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- **MARUYAMA, Kaname**
Kita-ku
Osaka-shi
Osaka 530-8323 (JP)
- **TEI, Shimei**
Kita-ku
Osaka-shi
Osaka 530-8323 (JP)

(30) Priority: 21.12.2012 JP 2012278769

(71) Applicant: **Daikin Industries, Ltd.**
Osaka 530-8323 (JP)

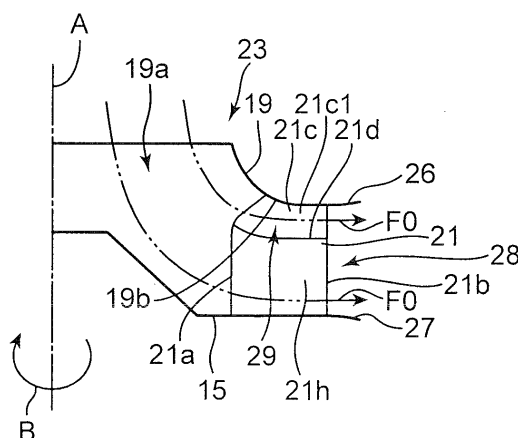
(74) Representative: **Hoffmann Eitle
Patent- und Rechtsanwälte PartmbB
Arabellastraße 30
81925 München (DE)**

(72) Inventors:
• IWATA, Tooru
Kita-ku
Osaka-shi
Osaka 530-8323 (JP)

(54) **CENTRIFUGAL FAN**

(57) A centrifugal fan (23) includes a hub (15), a plurality of blades (21), and a shroud (19). The blades (21) each have a curved part (21d) that is curved to incline toward a side (21c1) on which air impinges when a connected end (21c) connected to an inwardly protruding portion of the shroud (19) moves in a rotating direction of the centrifugal fan (23). The hub (15) includes a hub-side diffuser ring (27) that protrudes radially outward of the blades (21). The shroud (19) includes a shroud-side diffuser ring (26) that protrudes radially outward of the blades (21).

FIG. 5



Description

Technical Field

[0001] The present invention relates to a centrifugal fan.

Background Art

[0002] Centrifugal fans such as turbo fans have conventionally been used to supply air at high pressure in air handling units and other air conditioning apparatuses for large-scale air conditioning of the interior of a building. A turbo fan is a fan that has backward-inclined blades, and configured to blow out air radially outward. The turbo fan thus has the advantage of being simply configured since it does not require a scroll casing such as that of a sirocco fan. However, one problem is that the flow of air, immediately after being expelled by the blades, impinges on objects around the blades and is disturbed, which leads to increased noise and reduced efficiency.

[0003] For this reason, conventionally, in a configuration that includes a hub, a plurality of blades arranged in a circumferential direction of the hub, and a shroud arranged on the opposite side of the blades from the hub, diffuser rings are provided radially on the outer side of the blades, as in the turbo fans described in Patent Literature 1 and 2. In the turbo fans described in Patent Literature 1 and 2, the shroud and the hub have larger outer diameters than the outer diameter of the blades. Parts of the shroud and hub that are positioned on the outer side of the blades form the respective diffuser rings.

[0004] This provides the so-called diffuser effect, whereby the speed of the air expelled by the blades is reduced as the air passes through between the diffuser rings, i.e., the effect that effectively converts the kinetic energy of the air to pressure. This enables an improvement in the fan efficiency.

[0005] The blades in such a turbo fan are usually two-dimensional blades that have uniform cross sections orthogonal to the axial direction of the rotating shaft of the turbo fan at positions displaced along the axial direction. The two-dimensional blades are each connected to an inwardly protruding portion of the shroud at an acute angle.

[0006] In the configuration of the turbo fan having diffuser rings such as those described in Patent Literature 1 and 2, as shown in Fig. 13, when viewed in a cross section across the axial direction of the turbo fan (e.g., cross section at a position corresponding to the IV-IV cross section of the centrifugal fan 23 shown in Fig. 3), the blade 121, which is a two-dimensional blade, is arranged between the shroud 119 and hub 115. In a portion 129 where the blade 121 is connected to the shroud 119 at an acute angle, there is a region 129 where the air is easily disturbed. On the side of the shroud 119, this disturbance in the air causes a partial drop in the flow velocity of the air F10 that entered through an air inlet 119a into

the turbo fan, as shown in Fig. 14. There is, therefore, a possibility that there may be created a separation area 130 where the air F10 separates from the inner face of the shroud 119 as the air F10 travels from the air inlet 119a toward the outlet 128 along the blade 121. This accordingly makes it difficult to improve the diffuser effect of the diffuser rings 126 and 127 provided on the radially outer side of the hub 115 and shroud 119.

Citation List

Patent Literature

[0007]

Patent Literature 1: Japanese Unexamined Patent Publication No. H11-108403

Patent Literature 2: U.S. Patent Publication No. 2006/0228212

Summary of Invention

[0008] In view of the circumstances described above, an object of the present invention is to provide a centrifugal fan that can improve the diffuser effect of diffuser rings that converts kinetic energy of the air to pressure.

[0009] A centrifugal fan of the present invention is characterized to include: a hub; a plurality of blades arranged along a circumferential direction of the hub; and a shroud arranged on an opposite side of the blades from the hub, the blades each having a curved part that is curved to incline toward a side on which air impinges when a connected end connected to an inwardly protruding portion of the shroud moves in a rotating direction of the centrifugal fan, the hub having a hub-side diffuser ring that protrudes radially outward of the blades, and the shroud having a shroud-side diffuser ring that protrudes radially outward of the blades.

Brief Description of Drawings

[0010]

[Fig. 1] Fig. 1 is a longitudinal cross-sectional view illustrating the inside of an indoor unit of an air conditioner equipped with a centrifugal fan according to one embodiment of the present invention.

[Fig. 2] Fig. 2 is a perspective view of the centrifugal fan of Fig. 1.

[Fig. 3] Fig. 3 is a diagram of the centrifugal fan of Fig. 1 viewed from an air inlet side.

[Fig. 4] Fig. 4 is a cross section along IV-IV of Fig. 3.

[Fig. 5] Fig. 5 is an explanatory diagram schematically showing air flows inside the centrifugal fan of Fig. 1.

[Fig. 6] Fig. 6 is an enlarged view of a portion near a rear edge of a blade of Fig. 1.

[Fig. 7] Fig. 7 is an explanatory diagram showing

respective dimensions of the hub-side diffuser ring and shroud-side diffuser ring of the centrifugal fan of Fig. 1.

[Fig. 8] Fig. 8 is a graph showing the static efficiency of a centrifugal fan according to an embodiment of the present invention provided with both a shroud-side diffuser ring and a hub-side diffuser ring, along with the static efficiency of a centrifugal fan that does not include one or both of the diffuser rings.

[Fig. 9] Fig. 9 is a graph comparing the effect of diffuser rings to improve maximum static efficiency of a centrifugal fan having three-dimensional (3D) blades in one embodiment of the present invention, and the effect of diffuser rings to improve maximum static efficiency of a centrifugal fan having two-dimensional blades in an example comparable to the present invention.

[Figs. 10A and 10B] Fig. 10A is one of diagrams showing a flow velocity distribution near an outlet of a centrifugal fan, showing the flow velocity distribution near the outlet of the centrifugal fan having 3D blades and diffuser rings in one embodiment of the present invention, and Fig. 10B is one of diagrams showing a flow velocity distribution near an outlet of a centrifugal fan, showing the flow velocity distribution near the outlet of the centrifugal fan having two-dimensional blades and diffuser rings in a centrifugal fan in an example comparable to the present invention.

[Fig. 11] Fig. 11 is a cross-sectional explanatory diagram illustrating an example in which the hub-side diffuser ring forms a plane coplanar with the hub in a centrifugal fan according to a variation example of the present invention.

[Fig. 12] Fig. 12 is a cross-sectional explanatory diagram illustrating an example in which the shroud-side diffuser ring has a linearly extending portion in a centrifugal fan according to another variation example of the present invention.

