

Description

Technical Field

[0001] The present invention relates to a centrifugal fan for use in, for example, an indoor unit of an air conditioner.

Background Art

[0002] A centrifugal fan, for example, has conventionally been used as a fan of an indoor unit of an air conditioner. A fan motor of the centrifugal fan is driven to rotate an impeller thereof, whereby air is suctioned from a suction port of the indoor unit into the indoor unit. The suctioned air is guided to an air suction port of a shroud by a bell mouth (a flow of air guided to the air suction port by the bell mouth is referred to as "main flow" hereinafter).

[0003] The air of the main flow is sent to the outside of a radial direction by a plurality of blades arranged between a hub and the shroud in a circumferential direction. Most of the air is blown into a room through an outlet port of the indoor unit, but some of the air flows backward toward the bell mouth through a space outside an outer peripheral surface of the shroud in the indoor unit and merges with the main flow again through a gap between the bell mouth and the shroud (this flow in which the air flows back and merges with the main flow through the gap as described above is referred to as "leakage flow" hereinafter). As a result of the occurrence of the leakage

flow in which a part of the main flow diverges, the amount of air to be blown into the room decreases by the amount of the diverging air, reducing the fan efficiency of the centrifugal fan.

[0004] Patent Document 1, for example, discloses a centrifugal fan in which a number of grooves are provided on an outer surface of a bell mouth (fan guide) in order to prevent reduction in fan efficiency. In this centrifugal fan, the leakage flow that flows back toward the bell mouth through a space outside an outer peripheral surface of a shroud is introduced to a gap between the bell mouth and the shroud via the grooves (see paragraphs 0024 and 0052 and Figs. 5 and 6 of Patent Document 1). Patent Document 1 describes that reduction of the blowing performance thereof caused by a fluctuation of the leakage flow can be prevented by the assistance of the grooves guiding the leakage flow to obtain a stable air flow.

[0005] In order to obtain the stable air flow by guiding the leakage flow through the grooves in the centrifugal fan described in Patent Document 1, it is considered that some of the air in the leakage flow needs to be supplied to the inside of each groove.

[0006] However, because the air flowing around the grooves at high speeds tends to pass by the vicinity of the grooves instead of entering the grooves, the effect of guiding the air by means of the grooves is not necessarily sufficient. Therefore, the fan efficiency of the cen-

trifugal fan needs to be improved.

[0007]

Patent Document 1: Japanese Patent Application Laid-open No. 2001-3899

Summary of the Invention

[0008] The present invention was contrived in view of the circumstances described above, and an object thereof is to provide a centrifugal fan capable of preventing reduction in the fan efficiency thereof that is caused by the leakage flow.

[0009] A centrifugal fan of the present invention has an impeller (23) and a bell mouth (25). The impeller (23) includes a hub (15) that is fixed to a rotating shaft (13) of a fan motor (11), a shroud (19) that has an air suction port (19a) opened in a circular shape around a central axis of the rotating shaft (13) and is disposed to face the hub (15) on a front side (F) in an axial direction (A) of the rotating shaft (13), and a plurality of blades (21) that are arranged between the hub (15) and the shroud (19) along a circumferential direction of the air suction port (19a). The bell mouth (25) is disposed so as to face the shroud (19) on the front side (F) in the axial direction (A) and which has a part, on a rear side (R), inserted into the shroud (19) through the air suction port (19a) while a predetermined gap is kept between the part and a peripheral rim part (19e) of the air suction port (19a). The bell mouth (25) guides air suctioned from the front side (F) to the rear side (R) in the axial direction (A), to the air suction port (19a) of the shroud (19). The bell mouth (25) has a plurality of wall parts (27) provided on an outer peripheral surface (25s) of the bell mouth (25). The wall parts (27) are arranged at predetermined intervals on the outer peripheral surface (25s) in a circumferential direction of the outer peripheral surface (25s). Each of the wall parts (27) extends along the outer peripheral surface (25s) from the front side (F) to the rear side (R) in the axial direction (A) so as to be substantially parallel to the axial direction (A) and to a radial direction of the bell mouth (25).

Brief Description of the Drawings

[0010]

Fig. 1 is a cross-sectional diagram showing an indoor unit that has a centrifugal fan according to an embodiment of the present invention.

Fig. 2 is a bottom view showing a positional relationship among an impeller, a heat exchanger, and an outlet port of the indoor unit.

Fig. 3 is a perspective view showing the impeller of the centrifugal fan.

Fig. 4 is a side view showing a bell mouth of the centrifugal fan.

Fig. 5 is a plan view showing the bell mouth of the

centrifugal fan.

Fig. 6 is a side view showing a partial enlargement of the diagram shown in Fig. 4.

Fig. 7 is a cross-sectional diagram showing a partial enlargement of the centrifugal fan.

Fig. 8 is a cross-sectional diagram showing a positional relationship between a shroud of the impeller and the bell mouth.

Fig. 9 is a cross-sectional diagram showing a modification of the bell mouth.

Fig. 10 is a graph showing a relationship between an air volume and air flow noise.

Fig. 11 is a graph showing a relationship between an air volume and a motor input.

Description of Embodiments

[0011] A centrifugal fan 51 according to an embodiment of the present invention and an indoor unit 31 equipped with the centrifugal fan 51 are described hereinafter with reference to the drawings.

