, a fourth embodiment of the present invention will be described. Fig. 17 is a diagram of a similar mode to Fig. 5, relating to a fourth embodiment of the present invention. The fourth embodiment is similar to the first to third embodiments described above, with the exception of the part described below.

[0050] The centrifugal fan 301 according to the fourth embodiment has an extension part 310 which extends to the upstream side from the shroud outer peripheral end section 8 of the shroud main body section, and the front end 9 of this extension part 310 is positioned towards the inner side in the radial direction than the portion of the extension part 310 on the side of the shroud outer peripheral end section 8, as shown in Fig. 16.

[0051] In the fourth embodiment of this kind, similarly to the first embodiment, it is possible to achieve reduced noise by suppressing disturbance and reducing the outlet air flow velocity, as well as reducing the power consumption of the motor by reducing the air passage resistance.

[0052] Furthermore, according to the fourth embodiment, since the front end of the extension part is positioned towards the inner side in the radial direction than the portion of the extension part on the side of the shroud outer peripheral end section, then the eddy which is created in the region enclosed by the extension part and the shroud main body section is formed further towards the inside in the radial direction, and therefore a broader air passage width can be ensured in the extension part and the heat exchanger. Consequently, it is possible to achieve a centrifugal fan which restricts power consumption by reducing the air passage resistance.

Fifth Embodiment

[0053] Next, a fifth embodiment of the present invention will be described. The characteristic feature of the fifth embodiment is that the end section 29 of the heat exchanger 16 on the side of the air-conditioning device outlet port is closer to the air-conditioning device outlet port 19 than the inlet-side end section 28 of the centrifugal fan is, when viewed in a direction parallel to the axis of rotation 5. The abovementioned characteristic feature of the fifth embodiment can also be applied to any of the configurations of the first to fourth embodiments, and is depicted in Fig. 5 and Fig. 17 relating to the description given above. By the characteristic feature of this kind, it is possible to further enhance the effects of the first to fourth embodiments.

[0054] The contents of the present invention have been described above with reference to preferred embodiments, but it would be obvious to a person skilled in the art that various modifications can be made on the basis of the basic technical concepts and teachings of the present invention.

[0055] For example, the present invention is not limited to an air-conditioning device provided with a heat exchanger, and can be applied widely to air blower which has a wall on the outside of the outlet port in the radial direction, and which discharges the air flow that has been sucked in after causing the air flow to make a U turn.

[0056] Furthermore, the shape of the concave rounded surface which is constituted by the extension part and the shroud main body section is an example of a shape capable of forming a stable eddy, but the present invention is not limited to this and the rounded surface can also be configured as a rounded surface in which a plurality of circular arcs are joined together tangentially, in accordance with the length of the extension part. In other words, the present invention can also be applied to an air blower which is provided with a centrifugal fan according to the present invention as described above, and a motor which drives the centrifugal fan.

[Reference Signs List]

[0057]

1, 101, 201, 301	Centrifugal fan
2	Main plate

3	Shroud
3a	Fan inlet port
5	Axis of rotation
6	Direction of rotation
8	Shroud outer peripheral end section
10, 310	Extension part
11	Shroud main body section
16	Heat exchanger
19	Air-conditioning device outlet port
28	Inlet-side end section
29	End section on air-conditioning device inlet port side
25, 125, 225	Projection
30	Concave rounded surface
100	Air-conditioning device

Claims

1. A centrifugal fan comprising: a main plate; a shroud having a fan inlet port; and a plurality of vanes provided between the main plate and the shroud,
wherein the shroud has a shroud main body section and an extension part,
the extension part is a portion extending from a shroud outer peripheral end section of the shroud main body section to an upstream side when viewed in a direction parallel to an axis of rotation,
a radially outside surface of the shroud main body section,
and a radially inside surface of the extension part constitute a concave rounded surface, and
a direction of recess of the concave rounded surface is towards the upstream side when viewed in the direction parallel to the axis of rotation.

2. The centrifugal fan according to claim 1, wherein, when a curvature of the concave rounded surface is expressed as ρa, and a curvature of a curved surface constituted by the shroud outer peripheral end section of the shroud main body section and the radially outside surface of the extension part is expressed as pb, then ρa is smaller than pb.

3. The centrifugal fan according to claim 1 or 2, wherein an outer diameter Rsh of the shroud outer peripheral end section is greater than an outer diameter RO of the main plate.

4. The centrifugal fan according to claims 1 to 3, wherein a plurality of projections extending in the radial direction are formed on the concave rounded surface.

5. The centrifugal fan according to claim 4, wherein the plurality of projections are inclined in such a manner that, in plan view, the portion of each projection on the outside in the radial direction is positioned rearwards in a direction of rotation of the centrifugal fan, with respect to the portion of the projection on the inside in the radial direction.

6. The centrifugal fan according to any one of claims 1 to 5,
wherein a front end of the extension part is positioned towards the inner side in the radial direction than a portion of the extension part on the side of the shroud outer peripheral end section.

7. An air-conditioning device comprising: the centrifugal fan according to any one of claims 1 to 6; and a heat exchanger disposed on the outside of the centrifugal fan.

8. The air-conditioning device according to claim 7, wherein an end section of the heat exchanger on the side of an air-conditioning device outlet port is closer to the air-conditioning device outlet port than an inlet-side end section of the centrifugal fan is, when viewed in a direction parallel to an axis of rotation.