[Fig. 13] Fig. 13 is a cross-sectional view of a blade and its vicinity in a conventional centrifugal fan.

[Fig. 14] Fig. 14 is an explanatory diagram schematically showing air flows inside the conventional centrifugal fan.

Description of Embodiments

[0011] Hereinafter, an indoor unit of an air conditioner according to embodiments of the present invention will be described in detail with reference to the drawings.

[0012] The indoor unit 31 shown in Fig. 1 is a cassette type indoor unit that is embedded in the ceiling. This indoor unit 31 includes a generally cuboidal housing 33 that is embedded in an opening in the ceiling C, and a decorative panel 47 attached to the lower part of the housing 33. The decorative panel 47 has a dimension in plan view that is slightly larger than that of the housing 33 and is exposed in the room such as to cover the open-

ing in the ceiling C. The decorative panel 47 has a rectangular inlet grill 39 provided in the center and a plurality of (e.g. four) thin and long rectangular air outlets 37 provided along each side of this inlet grill 39.

[0013] The indoor unit 31 includes a blower 51 equipped with a centrifugal fan 23, a fan motor 11 that drives the centrifugal fan 23 to rotate, a heat exchanger 43 surrounding the outer side of the centrifugal fan 23, a drain pan 45, and an air filter 41.

[0014] The blower 51 includes the centrifugal fan 23 that is a turbo fan, and a bell mouth 25.

[0015] The centrifugal fan 23 includes, as shown in Fig. 1 to Fig. 3, a hub 15, a plurality of (e.g. seven in Fig. 2 and Fig. 3) blades 21 arranged in a circumferential direction of the hub 15, and a shroud 19 arranged on the opposite side of the blades 21 from the hub 15. As shown in Fig. 2 and Fig. 5, outlets 28 of the centrifugal fan 23, through which the air is blown out, are each formed by the spaces surrounded by the hub 15, shroud 19, and two blades 21.

[0016] The hub 15 is secured to the rotating shaft 13 of the fan motor 11 that is fixed to the top plate of the housing 33.

[0017] The hub 15 has a hub-side diffuser ring 27 that protrudes radially outward of the blades 21. More specifically, the hub-side diffuser ring 27 has a ring-like shape and is formed to extend outward beyond the rear edges 21 b of respective blades 21.

[0018] The shroud 19 is arranged opposite the hub 15 on the front side F in the axial direction A of the rotating shaft 13 (see Fig. 1). The shroud 19 includes an air inlet 19a that opens in the form of a circle around the rotating shaft 13. The outer diameter of the shroud 19 increases toward the rear side R (see Fig. 1). In other words, as shown in Fig. 4 and Fig. 5, the shroud 19 has a curved portion 19b that protrudes inward of the centrifugal fan 23 from the air inlet 19a to the outlet 28.

[0019] The shroud 19 has a shroud-side diffuser ring 26 that protrudes radially outward of the blades 21. The shroud-side diffuser ring 26 is formed to extend outward beyond the rear edges 21 b of respective blades 21 and arranged opposite the hub-side diffuser ring 27.

[0020] The mutually opposing faces of the hub-side diffuser ring 27 and shroud-side diffuser ring 26 are smoothly continuous with the mutually opposing faces of the hub 15 and shroud 19, respectively.

[0021] Moreover, the distance between the diffuser rings 27 and 26 is set such as to gradually increase radially outward of the centrifugal fan 23, as shown in Fig. 5.

[0022] The plurality of blades 21 are aligned and spaced apart a certain distance along the circumferential direction of the air inlet 19a between the hub 15 and shroud 19. One end on the front side F (see Fig. 1) of each blade 21 is joined to the inner face of the shroud 19. One end on the rear side R (see Fig. 1) of each blade 21 is joined to the hub 15. As shown in Fig. 3, each blade 21 is a backward-inclined blade that is inclined radially outward toward the opposite direction from the rotating

direction B (backward) relative to the radial direction of the hub 15 (i.e., so that the rear edges 21b of the blades 21 shown in Fig. 3 are positioned on the radially outer side than the front edges 21 a).

[0023] Each blade 21 shown in Fig. 2 to Fig. 6 is formed by a so-called 3D shape blade that is shaped such that its cross-sectional shape orthogonal to the axial direction A of the rotating shaft 13 of the motor 11 varies at positions displaced along the axial direction A. In other words, in such 3D blades 21, as shown in Fig. 2, the front edge 21a and rear edge 21b of the blade 21 have a twisted positional relationship, as well as the end on the front side F and the end on the rear side R of the blade 21 have a twisted relationship.

[0024] Each blade 21 includes, as shown in Fig. 3 to Fig. 5, a main part 21h joined to the hub 15, a curved part 21 d continuous with one end of the main part 21 h on the side of the shroud 19, and a connected end 21c continuous with one end of the curved part 21d on the side of the shroud 19. The rotating direction B in Fig. 4 is a direction extending perpendicularly to the paper plane of Fig. 4 toward the viewer.

[0025] The connected end 21c leads to an inwardly protruding portion 19b of the shroud 19. The inwardly protruding portion 19b of the shroud 19, more specifically, is a curved portion protruding inward of the centrifugal fan 23 as shown in Fig. 4, a portion excluding the part linearly extending radially inward.

[0026] The curved part 21 d is curved to incline toward a side 21c1 on which air impinges when the connected end 21c moves in the rotating direction B of the centrifugal fan 23.

[0027] More specifically, the curved part 21 d is formed by protruding a portion of the blade 21 on the side near the shroud 19 out, relative to the main part 21h, toward the side opposite from the side 21d1 which the air impinges on when that portion moves in the rotating direction B of the centrifugal fan 23. The connected end 21c is connected to the inwardly protruding portion 19b of the shroud 19 generally orthogonally to a tangential line C (see Fig. 4) of the inner face of the portion 19b. The curved part 21d is formed continuously from the front edge 21a to the rear edge 21b of the blade 21, as shown in Fig. 5.

[0028] Therefore, as shown in Fig. 4 and Fig. 5, on the side 21c1 of the connected end 21c of the blade 21 which the air impinges on when the connected end 21c moves in the rotating direction B, there is no portion where the blade 21 is connected to the shroud 19 at an acute angle. Instead, there is formed an extended area 29 that is recessed in the opposite direction from the side 21c1 which the air impinges on (i.e., extension recess 29) from the front edge 21a to the rear edge 21b of the blade 21a. This extension recess 29 ensures a sufficiently wide air passage. Consequently, a drop in the flow velocity of the air F0 near the connected end 21c can be prevented.

[0029] As shown in Fig. 6, a hub-side end 21e at the rear edge 21b of the blade 21 is positioned more forward

in the rotating direction B of the centrifugal fan 23 than a shroud-side end 21 f of the rear edge 21 b.

[0030] Since the hub-side end 21e at the rear edge 21 b of the blade 21 is located on the front side in the rotating direction B, the air flows along the inclined front surface 21g of the blade 21 (i.e., forward side in the rotating direction B) as indicated by arrow F1 in Fig. 6, and thus the air can readily flow toward the shroud 19. Thereby, the flow of the air F0 that passes through the centrifugal fan 23 is uniform along the axial direction A of the centrifugal fan 23, as shown in Fig. 5. Therefore, the diffuser effect of the pair of diffuser rings 26 and 27, i.e., the effect that converts the kinetic energy of the flow of the air F1 to a static pressure, in particular, the diffuser effect on the side of the shroud 19, can be improved.

[0031] In order to ensure the diffuser effect, the outer diameter D2 of the hub-side diffuser ring 27 and the outer diameter D3 of the shroud-side diffuser ring 26 are each set to be 1.1 times or more larger than the diameter D1 of the circumscribed circle of the plurality of blades 21, as shown in Fig. 7. While the outer diameter D2 of the hub-side diffuser ring 27 and the outer diameter D3 of the shroud-side diffuser ring 26 are set the same in Fig. 7, the present invention is not limited to this. These outer diameters D2 and D3 need not necessarily be the same.