[0012] As shown in Fig. 1, the indoor unit 31 is a ceiling-embedded type cassette indoor unit. This indoor unit 31 has a substantially rectangular parallelepiped housing 33 embedded in an opening provided on a ceiling, and a decorative panel 47 attached to a lower part of the housing 33. The decorative panel 47 is slightly larger than the housing 33 as viewed in planar view and is exposed inside a room while covering the opening of the ceiling. The decorative panel 47 has a rectangular suction grill 39 provided in a central part of the decorative panel 47 and four elongated rectangular outlet ports 37 provided along sides of the suction grill 39.

[0013] The indoor unit 31 has, in its housing 33, the centrifugal fan (turbofan) 51, a fan motor 11, a heat exchanger 43, a drain pan 45, an air filter 41, and the like. The centrifugal fan 51 includes an impeller 23 and a bell mouth 25. The fan motor 11 is fixed at substantially the center of a top panel of the housing 33. A rotating shaft 13 of the fan motor 11 extends downward.

[0014] As shown in Figs. 1 and 2, the heat exchanger 43 is thin and flat. The heat exchanger 43 stands upward from the dish-like drain pan 45 provided along a lower end part of the heat exchanger 43 and is disposed in a manner as to surround the impeller 23. The drain pan 45 is for storing water droplets generated in the heat exchanger 43. The stored water is discharged through a drainage path, which is not shown.

[0015] The air filter 41 is large enough to cover an inlet port of the bell mouth 25 and is provided along the suction grill 39 between the bell mouth 25 and the suction grill 39. When air is suctioned into the housing 33 through the suction grill 39 and passes through the air filter 41, the air filter 41 captures dust in the air.

[0016] As shown in Figs. 1 to 3, the impeller 23 includes a hub 15, a shroud 19, and a plurality of blades 21. The hub 15 is fixed to a lower end part of the rotating shaft 13 of the fan motor 11. The hub 15 is formed in a circular

shape around a central axis of the rotating shaft 13 as viewed in planar view.

[0017] The shroud 19 is disposed so as to face the hub 15 on a front side F in relation to the hub 15 in the axial direction A of the rotating shaft 13. The shroud 19 has an air suction port 19a opened in a circular shape around the central axis of the rotating shaft 13. An outer diameter of the shroud 19 increases from the front side F toward a rear side R.

[0018] The plurality of blades 21 are arranged along a circumferential direction of the air suction port 19a at predetermined intervals between the hub 15 and the shroud 19. An end part on the front side F of each blade 21 is joined to an inner surface of the shroud 19. An end part on the rear side R of each blade 21 is joined to the hub 15. Each of the blades 21 is a backward curved blade inclined in a direction opposite (backward) to a rotation direction with respect to a radial direction of the hub 15.

[0019] The bell mouth 25 is disposed so as to face the shroud 19 on the front side F in relation to the shroud 19 in the axial direction A. The bell mouth 25 includes a bell mouth main body 251 and a flange part 252 that projects from a peripheral rim on the front side F of the bell mouth main body 251 to a periphery of the bell mouth main body 251. The bell mouth 251 has a through-hole 25a provided in a front-back direction. An outer peripheral surface 25s of the bell mouth main body 251 is curved in a manner that an outer diameter thereof becomes small gradually from the front side F toward the rear side R.

[0020] As shown in Fig. 1, a part on the rear side R of the bell mouth main body 251 is inserted into the shroud 19 through the air suction port 19a while keeping a predetermined gap between the part and a peripheral rim part 19e of the air suction port 19a. Thus, the bell mouth 25 can guide the air to the air suction port 19a of the shroud 19, the air being suctioned from the front side F toward the rear side R through the through-hole 25a.

[0021] As shown in Figs. 4 and 5, the bell mouth 25 has a plurality of wall parts 27 that are arranged on the outer peripheral surface 25s of the bell mouth main body 251 in a circumferential direction at predetermined intervals. The wall parts 27 are provided on the outer peripheral surface 25s of the bell mouth 25. Each of the wall parts 27 extends along the outer peripheral surface 25s from the front side F toward the rear side R so as to be substantially parallel to the axial direction A and to a radial direction of the bell mouth 25.

[0022] As shown in Fig. 6, the bell mouth 25 has a plurality of airflow paths 253, each of which is surrounded by adjacent wall parts 27 and the outer peripheral surface 25s. These airflow paths 253 are directed along the axial direction A. Although the both sides and the bottom of each of these airflow paths 253 are surrounded by the adjacent wall parts 27 and the outer peripheral surface 25s of the bell mouth 25, an entrance and exit of the airflow path 253 for a leakage flow are opened and not blocked. The leakage flow, therefore, is guided reliably to the entrance of the airflow path 253 between the wall

parts 27 and then through the inside of the airflow path 253 from the front side F toward the rear side R.

[0023] As shown in Figs. 7 and 8, the height of each of the wall parts 27 with respect to the outer peripheral surface 25s gradually increases from an end part 27r thereof on the rear side R toward an end part 27f on the front side F. In other words, a height Hf of the end part 27f on the front side F of each wall part 27 is greater than a height Hr of the end part 27r on the rear side R. For example, the height Hr can be approximately 1 mm to 10 mm, and the height Hf can be approximately 3 mm to 20 mm, but the height Hr and the height Hf are not particularly limited to these ranges.

[0024] As shown in Figs. 6 and 8, in each wall part 27 the end part 27r on the rear side R is an inclined surface inclined with respect to the axial direction A. The height of this inclined surface with respect to the outer peripheral surface 25s decreases gradually from the front side F toward the rear side R.