FIG. 1

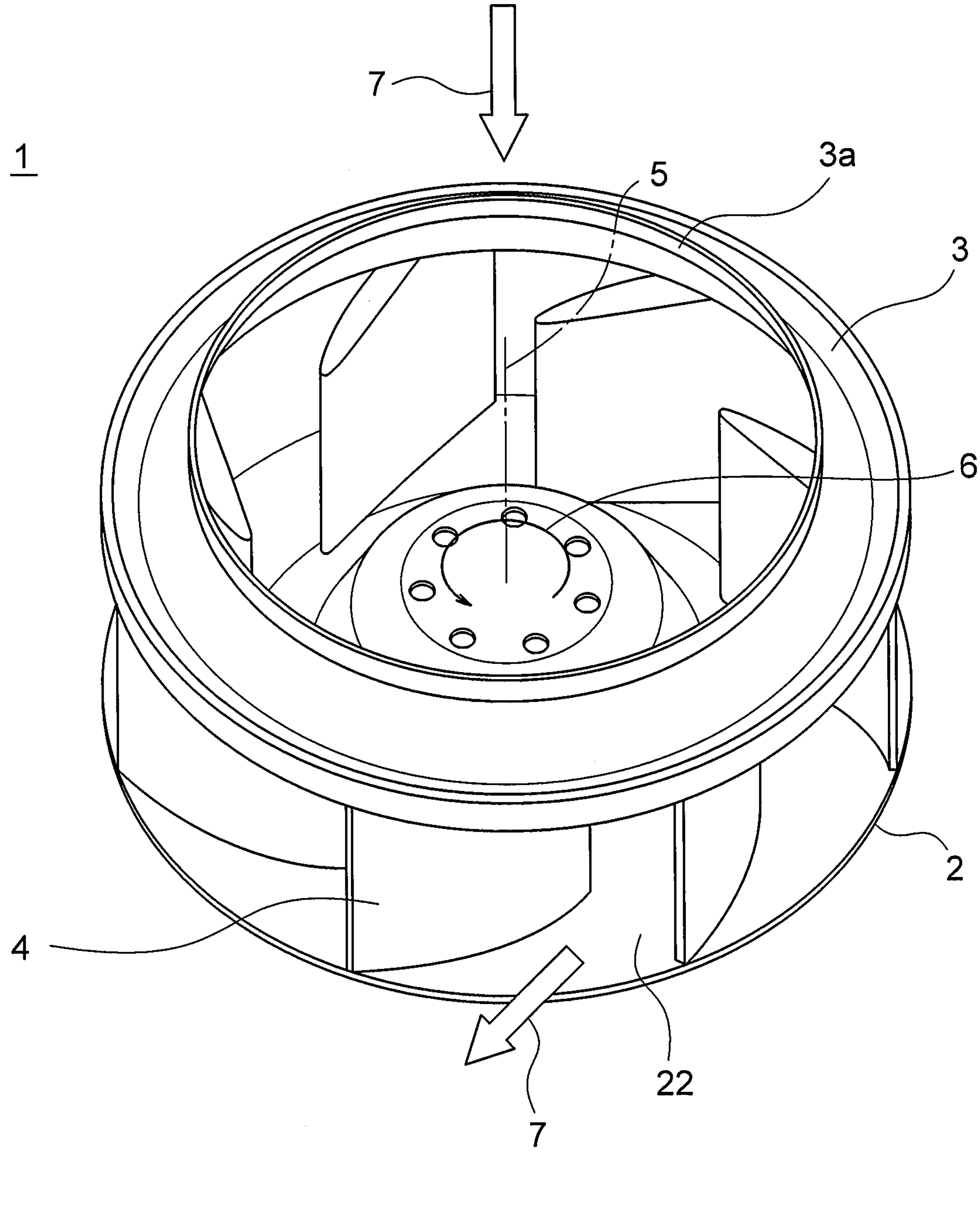


FIG. 2

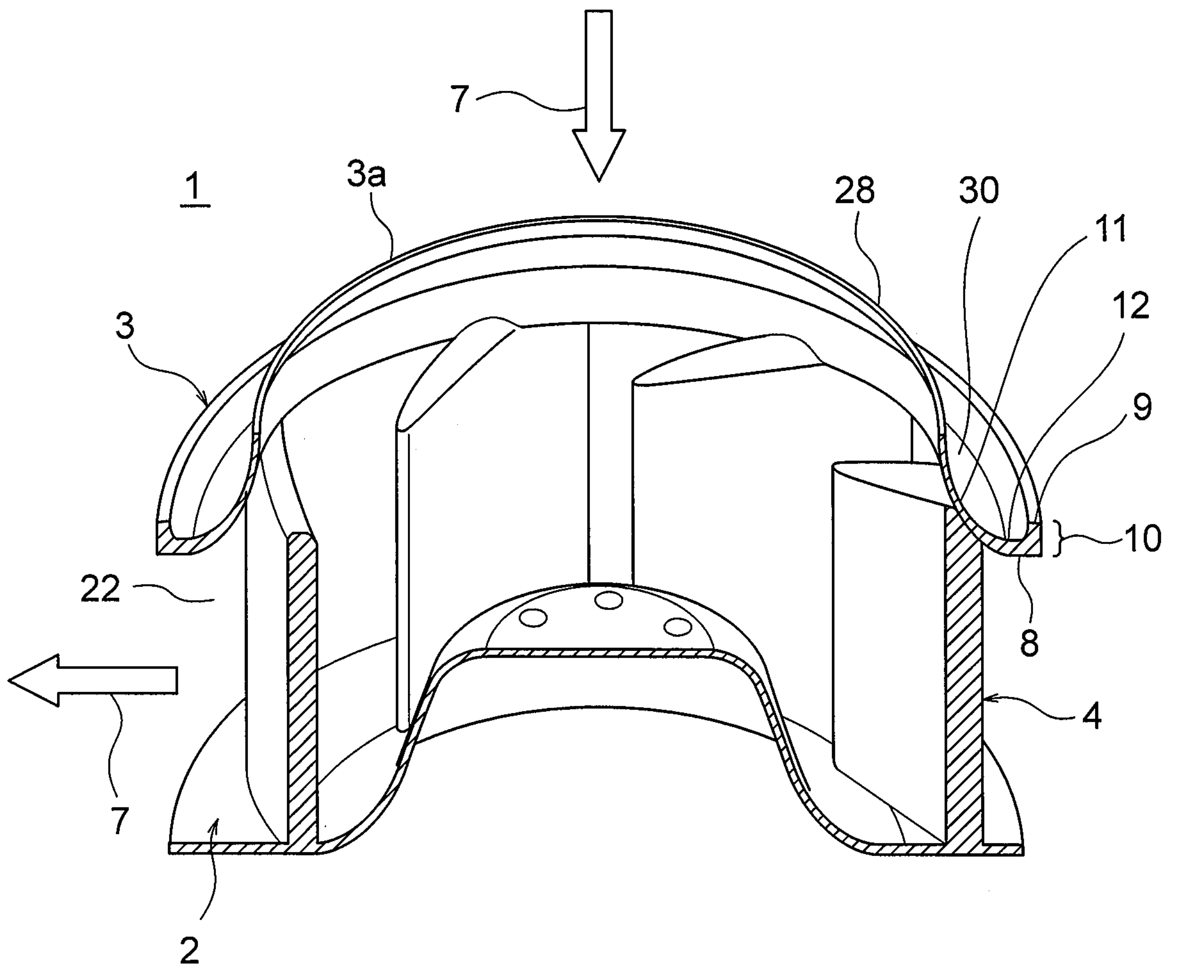


FIG. 3

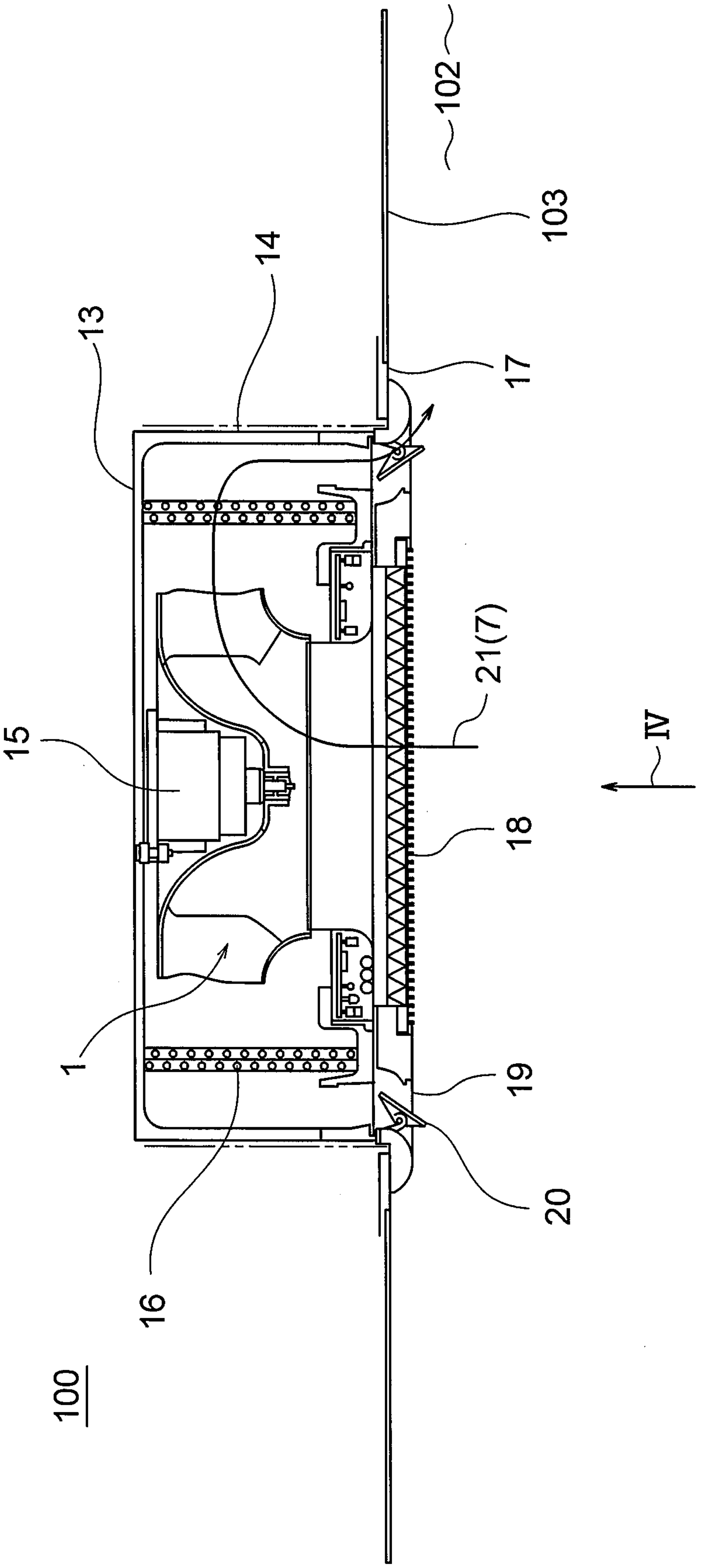