[0032] Moreover, as shown in Fig. 7, the distance H2 between the pair of diffuser rings 26 and 27 on the exit side (i.e., radially outer side) is set larger than the height H1 of the blade 21 on the exit side (i.e., rear edge 21 b). More specifically, the shroud-side diffuser ring 26 and hub-side diffuser ring 27 are arranged to incline away from each other toward the respective distal ends. This allows the flow of the air F0 to more smoothly pass through between the pair of diffuser rings 26 and 27.

[0033] The centrifugal fan 23 configured as described above, with the shroud-side diffuser ring 26 and hub-side diffuser ring 27, can have significantly higher static efficiency as compared to a centrifugal fan without these diffuser rings.

[0034] For example, as shown in the graph of Fig. 8, in which the horizontal axis represents flow coefficient ϕ , and the vertical axis represents static efficiency η , it can be seen that the static efficiency η is higher over the entire range of the flow coefficient ϕ as indicated by curve IV in the case with the centrifugal fan 23 of this embodiment that has both of the shroud-side diffuser ring 26 and hub-side diffuser ring 27, as compared to the static efficiency η in the case without these diffuser rings (curve I).

[0035] The static efficiency η in the case with only the hub-side diffuser ring tends to be higher in the range of $\phi < \text{about } 0.23$ of the flow coefficient ϕ , but not in the range of $\phi > \text{about } 0.23$, as indicated by curve II. On the other hand, the static efficiency η in the case with only the shroud-side diffuser ring tends to be higher in the range of $\phi > \text{about } 0.15$ of the flow coefficient ϕ , but not in the range of $\phi < \text{about } 0.15$, as indicated by curve III.

[0036] It can be seen from the graph of Fig. 8 that, as

compared to these cases indicated by curves II and III, in the case with both of the shroud-side diffuser ring and hub-side diffuser ring, the static efficiency η is improved in the entire range of the flow coefficient ϕ , as indicated by curve IV.

[0037] Fig. 9 shows maximum static efficiency (%) of the centrifugal fan 23 of this embodiment (bar I) and maximum static efficiency (%) of a centrifugal fan with two-dimensional blades as an example comparable to the present invention (bar II). A two-dimensional blade referred to herein is a blade that has uniform cross sections orthogonal to the axial direction of the rotating shaft of the centrifugal fan at positions displaced along the axial direction (e.g., blade 121 shown in Fig. 13 and Fig. 14).

[0038] The centrifugal fan 23 of this embodiment has 3D shape blades 21 (so-called 3D blades) as mentioned above, as well as the pair of diffuser rings 26 and 27. In this 3D blade 21, the connected end 21c on the side of the shroud 19 has the curved part 21d (see Fig. 4 and **[0039]** Fig. 5). Moreover, the hub-side end 21e (see Fig. 6) at the rear edge 21b of the blade 21 is positioned more forward in the rotating direction B of the centrifugal fan 23 than the shroud-side end 21f of the rear edge 21b.

[0040] As can be seen from the bar II in the chart of Fig. 9, in the centrifugal fan with two-dimensional blades that is an example comparable to the present invention, the maximum static efficiency when diffuser rings are provided on both of the shroud side and hub side (see b1 of bar II) is improved by 1.9% as compared to the maximum static efficiency when no diffuser rings are provided (see b2 of bar II).

[0041] On the other hand, as indicated by bar I in the chart of Fig. 9, in the centrifugal fan 23 with 3D blades 21 as in this embodiment, the maximum static efficiency when diffuser rings 26 and 27 are provided on both of the shroud side and hub side (see a1 of bar I) is improved by 3.3% as compared to the maximum static efficiency when the diffuser rings 26 and 27 are not provided (see a2 of bar I).

[0042] From these results, it is understood that, in a centrifugal fan, the effect of providing diffuser rings to improve the maximum static efficiency (%) is higher in a configuration with 3D blades 21 combined with the diffuser rings 26 and 27 as in this embodiment than in a configuration with two-dimensional blades combined with diffuser rings as in the comparative example.

[0043] Such a difference in the effect is evident from a comparison of flow velocity distribution of the air blown out from the respective centrifugal fans of this embodiment and comparative example, as shown in Fig. 10A and Fig. 10B. In Fig. 10A and Fig. 10B, in the portions near the exit of the outlets 28 and 128, the thinner the shading is, the higher the speed of the air flow (flow velocity) in these regions.

[0044] Fig. 10A shows the flow velocity distribution near the outlet 28 of the centrifugal fan 23 having the 3D blades (see blade 21 in Fig. 4 to Fig. 6) as well as the pair of diffuser rings 26 and 27 of this embodiment. Fig.

10B shows the flow velocity distribution near the outlet 128 of the centrifugal fan 123 having two-dimensional blades 121 and a pair of diffuser rings 126 and 127 as a comparative example.

[0045] In the flow velocity distribution shown in Fig. 10B, the air blown out from the outlet 128 of the centrifugal fan 123 of the comparative example separates from the shroud 119 and flows obliquely from the shroud 119 side toward the hub 115 side, so that the flow velocity distribution at the outlet 128 is not uniform as compared to the flow velocity distribution at the outlet 28 of the centrifugal fan 23 of the embodiment shown in Fig. 10A. This indicates that the function of collecting kinetic pressure (function of converting kinetic pressure to static pressure, i.e., function of converting kinetic energy of the air to pressure energy), which is the role of the diffuser rings 126 and 127 in the centrifugal fan 123 of the comparative example, is not fully achieved. Accordingly, there is a higher ratio of kinetic energy of the air that is not converted to pressure energy, so that the static efficiency of the centrifugal fan 123 is improved only limitedly.

[0046] On the other hand, in the flow velocity distribution of the centrifugal fan 23 of this embodiment shown in Fig. 10A, the air flowing near the diffuser ring 26 on the shroud 19 side is ensured due to the 3D shape blades 21 so that the air blown out from the outlet 28 is not biased toward the hub 15 side, and hence the flow velocity distribution at the outlet 28 is substantially uniform.

[0047] More specifically, the air flows on the shroud 19 side through the extension recess 29 (see Fig. 4 and Fig. 5) that is formed by the curved part 21d of the blade 21, so that the air hardly separates from the shroud 19. Moreover, since the hub-side end 21e at the rear edge 21b of the blade 21 is positioned more forward in the rotating direction B of the centrifugal fan 23 than the shroud-side end 21f of the rear edge 21b, the air flows along the inclined front surface 21g of the blade 21 (i.e., forward side in the rotating direction B) as indicated by arrow F1 in Fig. 6, and thus the air can readily flow toward the shroud 19 side.

[0048] Therefore, the flow velocity distribution at the outlet 28 is substantially uniform. Namely, the air blown out from the outlet 28 flows not only near the diffuser ring 27 on the hub 15 side, but also near the diffuser ring 26 on the shroud 19 side. Since the flow velocity distribution at the outlet 28 is uniform, kinetic pressure is collected favorably, so that there is a lower ratio of kinetic energy of the air that is not converted to pressure energy, whereby the static efficiency of the centrifugal fan 123 can be improved.

[0049] From the results of experiments shown in Fig. 9 and Fig. 10 described above, it can be seen that the centrifugal fan 23 of this embodiment has improved static efficiency because it has the 3D shape blades 21 as well as the pair of diffuser rings 26 and 27, as compared to the conventional centrifugal fan having two-dimensional blades and a pair of diffuser rings.

[0050] Other configurations of the indoor unit 31 are

the same as those of a conventional cassette type indoor unit embedded in the ceiling. More specifically, it is configured as follows:

[0051] As shown in Fig. 1, the bell mouth 25 of the blower 51 is arranged opposite the shroud 19 on the front side F in the axial direction A. The bell mouth 25 has a curved shape with its outer diameter decreasing toward the rear side R.