[0025] On the other hand, the peripheral rim part 19e of the air suction port 19a is an inclined surface inclined with respect to the axial direction A, as shown in Fig. 8. The inclined surface of the peripheral rim part 19e is provided so as to face the inclined surface of the end part 27r on the rear side R of each wall part 27. Specifically, a tip end of the end part 27r on the rear side R of each wall part 27 is provided in the position (substantially at the same level) so as to almost face radially a tip end of the peripheral rim part 19e, which is an end part on the front side F of the shroud 19. The inclined surface of the peripheral rim part 19e is inclined in a manner that a part thereof on the rear side R is positioned more inward in the radial direction than a part on the front side F. The inclined surface of the end part 27r of each wall part 27 is inclined in a manner that a part thereof on the rear side R is positioned more inward in the radial direction than a part on the front side F. Because the end parts of the peripheral rim part 19e and of each wall part 27 are configured by the inclined surfaces, the end part 27r on the rear side R of each wall part 27 can be extended to the position facing the peripheral rim part 19e of the shroud 19 or to a position in the vicinity of this position.

[0026] The bell mouth 25 may be formed by integrally molding each wall part 27 with the bell mouth main body 251 by means of, for example, sheet-metal processing or resin molding processing, or may be formed by molding each wall part 27 separately from the bell mouth main body 251 and then joining each wall part 27 to the bell mouth main body 251.

[0027] Fig. 9 is a cross-sectional diagram showing a modification of the bell mouth 25. This bell mouth 25, as with the bell mouth 25 shown in Fig. 5, has a plurality of wall parts 27 arranged on an outer peripheral surface of the bell mouth 25 in a circumferential direction at predetermined intervals. The wall parts 27 are provided on the outer peripheral surface of the bell mouth 25. Each of the wall parts 27 extends along the outer peripheral surface from the front side F toward the rear side R so as to be

substantially parallel to the axial direction A and to the radial direction of the bell mouth 25.

[0028] This bell mouth 25 is formed by integrally molding each wall part 27 with a bell mouth main body by means of, for example, sheet-metal processing or resin molding processing. A plurality of grooves 254 are formed on an inner surface of the bell mouth 25 so as to correspond to the plurality of wall parts 27. The grooves 254 are arranged on the inner surface along the circumferential direction thereof at predetermined intervals. Each of the grooves 254 extends along the inner surface from the front side F toward the rear side R so as to be substantially parallel to the axial direction A and to the radial direction of the bell mouth 25. The thickness of the bell mouth 25 can be made substantially entirely constant. Molding the bell mouth 25 by means of, for example, resin molding processing can prevent the generation of shrinkage or other molding defects. These grooves 254 play a role of guiding a main flow flowing through the through-hole 25a of the bell mouth 25.

[0029] Flows of air in the centrifugal fan 51 are described next. As shown in Fig. 8, a main flow S of air guided to the air suction port 19a of the shroud 19 by the bell mouth main body 251 of the bell mouth 25 flows mainly in a direction along the axial direction A of the rotating shaft 13 of the shroud 19, in the vicinity of the air suction port 19a.

[0030] In a conventional centrifugal fan with no wall parts 27, in the vicinity of the air suction port 19a a leakage flow M1 is affected by air that flows in a direction K of rotation of the shroud 19 when the shroud 19 rotates in this rotation direction K, as indicated by a dashed arrow M1. Therefore, the leakage flow M1 flows obliquely from the axial direction A to the rotation direction K. Therefore, when this leakage flow M1 merges with the main flow S, the main flow S is disturbed by the leakage flow M1, increasing the air flow noise and reducing the fan efficiency.

[0031] In the centrifugal fan 51 of the present embodiment, on the other hand, the leakage flow M is guided from the front side F to the rear side R along each airflow path 253 surrounded by the adjacent wall parts 27 and the outer peripheral surface 25S of the bell mouth main body 251 as indicated by a dashed-dotted arrow M, and then passes through a gap between the end part on the rear side R of the bell mouth main body 251 and the end part on the front side F of the shroud 19. In the vicinity of the air suction port 19a, the direction of the leakage flow M passing through the gap is corrected to be more similar to the axial direction A than that of the conventional centrifugal fan is. This can prevent interference caused when the leakage flow M merges with the main flow S.

[0032] Fig. 10 is a graph showing a relationship between an air volume and air flow noise. Fig. 11 is a graph showing a relationship between the air volume and a motor input. The solid lines shown in Figs. 10 and 11 show the characteristics of the indoor unit 31 having the centrifugal fan 51 according to the present embodiment

shown in Figs. 1 to 8 (example). Dashed lines shown in Figs. 10 and 11 show the characteristics of the indoor unit 31 having a conventional bell mouth with no wall parts 27 (comparative example).

[0033] The data shown in Fig. 10 are measured by using the bell mouth 25 in which the bell mouth main body 251 is provided with the wall parts 27 that become tall gradually from the rear side R toward the front side F, with the height Hr on the rear side R being 3 mm and the height Hf on the front side F being 5 mm. The data shown in Fig. 11 are measured by using the bell mouth 25 in which the bell mouth main body 251 is provided with the wall parts 27 that become tall gradually from the rear side R toward the front side F, with the height Hr on the rear side R being 6 mm and the height Hf on the front side F being 8 mm.

[0034] As shown in Fig. 10, the air flow noise of the example is lower than that of the comparative example. Moreover, the effect of reducing the air flow noise increases as the air volume increases. One vertical scale on the graph shown in Fig. 10 is 1 dBA.