FIG. 4

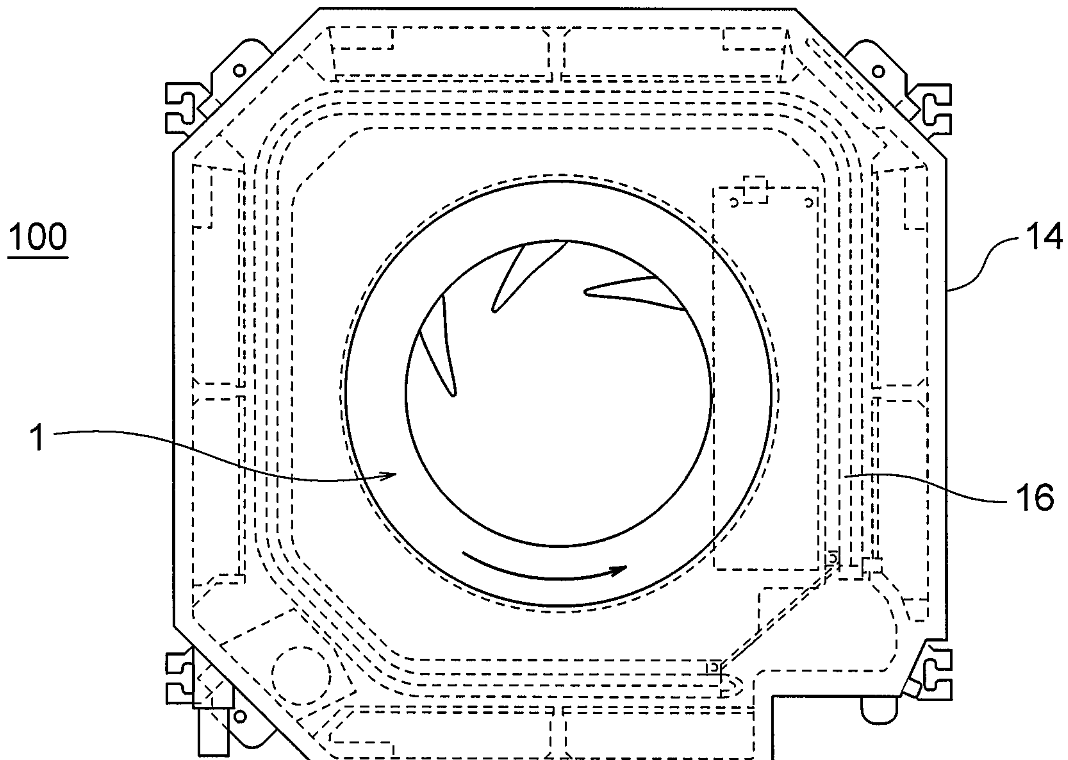


FIG. 5

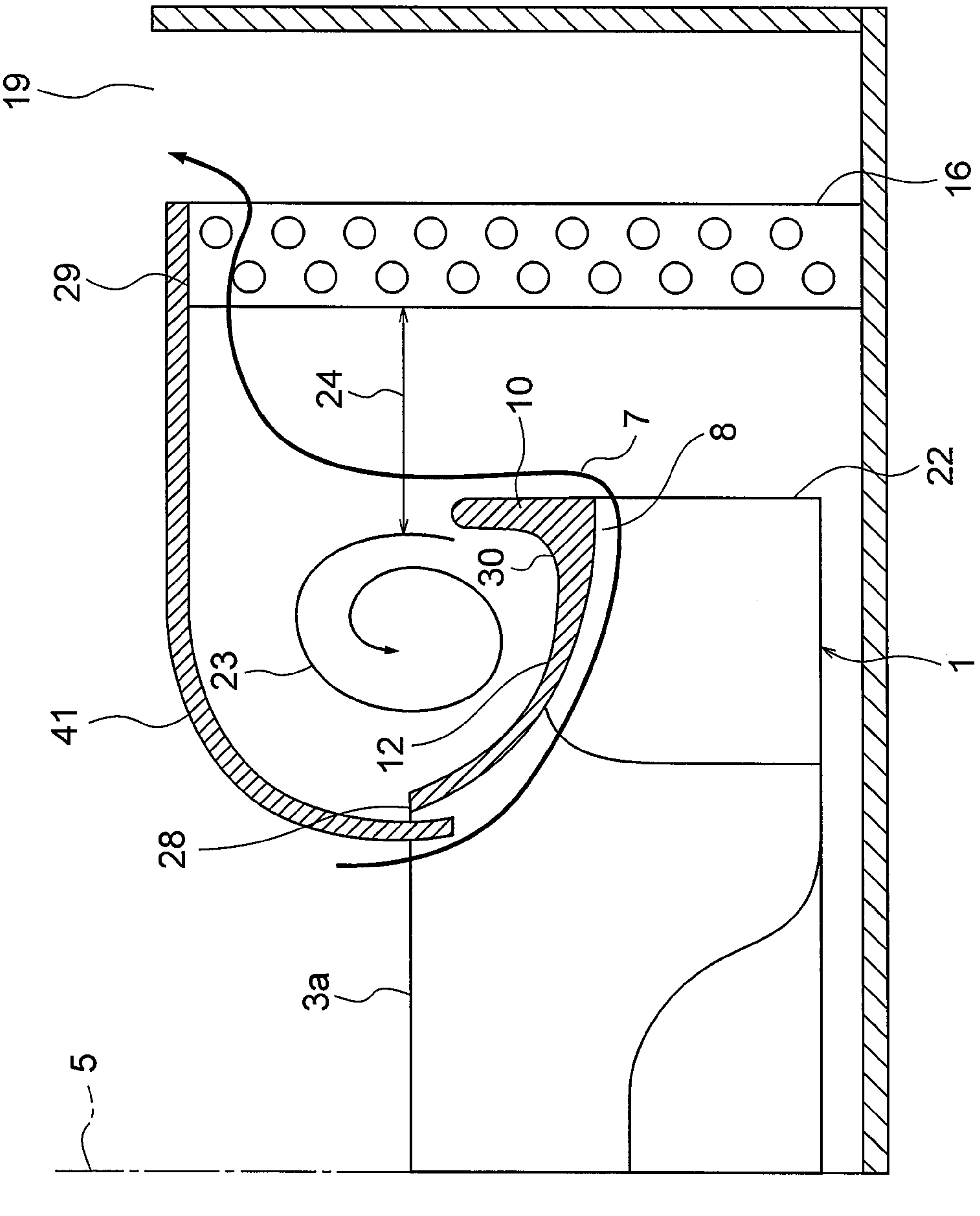


FIG. 6