[0052] As shown in Fig. 1, the heat exchanger 43 has a flat shape with a small thickness. The heat exchanger 43 is arranged to stand upright upward from the dish-like drain pan 45 that extends along the lower end of the heat exchanger, such as to surround the centrifugal fan 23. The heat exchanger 43 has a configuration including, for example, a plurality of fins, and a plurality of pipes extending through these fins, wherein heat is exchanged between a refrigerant flowing inside each pipe and the air around the fins. The drain pan 45 collects water droplets generated in the heat exchanger 43. Collected water is discharged through a water drain passage that is not shown. The air filter 41 has a size large enough to cover the entrance of the bell mouth 25 and is provided between the bell mouth 25 and inlet grill 39 along the inlet grill 39. The air filter 41 catches dust contained in the air sucked into the housing 33 through the inlet grill 39.

[0053] In the indoor unit 31 configured as described above, flow of the air F0 shown in Fig. 1 can be generated inside the indoor unit 31 by driving the fan motor 11 to rotate the centrifugal fan 23 of the blower 51. Namely, the room air sucked in through the inlet grill 39 flows through inside the bell mouth 25 of the blower 51 toward the centrifugal fan 23. The air that has reached the centrifugal fan 23 is blown out radially outward of the centrifugal fan 23, and, by exchanging heat with the refrigerant as it passes through the heat exchanger 43 disposed outside the centrifugal fan 23, it is cooled, or heated. After the heat exchange, the air is supplied into the room through the air outlets 37.

[0054] When the indoor unit 31 is operating as described above, as shown in Fig. 4 and Fig. 5, in the portions inside the rotating centrifugal fan 23 where the blades 21 are connected to the shroud 19, the air F0 is allowed to smoothly flow through the extension recess 29 of each blade 21 that is formed on the side 21c1 which the air impinges on when the connected end 21c moves in the rotating direction B, so that there is less area where flow of the air F0 can be disturbed easily in the portion where the blades 21 are connected to the shroud 19. Therefore, on the shroud 19 side, a drop in the flow velocity of the air due to a disturbance in the air can be prevented, as well as creation of an area where the air separates from the inner face of the shroud 19 can be prevented, as a result of which the diffuser effect is improved.

[0055] As described above, in the indoor unit 31 of this embodiment, in a configuration equipped with the blower 51 including the centrifugal fan 23 having the diffuser rings, the blades 21 each have a curved part 21d that is

curved to incline toward the side 21c1 on which the air impinges when a connected end 21c connected to an inwardly protruding portion of the shroud 19 moves in the rotating direction B of the centrifugal fan 23, as shown in Fig. 4 and Fig. 5. Thus, there are no portions where the blades 21 are connected to the shroud 19 at an acute angle. As a result, in the portions where the blades 21 are connected to the shroud 19 (in particular, the extension recesses 29 each formed on the side 21c1 which the air impinges on when the connected end 21c moves in the rotating direction B), the air F0 is allowed to smoothly flow, so that there is less area where flow of the air F0 can be disturbed easily in these portions. This way, on the shroud 19 side, a drop in the flow velocity of the air F0 due to a disturbance in the air F0 can be prevented, as well as creation of an area where the air F0 separates from the inner face of the shroud 19 can be prevented. Consequently, the diffuser effect of the shroud-side diffuser ring 26 and hub-side diffuser ring 27 that converts the kinetic energy of the air F0 to pressure, in particular, the diffuser effect of the shroud-side diffuser ring 26, is improved.

[0056] In the indoor unit 31 of this embodiment, as shown in Fig. 6, the hub-side end 21e at the rear edge 21b of the blade 21 is positioned more forward in the rotating direction B than the shroud-side end 21f. Therefore, the air can flow easily toward the shroud 19 side because of the inclination of the blades 21 relative to the axial direction of the centrifugal fan 23, whereby the separation of air on the shroud 19 side can be prevented even more. Also, this makes the air flow uniform along the axial direction A of the centrifugal fan 23. Consequently, the diffuser effect of the hub 15 side and the shroud-side diffuser ring 26 that converts the kinetic energy of the air to pressure, in particular, the diffuser effect of the shroud-side diffuser ring 26, is improved.

[0057] In the indoor unit 31 of this embodiment, as shown in Fig. 7, the outer diameter D2 of the hub-side diffuser ring 27 and the outer diameter D3 of the shroud-side diffuser ring 26 are each 1.1 times or more larger than the diameter D1 of the circumscribed circle of the plurality of blades 21. Therefore, the diffuser effect of the hub 15 side and the shroud-side diffuser ring 26 that converts the kinetic energy of the air to pressure can be achieved reliably.

[0058] While the shroud-side diffuser ring 26 and hub-side diffuser ring 27 are arranged to incline away from each other toward the respective distal ends in the embodiment described above, the present invention is not limited to this. As a variation example of the present invention, as shown in Fig. 11, the shroud-side diffuser ring 26 may include a portion bent in the axial direction A of the centrifugal fan 23 away from the hub-side diffuser ring 27, and the hub-side diffuser ring 27 may extend in the radial direction R of the centrifugal fan 23. In this configuration, the shroud-side diffuser ring 26 bends in the axial direction A of the centrifugal fan 23 from the radial outer edge of the shroud 19 such as to be away

from the hub-side diffuser ring 27, while the hub-side diffuser ring 27 extends in the radial direction R of the centrifugal fan 23. Namely, the shroud-side diffuser ring 26 is shaped to broaden in the axial direction A of the centrifugal fan 23. Therefore, the air can be made to flow more smoothly between the hub-side diffuser ring 27 and shroud-side diffuser ring 26. Moreover, since the hub-side diffuser ring 27 is not broadened in the axial direction but extends in the radial direction, it can form a plane coplanar with the portion of the hub 15 located inner than the hub-side diffuser ring 27, whereby an increase in the processing cost for the hub 15 can be suppressed. The shroud 19 is conventionally subjected to curved surface machining, so that the shroud-side diffuser ring 26 can be shaped to broaden in the axial direction A without incurring an increase in the processing cost. Therefore, an increase in the processing cost of the entire centrifugal fan 23 can be suppressed.

[0059] The planar hub 15 such as the one described above is secured to the rotating shaft 13 of the motor 11 with a boss 30, which is a component separate from the hub 15. The boss 30 may be fixed to the hub 15, or not fixed to the hub.

[0060] The shape of the shroud-side diffuser ring 26 is not limited to a particular one in the present invention. For example, in another variation example of this embodiment, as shown in Fig. 12, the shroud-side diffuser ring 26 may further include a linearly extending portion 26a in addition to a curved portion 26b. More specifically, the shroud-side diffuser ring 26 may include a portion 26a linearly extending continuously from an edge of the shroud 19, and a portion 26b extending in a circular arc form radially outward from the linearly extending portion 26a.

[0061] The linearly extending portion 26a is continuous with the radially outer edge of the shroud 19, and extends linearly in the radial direction. The portion 26b extending in a circular arc form is continuous with the radially outer edge of the linearly extending portion 26a, and bends in a circular arc form away from the hub-side diffuser ring 27 along the radial direction.

[0062] In the variation example shown in Fig. 12, the shroud-side diffuser ring 26 includes a linearly extending portion 26a, so that the air F0 that flows along the inner wall of the shroud 19 can smoothly flow along the linearly extending portion 26a when the air reached the shroud-side diffuser ring 26. Therefore, separation of the air F0 at the shroud-side diffuser ring 26 can be prevented. Moreover, the shroud 19 and the shroud-side diffuser ring 26 are smoothly continuous with each other because of the linearly extending portion 26a. Therefore, the shroud 19 and shroud-side diffuser ring 26 can be made easily from resin.

[0063] While the shroud-side diffuser ring 26 shown in Fig. 12 has a portion 26b that extends in a circular arc form, the present invention is not limited to this. The shroud-side diffuser ring 26 may include a portion that is bent linearly in a direction away from the hub-side diffuser

ring 27 along the radial direction, instead of the portion 26b that extends in a circular arc form.

[0064] Alternatively, the shroud-side diffuser ring 26 may be formed only by a linearly extending portion 26a, or only by a portion 26b that extends in a circular arc form.