[0035] As shown in Fig. 11, the motor input of the example is lower than that of the comparative example. The motor input that is required in the example to obtain the same air volume as the comparative example is lower than that of the comparative example. In other words, the amount of leakage flow of the example is lower than that of the comparative example. One vertical scale of the graph shown in Fig. 11 is 10 W.

[0036] <Summary of the embodiment>

[0037] The summary of the above-described embodiment is described hereinafter.

[0038] (1) The centrifugal fan of the present embodiment has an impeller and a bell mouth. The impeller includes a hub fixed to a rotating shaft of a fan motor, a shroud that has an air suction port opened in a circular shape around a central axis of the rotating shaft and is disposed in relation to the hub so as to face the hub on a front side in an axial direction of the rotating shaft, and a plurality of blades that are arranged between the hub and the shroud along a circumferential direction of the air suction port. The bell mouth is disposed in relation to the shroud so as to face the shroud on the front side in the axial direction and has a part thereof on a rear side inserted into the shroud through the air suction port while keeping a predetermined gap between the part and a peripheral rim part of the air suction port. The bell mouth guides air suctioned from the front side to the rear side in the axial direction, to the air suction port of the shroud. The bell mouth has a plurality of wall parts provided on an outer peripheral surface of the bell mouth. The wall parts are arranged on the outer peripheral surface of the bell mouth in a circumferential direction at predetermined intervals. Each of the wall parts extends along the outer peripheral surface from the front side to the rear side in the axial direction so as to be substantially parallel to the axial direction and to a radial direction of the bell mouth.

[0039] According to this aspect, the plurality of wall

parts of the bell mouth can be resistances to the leakage flow, reducing the amount of leakage flow. Moreover, the direction of the leakage flow can be made similar to the direction of the main flow, preventing the main flow from being disturbed when the leakage flow merges with the main flow. As a result, a decrease in the fan efficiency can be prevented. These effects are described specifically hereinafter in more detail.

[0040] Specifically, the air of the main flow that is guided to the air suction port of the shroud by the bell mouth mainly flows in a direction along the axial direction of the rotating shaft, in the vicinity of the air suction port. In the conventional centrifugal fan, the leakage flow is affected by the air that flows in the direction of rotation of the shroud, thereby flowing obliquely from the axial direction of the rotating shaft to this rotation direction. In the vicinity of the air suction port where the leakage flow merges with the main flow as described above, the direction of the main flow is significantly different from the direction of the leakage flow. Therefore, when the leakage flow merges with the main flow, the main flow is disturbed by the leakage flow, causing a reduction in the fan efficiency.

[0041] In the present embodiment, on the other hand, each of the wall parts extends along the outer peripheral surface of the bell mouth from the front side to the rear side in the axial direction so as to be substantially parallel to the axial direction and to the radial direction. In other words, each airflow path between the adjacent wall parts extends in the direction along the axial direction. The airflow path configures a space whose sides and bottom are surrounded by the adjacent wall parts and the outer peripheral surface of the bell mouth. The entrance and exit of the airflow path for the leakage flow are opened and not blocked. The leakage flow, therefore, can reliably be let pass through the airflow path between the wall parts. Hence, an excellent effect of guiding the leakage flow can be obtained.

[0042] When the leakage flow that flows obliquely reaches the wall parts and passes through the airflow path between the wall parts, the direction of the leakage flow is corrected to the axial direction by the airflow path, further increasing the resistance to the air passing through the airflow path, more than when no wall parts are provided. As a result, the amount of leakage flow diverging from the main flow can be reduced. Moreover, in the vicinity of the air suction port, the direction of the leakage flow rectified by the airflow path becomes similar to the axial direction, which is the direction of the main flow. This can reduce the level of interference caused to the main flow by the leakage flow when the leakage flow merges with the main flow in the vicinity of the air suction port. As a result, a decrease in the fan efficiency caused by the leakage flow can be prevented.

[0043] (2) In the centrifugal fan, it is preferred that a height of an end part on the front side of each wall part with respect to the outer peripheral surface be greater than a height of an end part on the rear side of each wall part with respect to the outer peripheral surface.

[0044] According to this aspect, each wall part can catch a large amount of leakage flow at the tall end part on the rear side and guide the leakage flow to the airflow path, while preventing the short end part on the front side and the peripheral rim part of the air suction port of the shroud from coming into contact with each other at the short end part on the front side.

[0045] (3) In the centrifugal fan, a height of each wall with respect to the outer peripheral surface may increase gradually from the end part on the rear side toward the end part on the front side.

[0046] In this aspect, the height of each wall part changes smoothly, making the flow of air smooth in the airflow path.

[0047] (4) In the centrifugal fan, the end part on the rear side of each wall part may be an inclined surface in which the height thereof with respect to the outer peripheral surface decreases gradually from the front side toward the rear side, and the peripheral rim part of the air suction port may be an inclined surface facing the inclined surface of each wall part.

[0048] In this aspect, because the end part on the rear side of each wall part and the peripheral rim part of the air suction port are formed as the inclined surfaces facing each other, each wall part can be extended to the vicinity of the shroud. This can prevent the wall parts and the shroud from coming into contact with each other when the shroud rotates.

[0049] The above has described the embodiment of the present invention. However, the present invention is not limited to the embodiment, and various modifications, improvements etc. can be made within the scope of the present invention.

[0050] For example, the embodiment has described the example in which the height of each of the wall parts is increased gradually from the rear side toward the front side; however, the height may be increased in a stepwise manner from the rear side toward the front side. In addition, the height of each wall part may be constant all the way from the rear side to the front side or reduced from the rear side toward the front side.