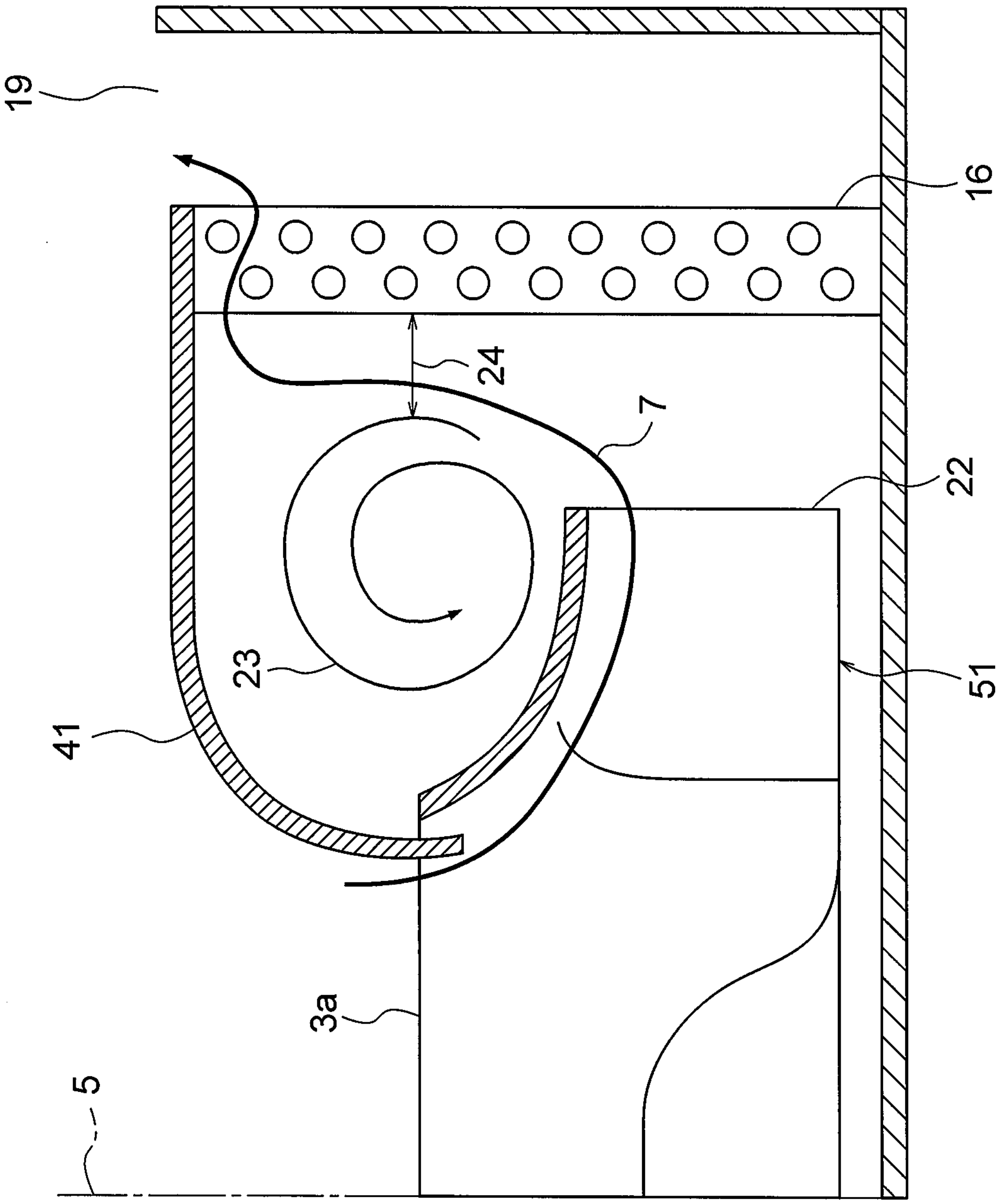


FIG. 7

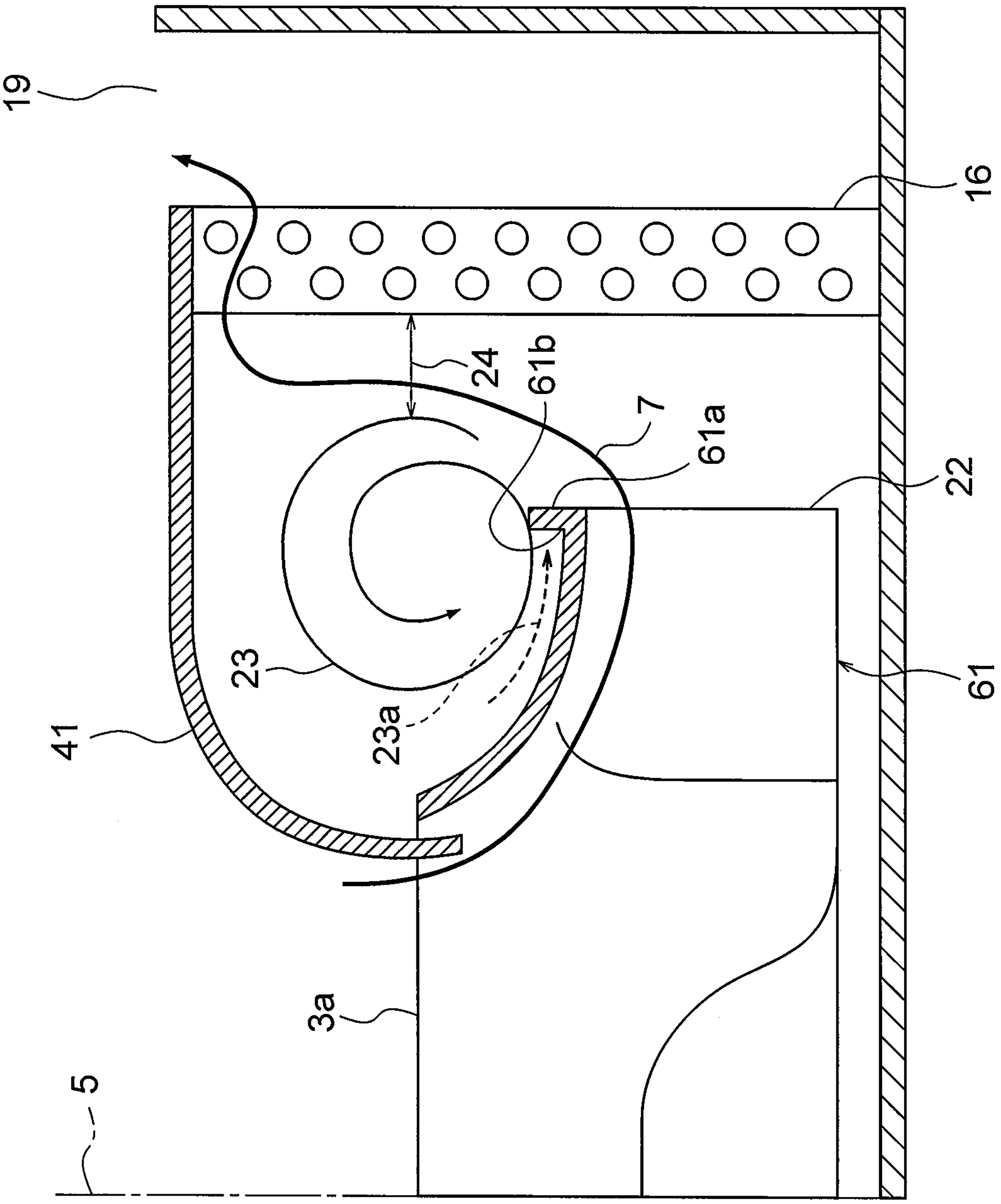
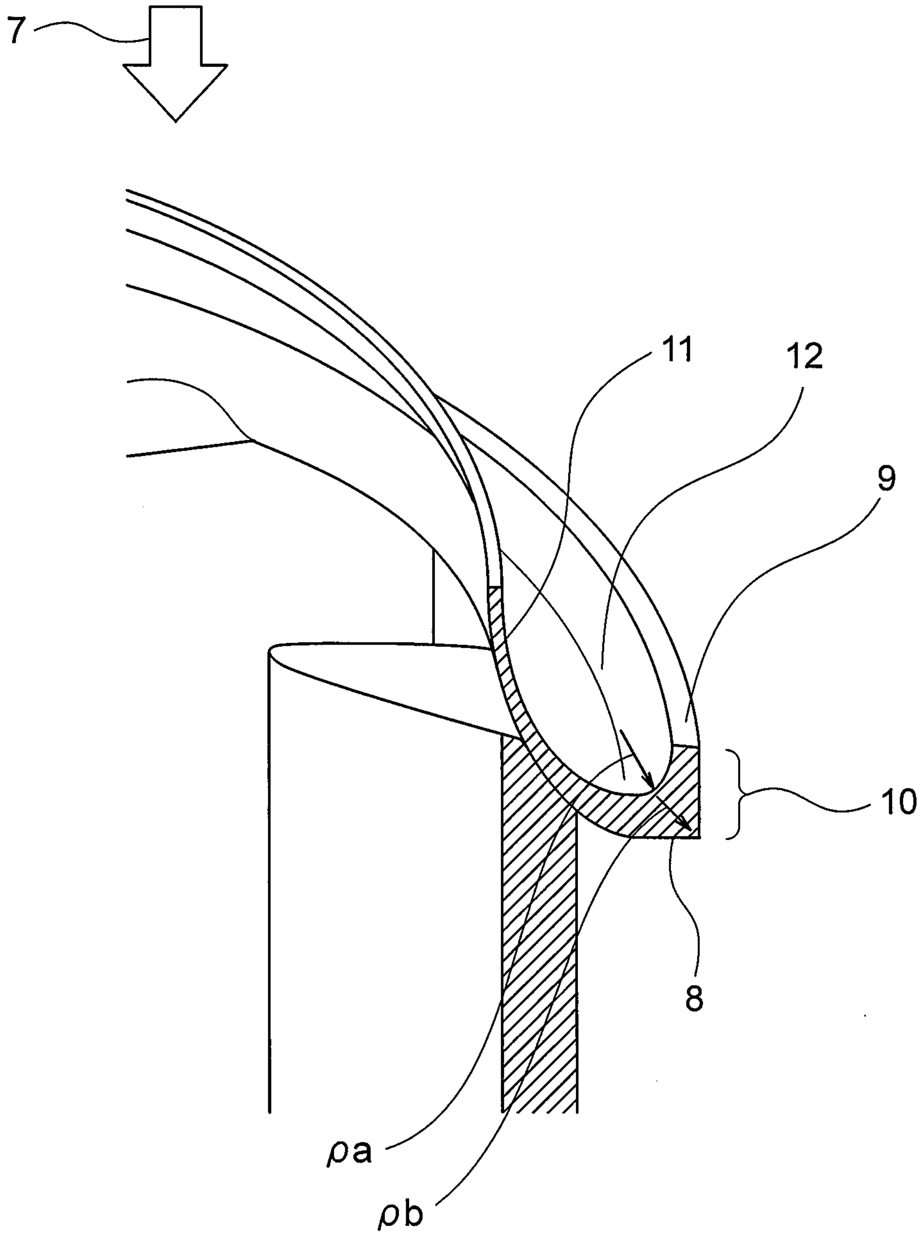