[0065] In the embodiment described above, the connected end 21c of the blade 21 is orthogonal to the tangential line C of the inner face of the inwardly protruding portion 19b of the shroud 19, but the present invention is not limited to this. In the present invention, the connected end 21c may be connected to the inwardly protruding portion 19b of the shroud 19 at an angle that is not acute, and may be arranged, for example, orthogonal, or at an angle of 90° or more to the tangential line C of the inner face of the portion 19b.

[0066] The specific embodiments described above generally include the invention having the following configurations.

[0067] The centrifugal fan 23 of this embodiment is characterized to include a hub 15; a plurality of blades 21 arranged along a circumferential direction of the hub 15; and a shroud 19 arranged on an opposite side of the blades 21 from the hub 15, the blades 21 each having a curved part 21 d that is curved to incline toward the side 21c1 on which the air impinges when a connected end 21c connected to an inwardly protruding portion of the shroud 19 moves in a rotating direction of the centrifugal fan 23, the hub 15 having a hub-side diffuser ring 27 that protrudes radially outward of the blades 21, and the shroud 19 having a shroud-side diffuser ring 26 that protrudes radially outward of the blades 21.

[0068] According to this configuration, the blades 21 each have a curved part 21 d that is curved to incline toward the side 21c1 on which the air impinges when a connected end 21c connected to an inwardly protruding portion of the shroud 19 moves in a rotating direction of the centrifugal fan 23, so that there is no portion where the blade 21 is connected to the shroud 19 at an acute angle. As a result, in the portions where the blades 21 are connected to the shroud 19, the air is allowed to smoothly flow, so that there is less area where the air flow can be disturbed easily in these portions. This way, on the shroud 19 side, a drop in the flow velocity of the air due to a disturbance in the air can be prevented, as well as creation of an area where the air separates from the inner face of the shroud 19 can be prevented. Consequently, the diffuser effect of the hub 15 side and the shroud-side diffuser ring 26 that converts the kinetic energy of the air to pressure, in particular, the diffuser effect of the shroud-side diffuser ring 26, is improved.

[0069] The hub-side end 21e at the rear edge 21 b of the blade 21 should preferably be positioned more forward in the rotating direction of the centrifugal fan 23 than the shroud-side end 21f of the rear edge 21b.

[0070] According to this configuration, the hub-side end 21e at the rear edge 21b of the blade 21 is positioned more forward in the rotating direction than the shroud-side end 21 f, so that the air can flow easily toward the

shroud 19 side because of the inclination of the blades 21 relative to the axial direction of the centrifugal fan 23, whereby the separation of air on the shroud 19 side can be prevented even more. This also makes the air flow uniform in the axial direction of the centrifugal fan 23, as a result of which the diffuser effect of the hub 15 side and the shroud-side diffuser ring 26 that converts the kinetic energy of the air to pressure, in particular, the diffuser effect of the shroud-side diffuser ring 26, is improved.

[0071] The hub-side diffuser ring 27 and the shroud-side diffuser ring 26 should preferably have outer diameters that are each 1.1 times or more larger than a diameter of a circumscribed circle of the plurality of blades 21.

[0072] According to this configuration, the diffuser effect of the hub-side diffuser ring 27 and shroud-side diffuser ring 26 that converts the kinetic energy of the air to pressure can be achieved reliably.

[0073] The shroud-side diffuser ring 26 should preferably include a portion 26a linearly extending in a radial direction of the centrifugal fan 23 continuously from an edge of the shroud 19.

[0074] According to this configuration, the air that flows along the inner wall of the shroud 19 can smoothly flow along the linearly extending portion 26a when the air reached the shroud-side diffuser ring 26. Therefore, separation of the air at the shroud-side diffuser ring 26 can be prevented.

[0075] The shroud-side diffuser ring 26 should preferably include a portion bent in an axial direction of the centrifugal fan 23 away from the hub-side diffuser ring 27, and the hub-side diffuser ring 27 should preferably extend in a radial direction of the centrifugal fan 23.

[0076] According to this configuration, the shroud-side diffuser ring 26 is formed to broaden in the axial direction of the centrifugal fan 23, so that the air can be made to flow more smoothly between the hub-side diffuser ring 27 and shroud-side diffuser ring 26. Moreover, since the hub-side diffuser ring 27 is not broadened in the axial direction but extends in the radial direction, it can form a plane coplanar with the portion of the hub 15 located inner than the hub-side diffuser ring 27, whereby an increase in the processing cost for the hub 15 can be suppressed. The shroud 19 is conventionally subjected to curved surface machining, so that the shroud-side diffuser ring 26 can be shaped to broaden in the axial direction without incurring an increase in the processing cost. Therefore, an increase in the processing cost of the entire centrifugal fan 23 can be suppressed.

Claims

1. A centrifugal fan comprising:

- a hub;
- a plurality of blades arranged along a circumferential direction of the hub; and
- a shroud arranged on an opposite side of the

blades from the hub,

the blades each having a curved part that is curved to incline toward a side on which air impinges when a connected end connected to an inwardly protruding portion of the shroud moves in a rotating direction of the centrifugal fan, the hub having a hub-side diffuser ring that protrudes radially outward of the blades, and the shroud having a shroud-side diffuser ring that protrudes radially outward of the blades.

2. The centrifugal fan according to claim 1, wherein a hub-side end at a rear edge of each of the blades is positioned more forward in the rotating direction of the centrifugal fan than a shroud-side end of the rear edge.
3. The centrifugal fan according to claim 1 or 2, wherein the hub-side diffuser ring and the shroud-side diffuser ring have outer diameters that are each 1.1 times or more larger than a diameter of a circumscribed circle of the plurality of blades.
4. The centrifugal fan according to any one of claims 1 to 3, wherein the shroud-side diffuser ring includes a portion linearly extending in a radial direction of the centrifugal fan continuously from an edge of the shroud.
5. The centrifugal fan according to any one of claims 1 to 4, wherein the shroud-side diffuser ring includes a portion bent in an axial direction of the centrifugal fan away from the hub-side diffuser ring, and the hub-side diffuser ring extends in a radial direction of the centrifugal fan.