[0051] The embodiment has described the example in which the end part on the rear side of each wall part is the inclined surface in which the height thereof decreases gradually from the front side toward the rear side, and the peripheral rim part of the air suction port is the inclined surface facing the inclined surface of each wall part. However, the present invention is not limited thereto. The end part on the rear side of each wall part may not be an inclined surface but a surface perpendicular to the axial direction. Similarly, the peripheral rim part of the air suction port may be a surface perpendicular to the axial direction.

[0052] The embodiment has described the example in which the tip end of the end part on the rear side of each wall part is provided in the position (substantially at the same level) so as to almost face radially the tip end of the peripheral rim part, which is the end part on the front

side of the shroud. However, the present invention is not limited thereto. The end part on the rear side of each wall part may be provided in front of or behind the end part on the front side of the shroud.

[0053] The embodiment has described the example in which the centrifugal fan is used in an indoor unit of an air conditioner; however, the centrifugal fan can be applied to other uses.

10 Explanation of Reference Numerals

[0054]

11	Fan motor
13	Rotating shaft
15	Hub
17	Air suction port
19e	Peripheral rim part of air suction port
19	Shroud
21	Blade
23	Impeller
25	Bell mouth
251	Bell mouth main body
252	Flange part
253	Airflow path
25a	Through-hole
25s	Outer peripheral surface of bell mouth main body
27	Wall part
27f	Front-side end part of wall part
27r	Rear-side end part of wall part
31	Indoor unit
A	Axial direction of rotating shaft of fan motor
F	Front side
R	Rear side

Claims

1. A centrifugal fan, comprising:

an impeller (23), which includes a hub (15) that is fixed to a rotating shaft (13) of a fan motor (11), a shroud (19) that has an air suction port (19a) opened in a circular shape around a central axis of the rotating shaft (13) and is disposed to face the hub (15) on a front side (F) in an axial direction of the rotating shaft (13), and a plurality of blades (21) that are arranged between the hub (15) and the shroud (19) along a circumferential direction of the air suction port (19a); and a bell mouth (25), which is disposed to face the shroud (19) on the front side (F) in the axial direction and which has a part on a rear side (R), inserted into the shroud (19) through the air suction port (19a) while a predetermined gap is kept between the part and a peripheral rim part (19e) of the air suction port (19a), and moreover which guides air suctioned from the front side (F) to

the rear side (R) in the axial direction, to the air suction port (19a) of the shroud (19), wherein the bell mouth (25) has a plurality of wall parts (27) provided on an outer peripheral surface (25s) of the bell mouth (25), the wall parts (27) are arranged at predetermined intervals on the outer peripheral surface (25s) in a circumferential direction of the outer peripheral surface (25s), and each of the wall parts (27) extends along the outer peripheral surface (25s) from the front side (F) to the rear side (R) in the axial direction so as to be substantially parallel to the axial direction and to a radial direction of the bell mouth (25).

2. The centrifugal fan according to claim 1, wherein a height of an end part (27f) on the front side (F) of each wall part (27) with respect to the outer peripheral surface (25s) is greater than a height of an end part (27r) on the rear side (R) of each wall part (27) with respect to the outer peripheral surface (25s).
3. The centrifugal fan according to claim 2, wherein a height of each wall (27) with respect to the outer peripheral surface (25s) increases gradually from the end part (27r) on the rear side (R) toward the end part (27f) on the front side (F).
4. The centrifugal fan according to any of claims 1 to 3, wherein the end part (27r) on the rear side (R) of each wall part (27) is an inclined surface in which the height thereof with respect to the outer peripheral surface (25s) decreases gradually from the front side (F) toward the rear side (R), and the peripheral rim part (19e) of the air suction port (19a) is an inclined surface facing the inclined surface of each wall part (27).