FIG. 8



ρa < ρb

FIG. 9

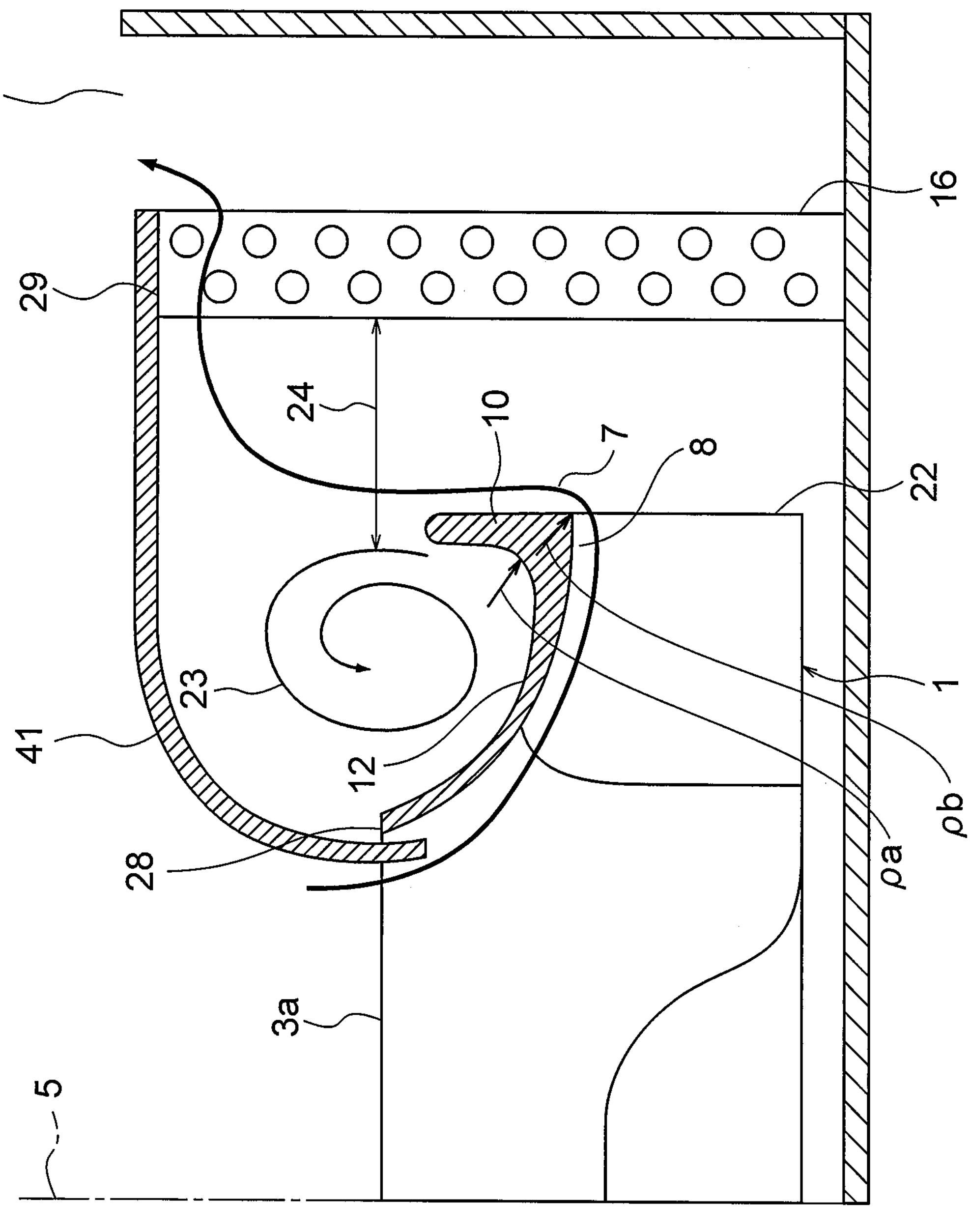


FIG. 10

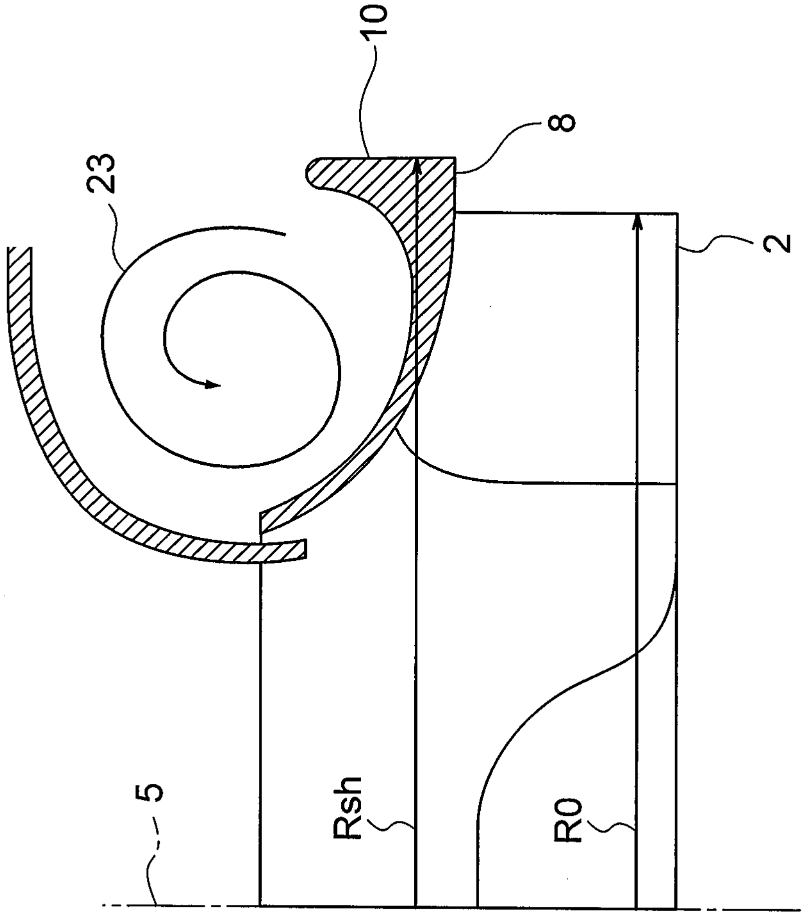


FIG. 11

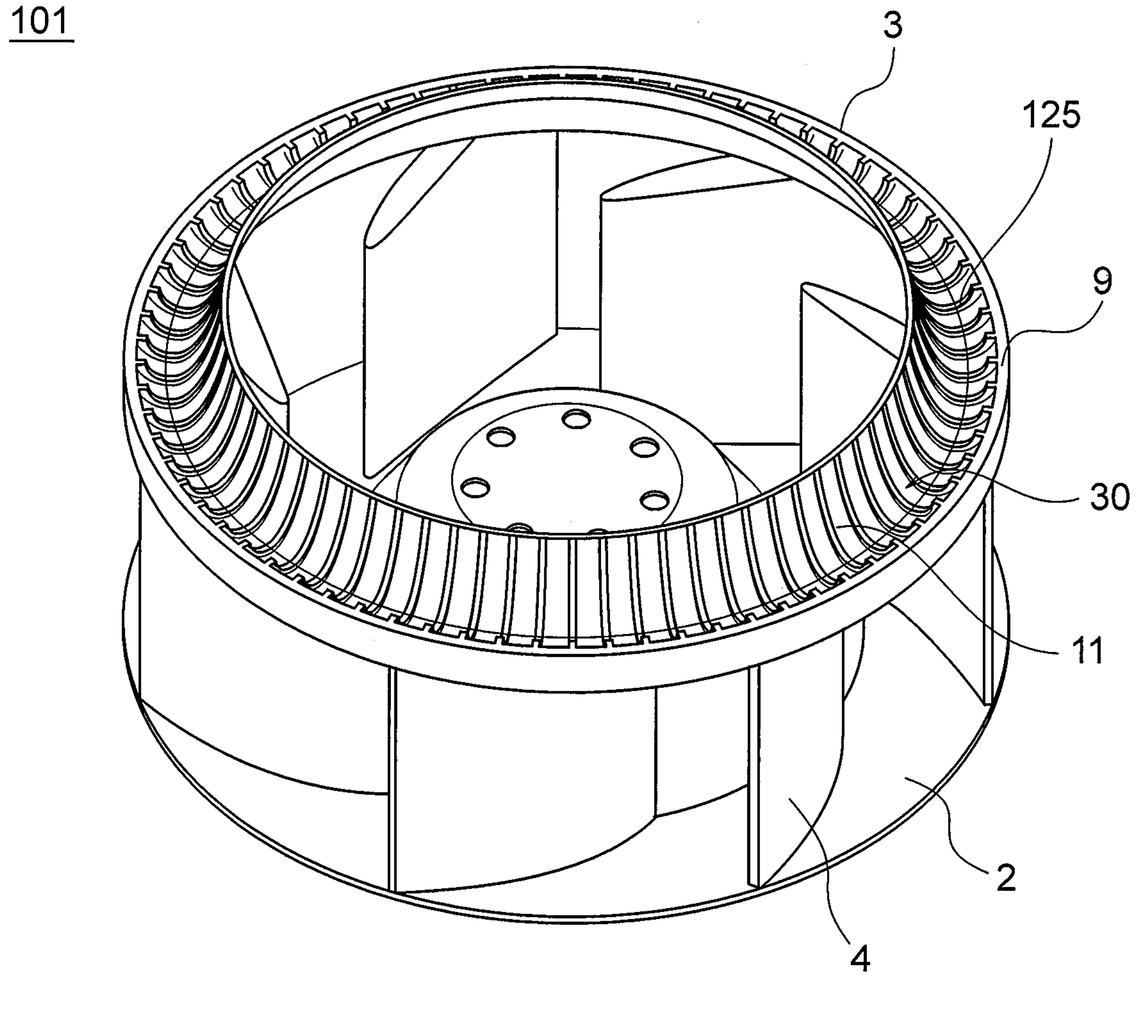


FIG. 12

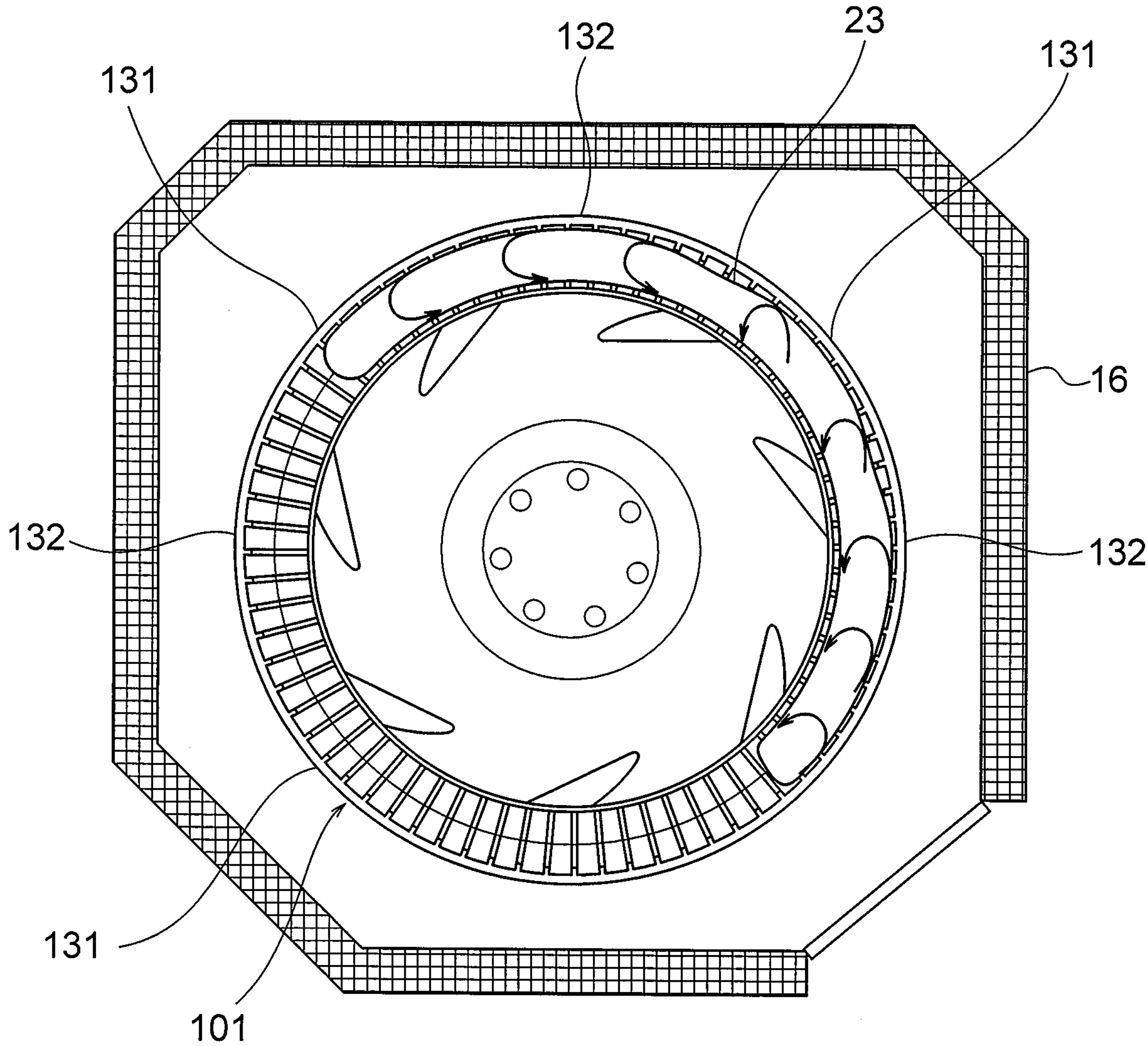


FIG. 13

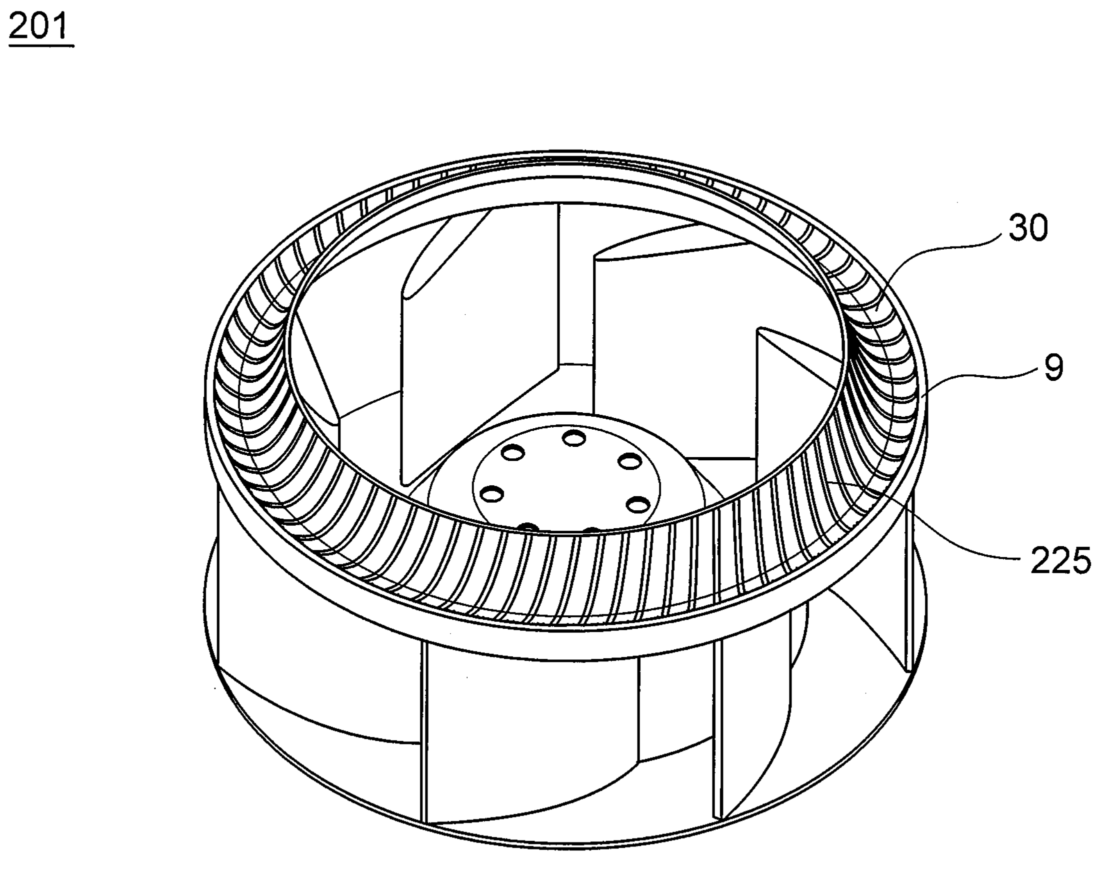


FIG. 14

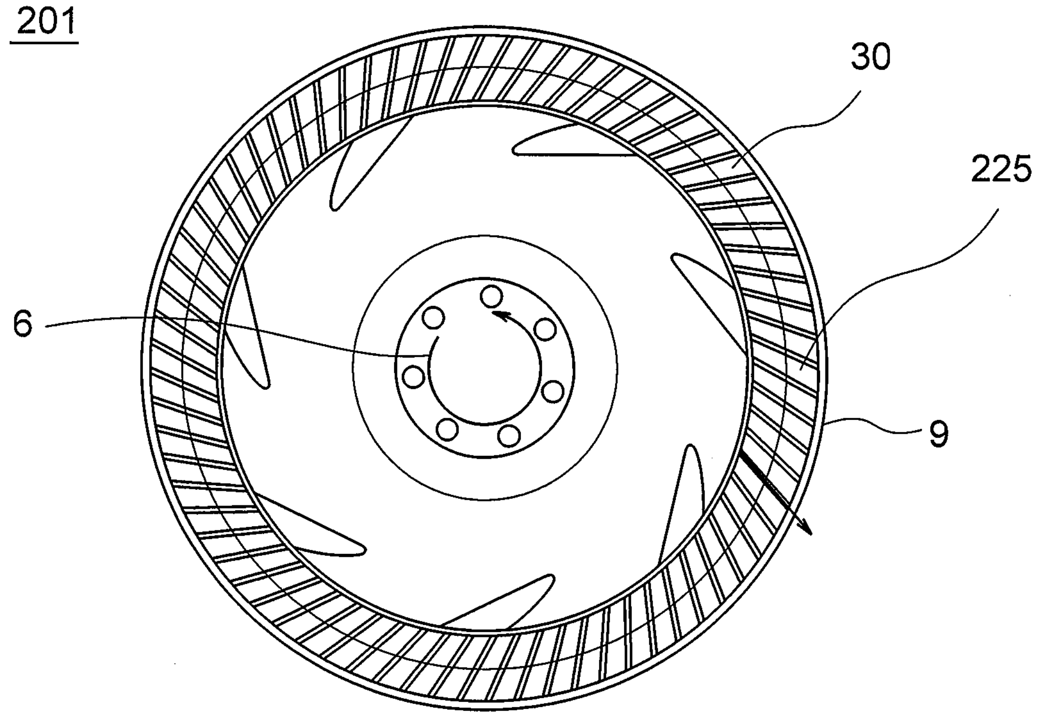


FIG. 15

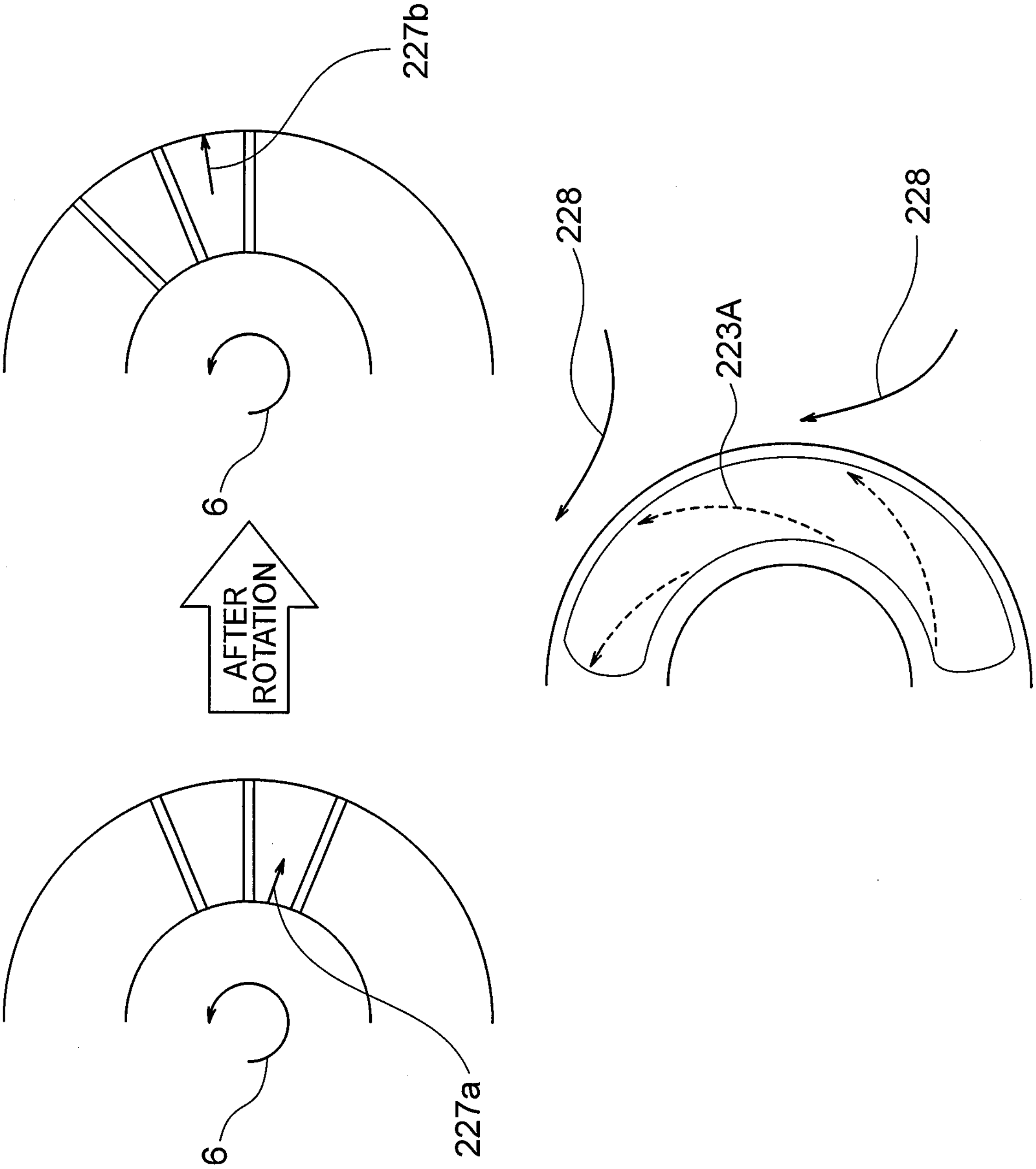


FIG. 16

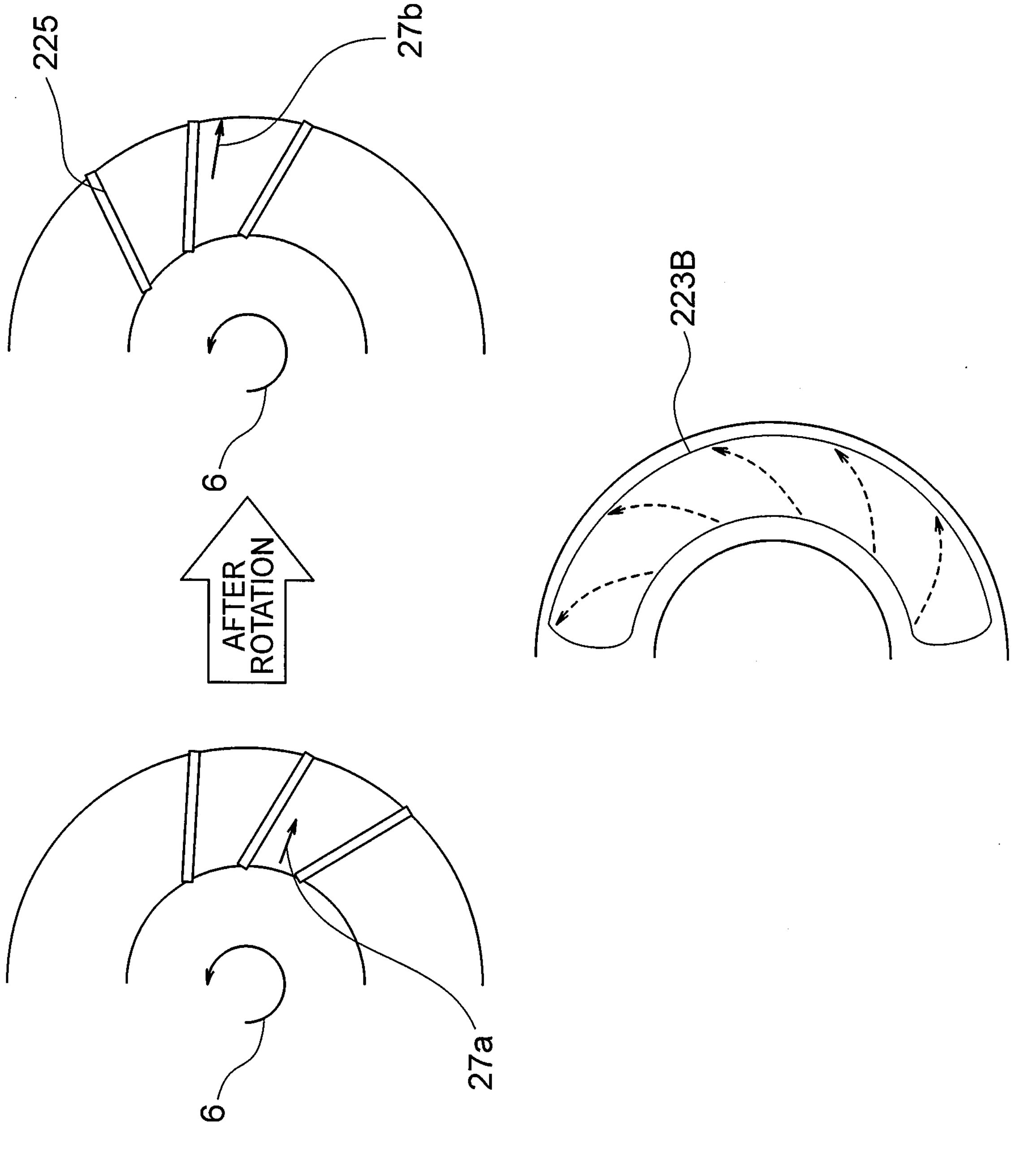
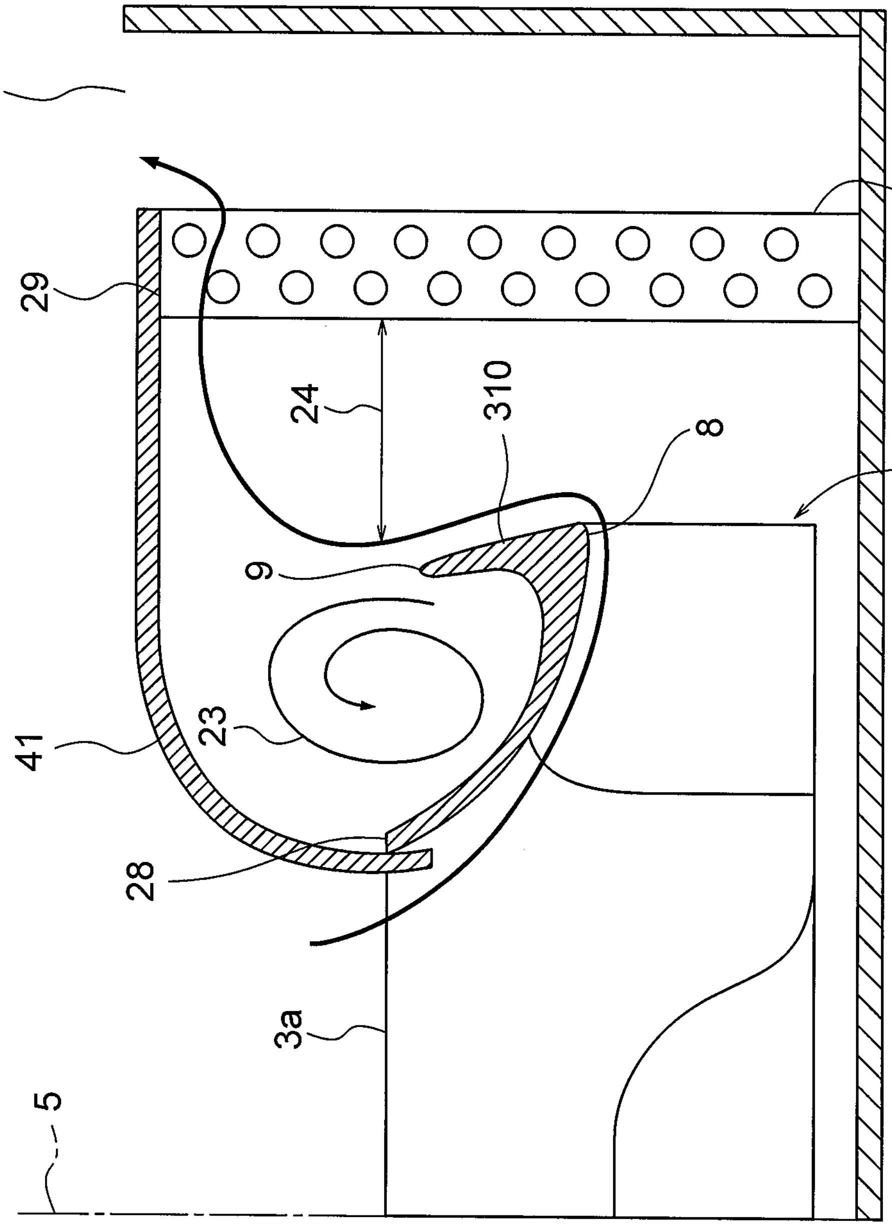