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FIG. 1

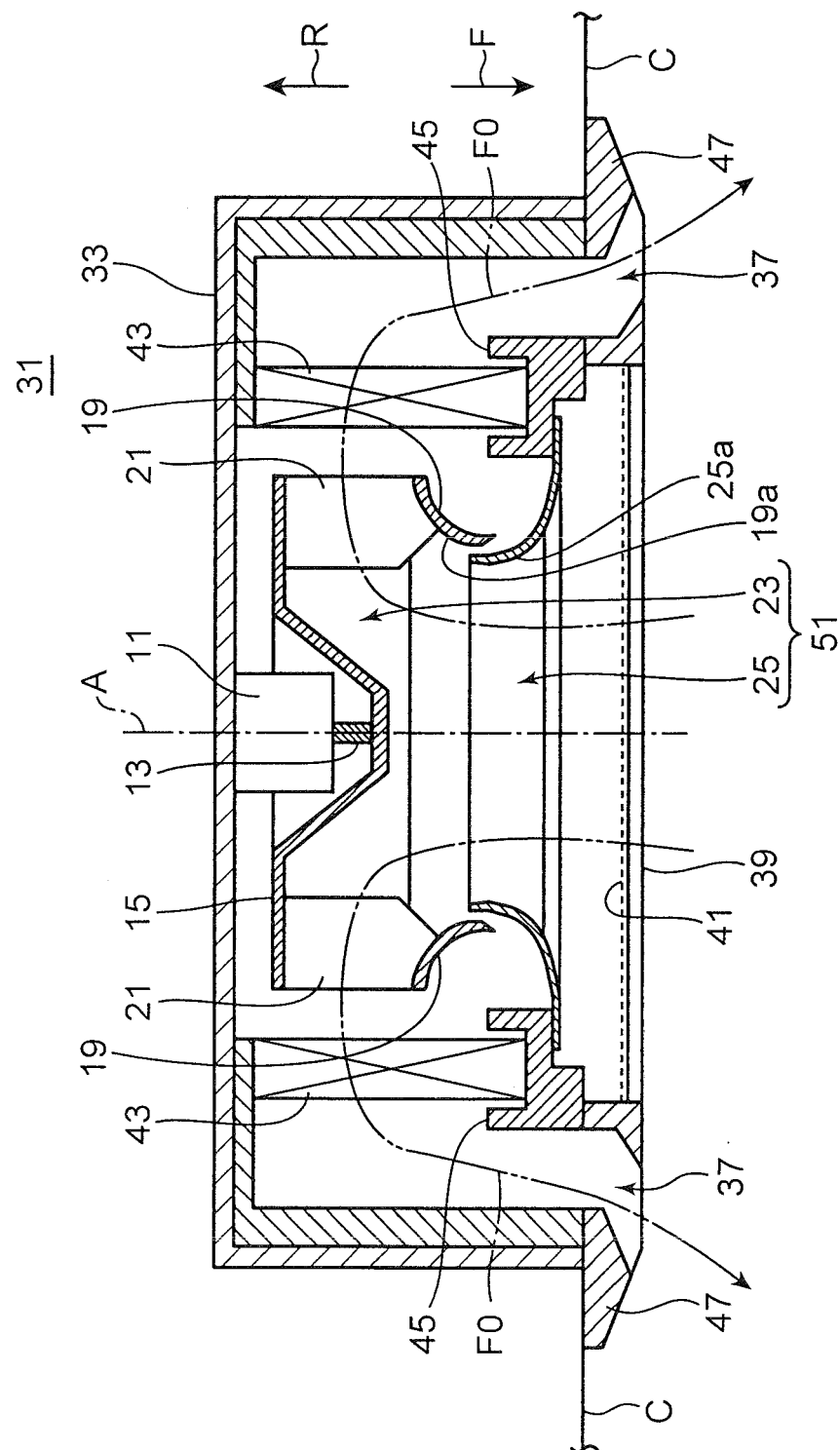


FIG. 2

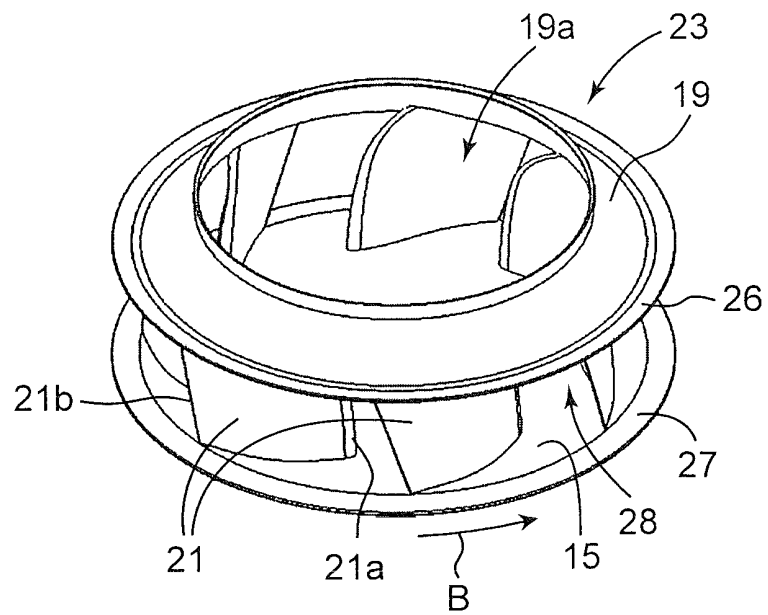


FIG. 3

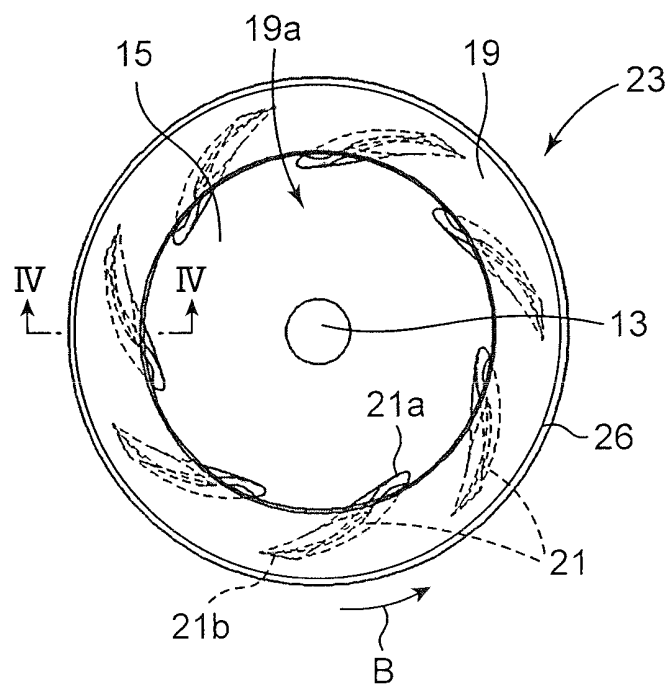


FIG. 4

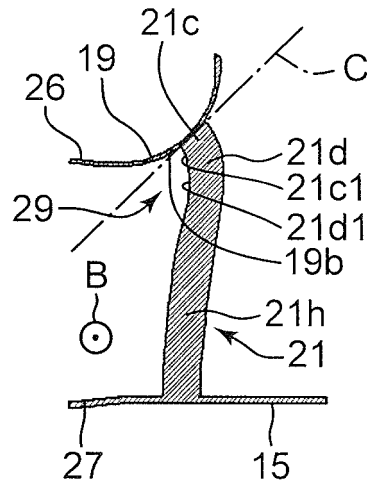


FIG. 5

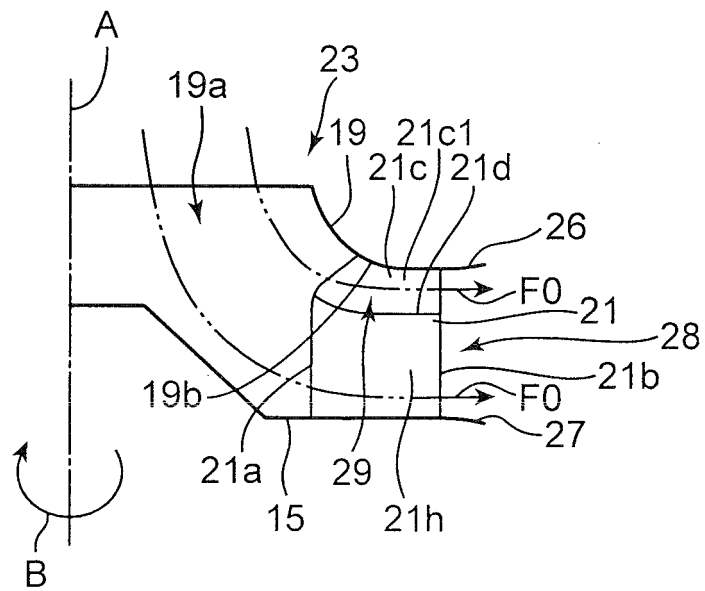


FIG. 6

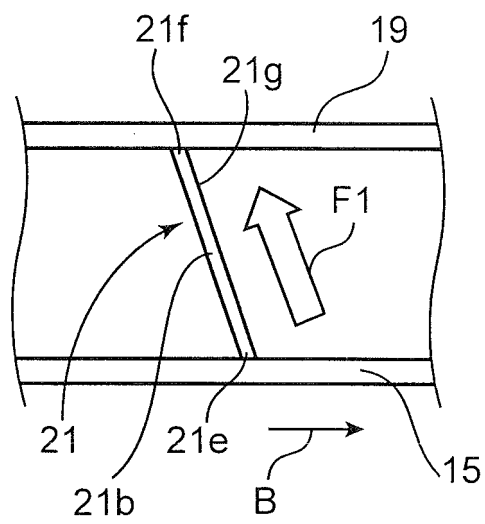


FIG. 7

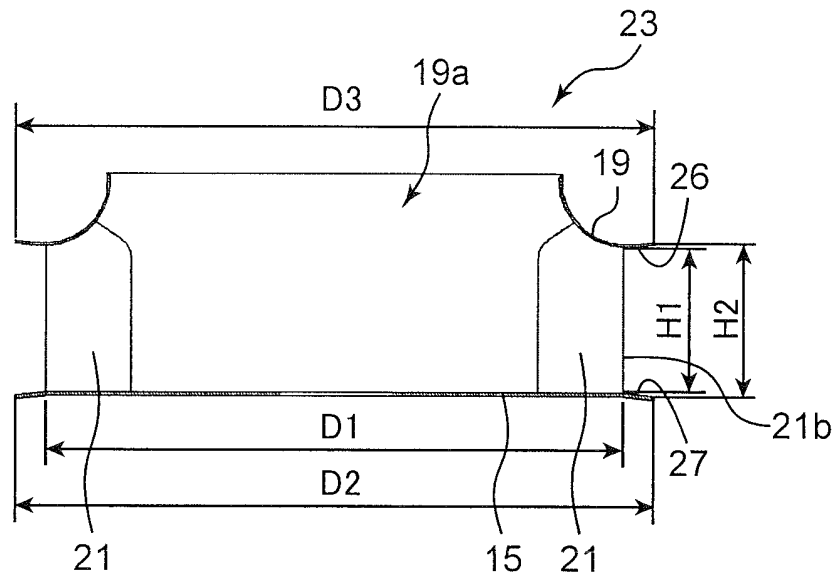


FIG. 8

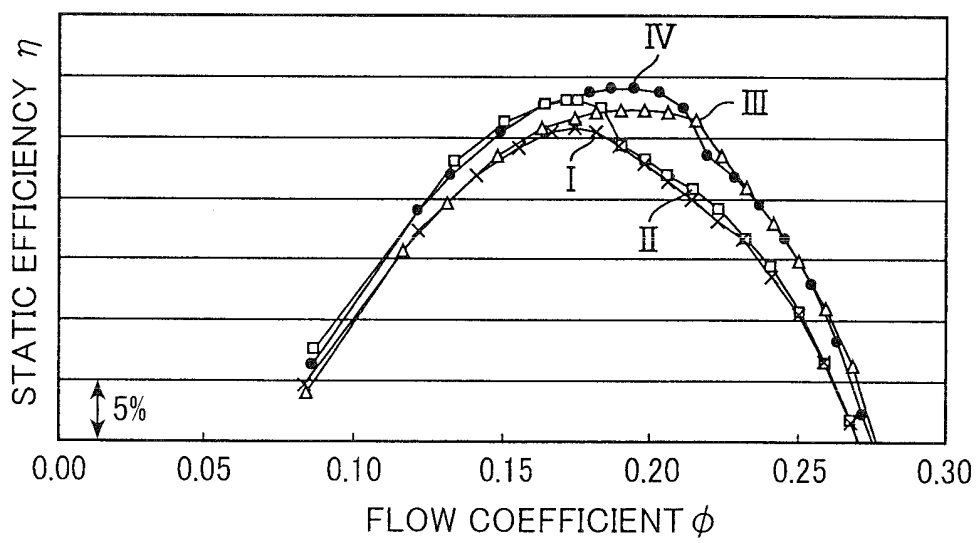


FIG. 9

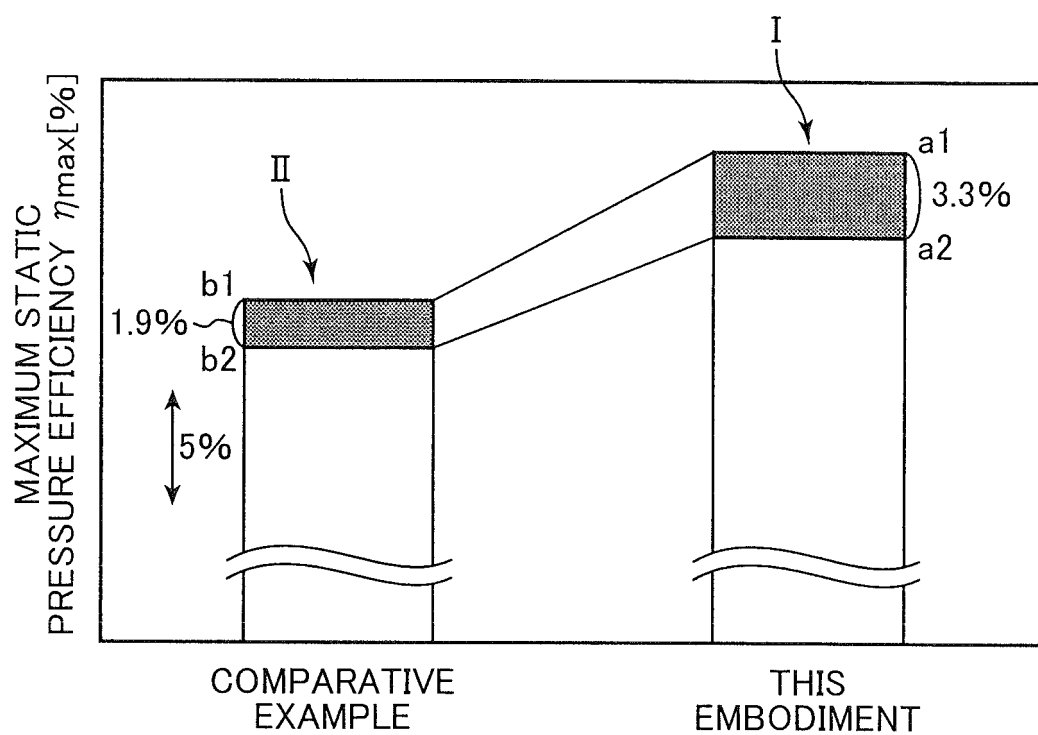


FIG. 10A

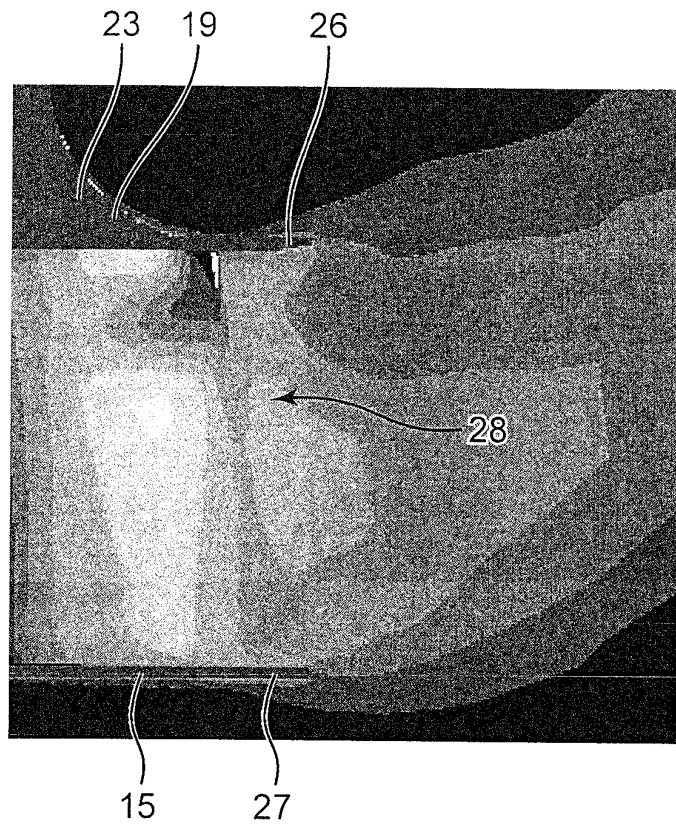


FIG. 10B

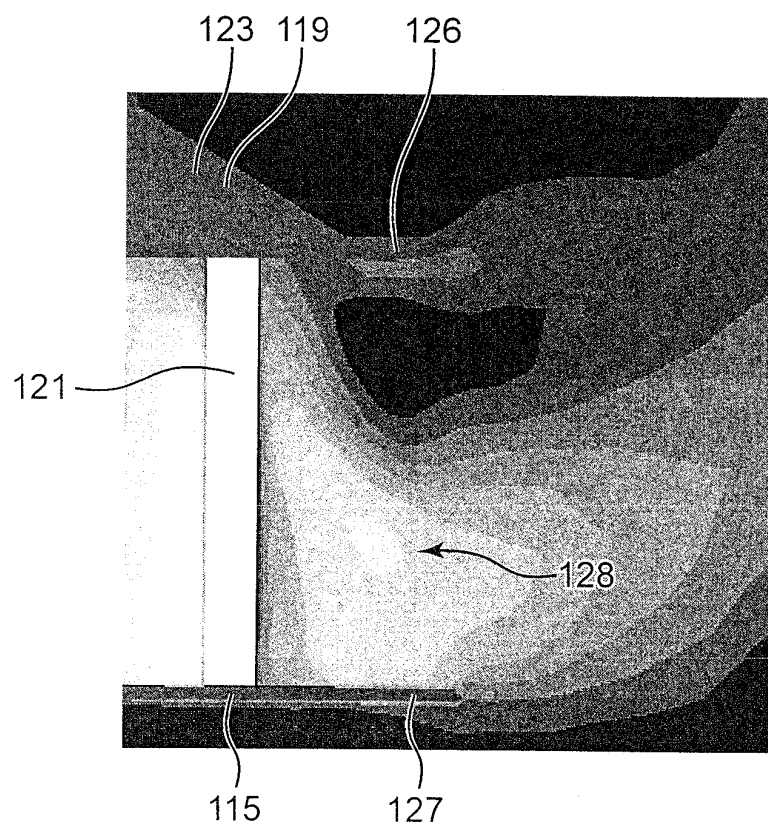


FIG. 11

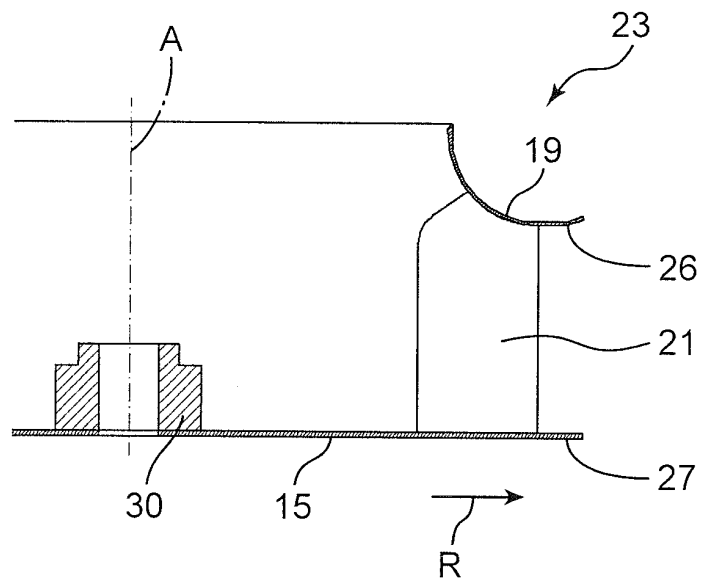


FIG. 12

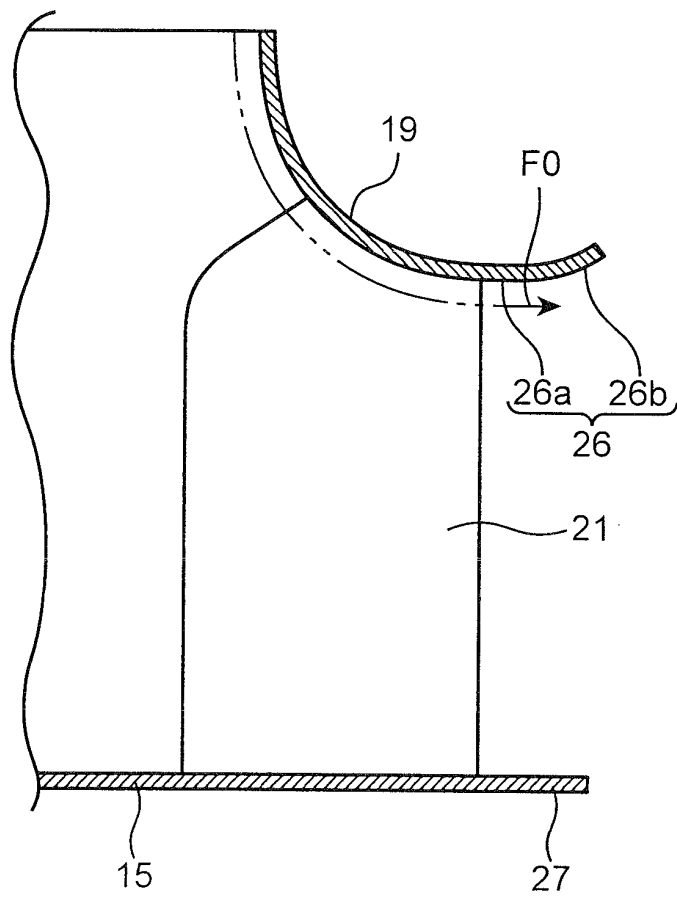


FIG. 13

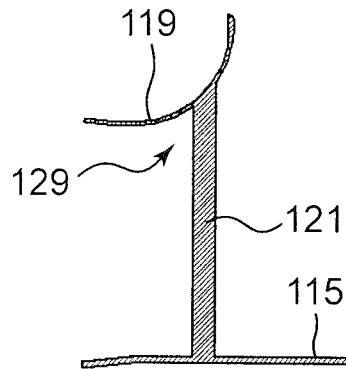
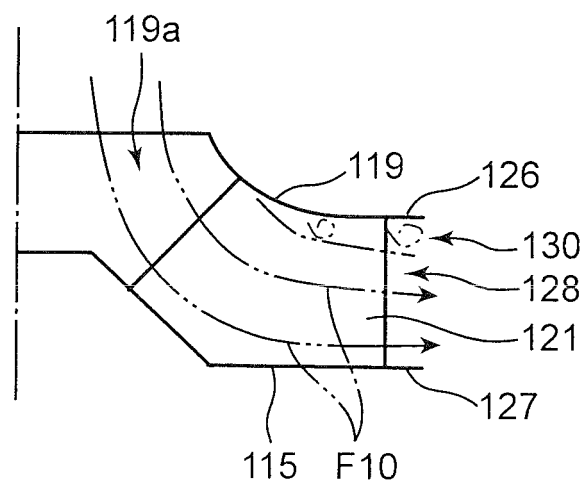


FIG. 14