FIG. 1

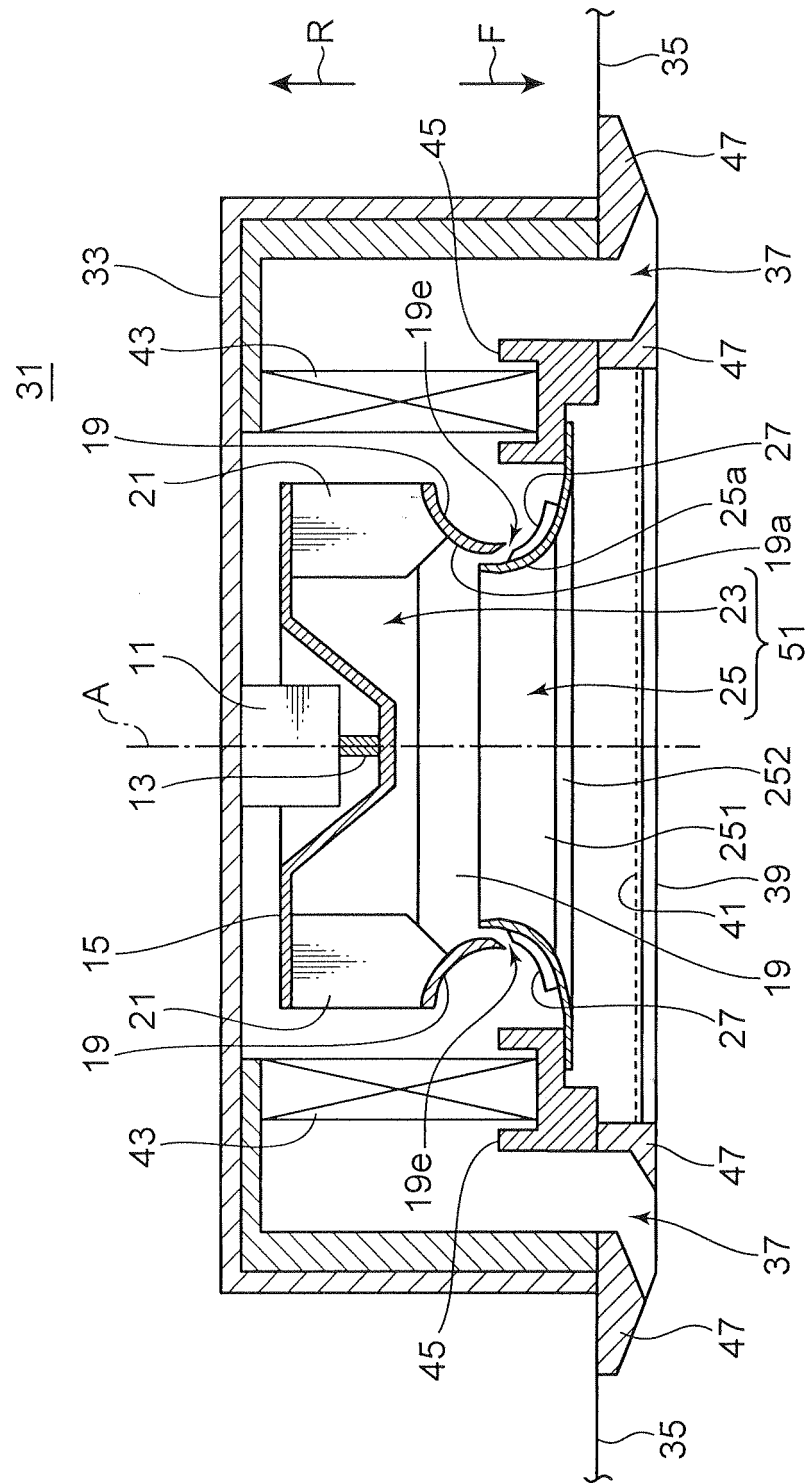


FIG. 2

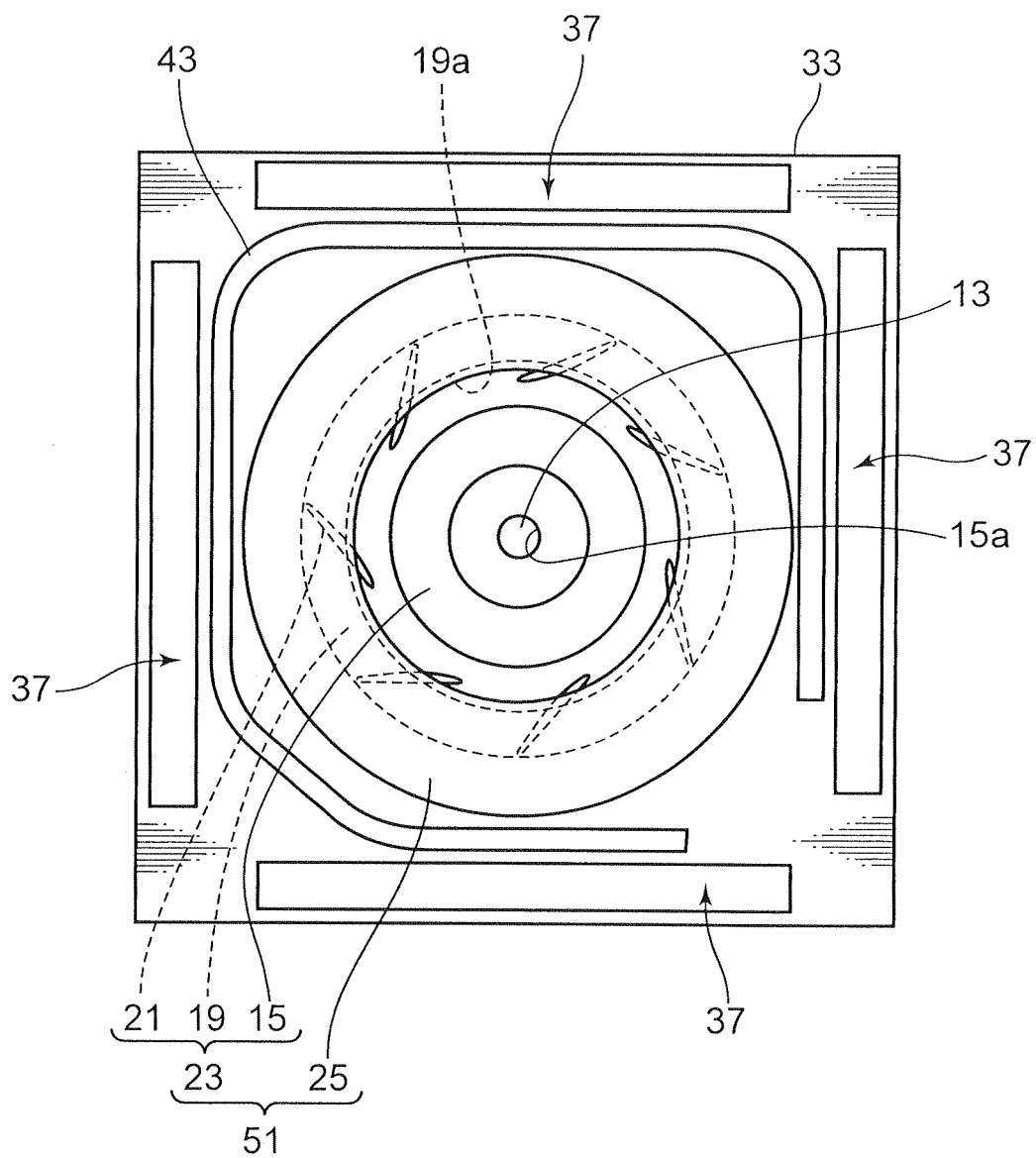