FIG. 17



INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2014/051641

A. CLASSIFICATION OF SUBJECT MATTER

F04D29/28(2006.01)i, *F24F1/00*(2011.01)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)
F04D29/28, 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	1996-2014
Kokai Jitsuyo Shinan Koho	1971-2014	Toroku Jitsuyo Shinan Koho	1994-2014

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.
X Y	WO 1998/058213 A1 (Daikin Industries, Ltd.), 23 December 1998 (23.12.1998), fig. 1 & EP 000926452 A1 & JP 003116379 B	1-3,7,8 4
Y	WO 2007/040073 A1 (Daikin Industries, Ltd.), 12 April 2007 (12.04.2007), fig. 4, 5 & US 2009/0255654 A1 & EP 001933039 A1 & KR 10-2088-0037722 A & CN 101253333 A	4
A	JP 2012-207600 A (Minebea Co., Ltd.), 25 October 2012 (25.10.2012), fig. 4 (Family: none)	1-8

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"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	Date of mailing of the international search report
17 February, 2014 (17.02.14)	25 February, 2014 (25.02.14)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2014/051641

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2000-120582 A (Matsushita Seiko Co., Ltd.), 25 April 2000 (25.04.2000), fig. 7, 9 (Family: none)	1-8

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2000120582 A **[0006]**
- JP 2012207600 A **[0006]**