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2013/007447

A. CLASSIFICATION OF SUBJECT MATTER

F04D29/30(2006.01)i, F04D29/28(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F04D29/30, F04D29/28

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.
A	JP 2010-78274 A (Daikin Industries, Ltd.), 08 April 2010 (08.04.2010), entire text; all drawings & EP 2345852 A1 & WO 2010/035584 A1	1-5
A	JP 2009-174541 A (Daikin Industries, Ltd.), 06 August 2009 (06.08.2009), entire text; all drawings & JP 2009-150380 A & US 2010/0202886 A1 & EP 2213882 A1 & WO 2009/069606 A1 & KR 10-2010-0066561 A & CN 101821513 A	1-5

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

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Date of the actual completion of the international search

04 March, 2014 (04.03.14)

Date of mailing of the international search report

18 March, 2014 (18.03.14)

Name and mailing address of the ISA/
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Facsimile No.

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

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2013/007447

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 116183/1983 (Laid-open No. 23300/1985)	1-5
	(Kawasaki Heavy Industries, Ltd., Kawasaki Steel Corp.),	
	18 February 1985 (18.02.1985),	
	entire text; all drawings	
	(Family: none)	
A	JP 2001-140789 A (Daikin Industries, Ltd.),	1-5
	22 May 2001 (22.05.2001),	
	entire text; all drawings	
	(Family: none)	

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

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP H11108403 B [0007]
- US 20060228212 A [0007]