FIG. 3

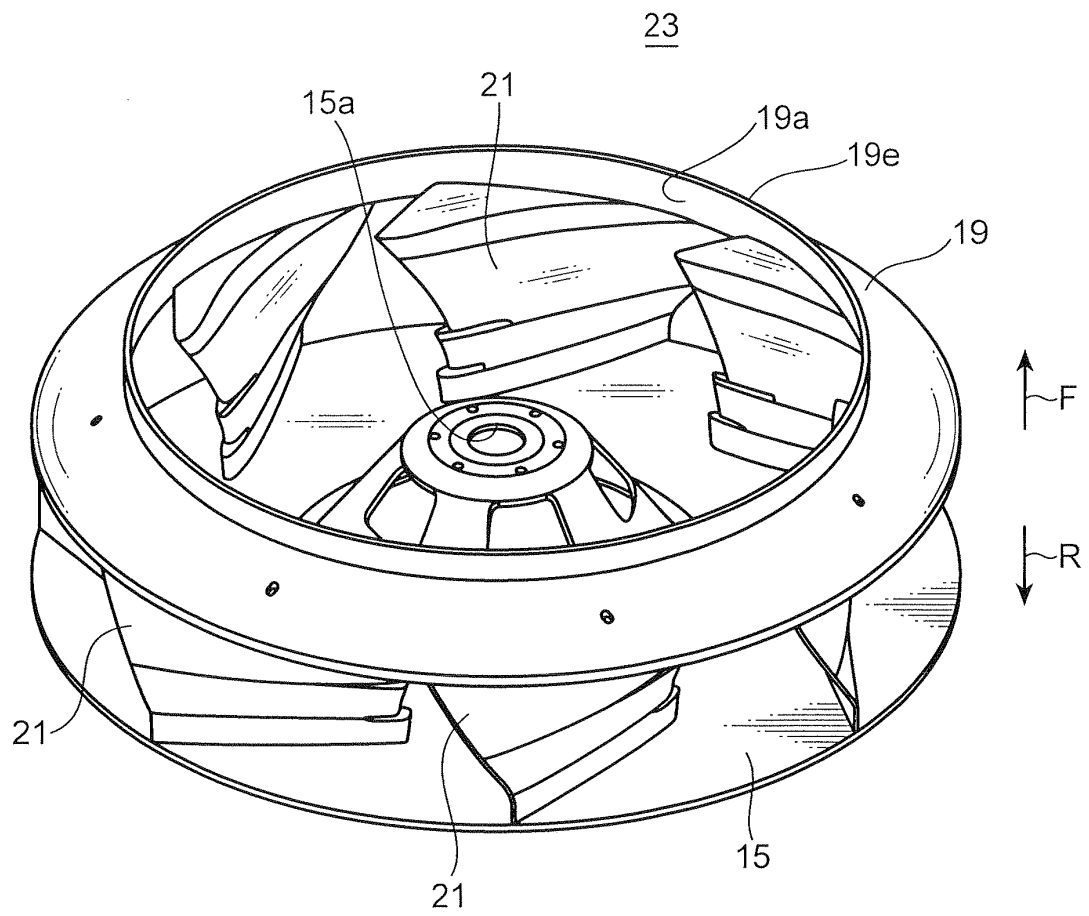


FIG. 4

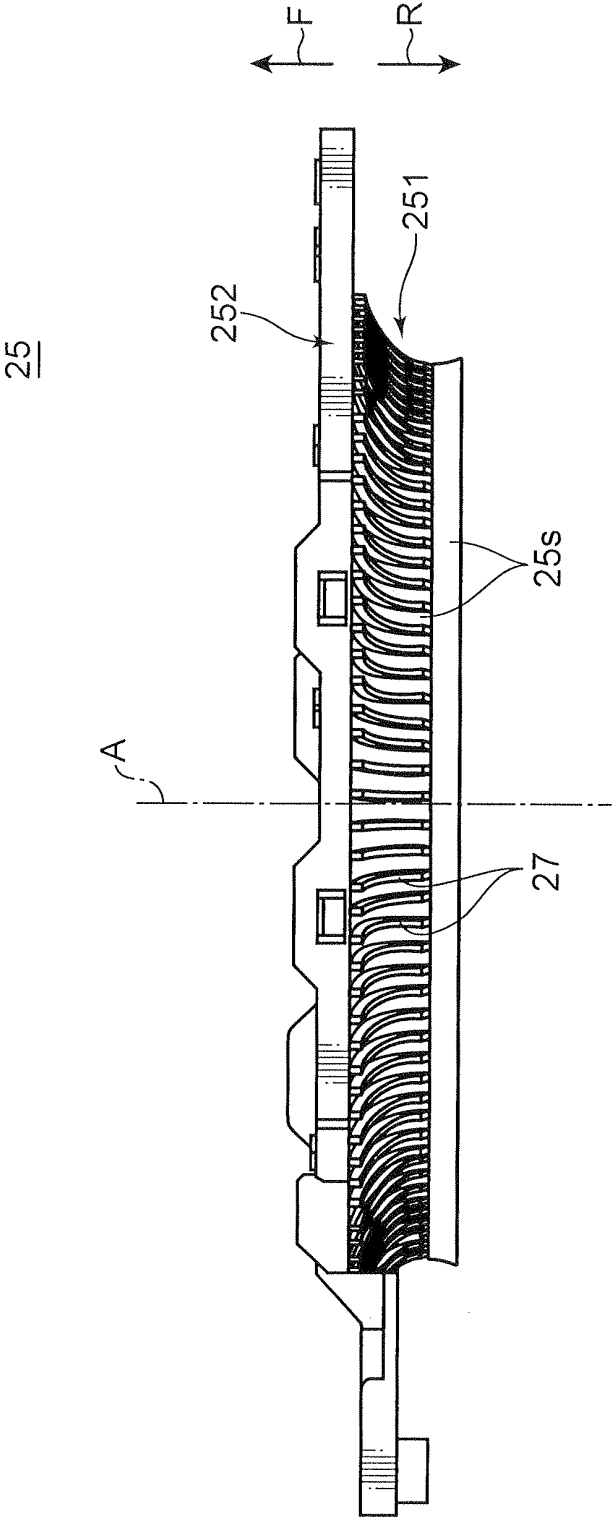


FIG. 5

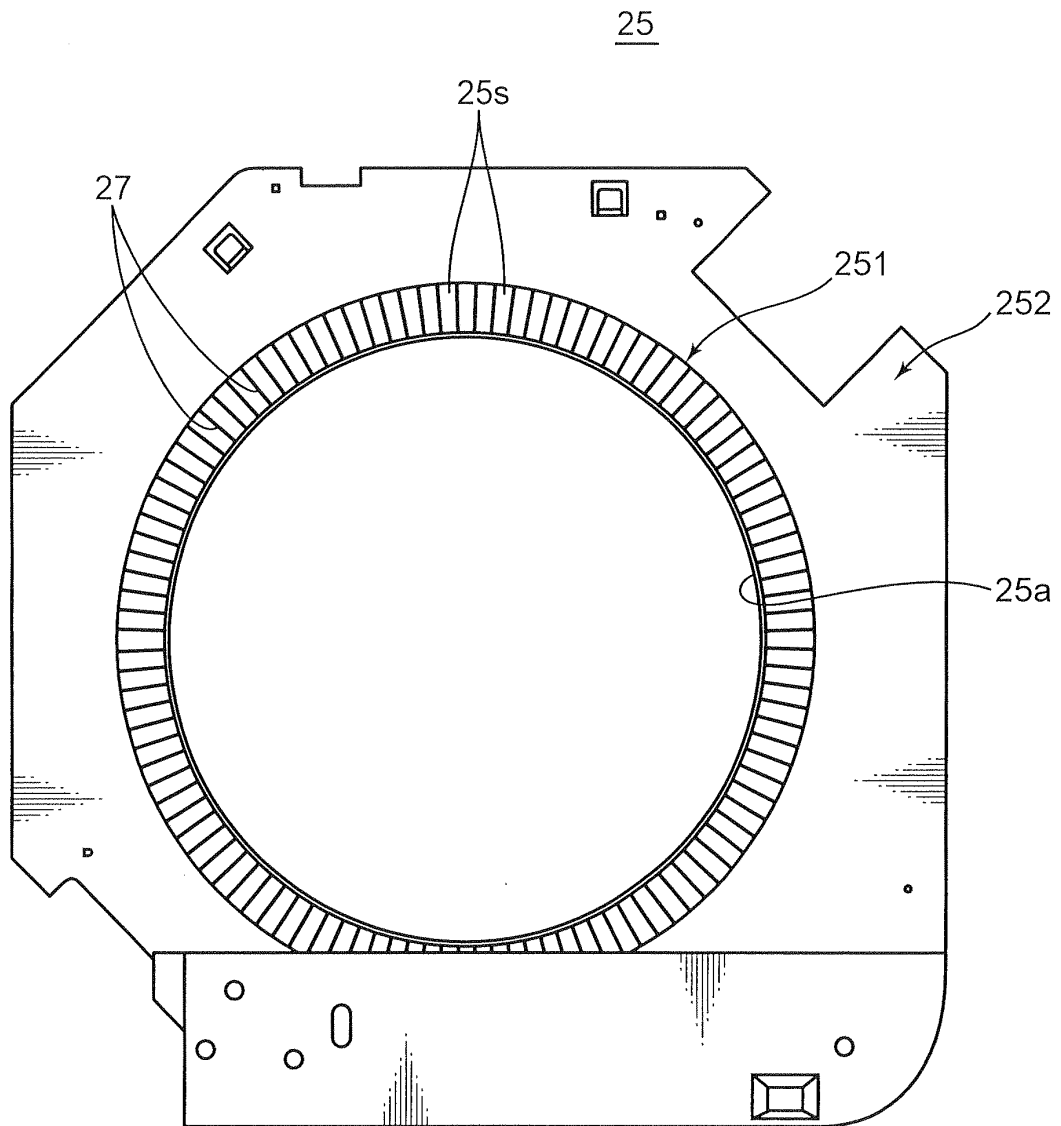


FIG. 6

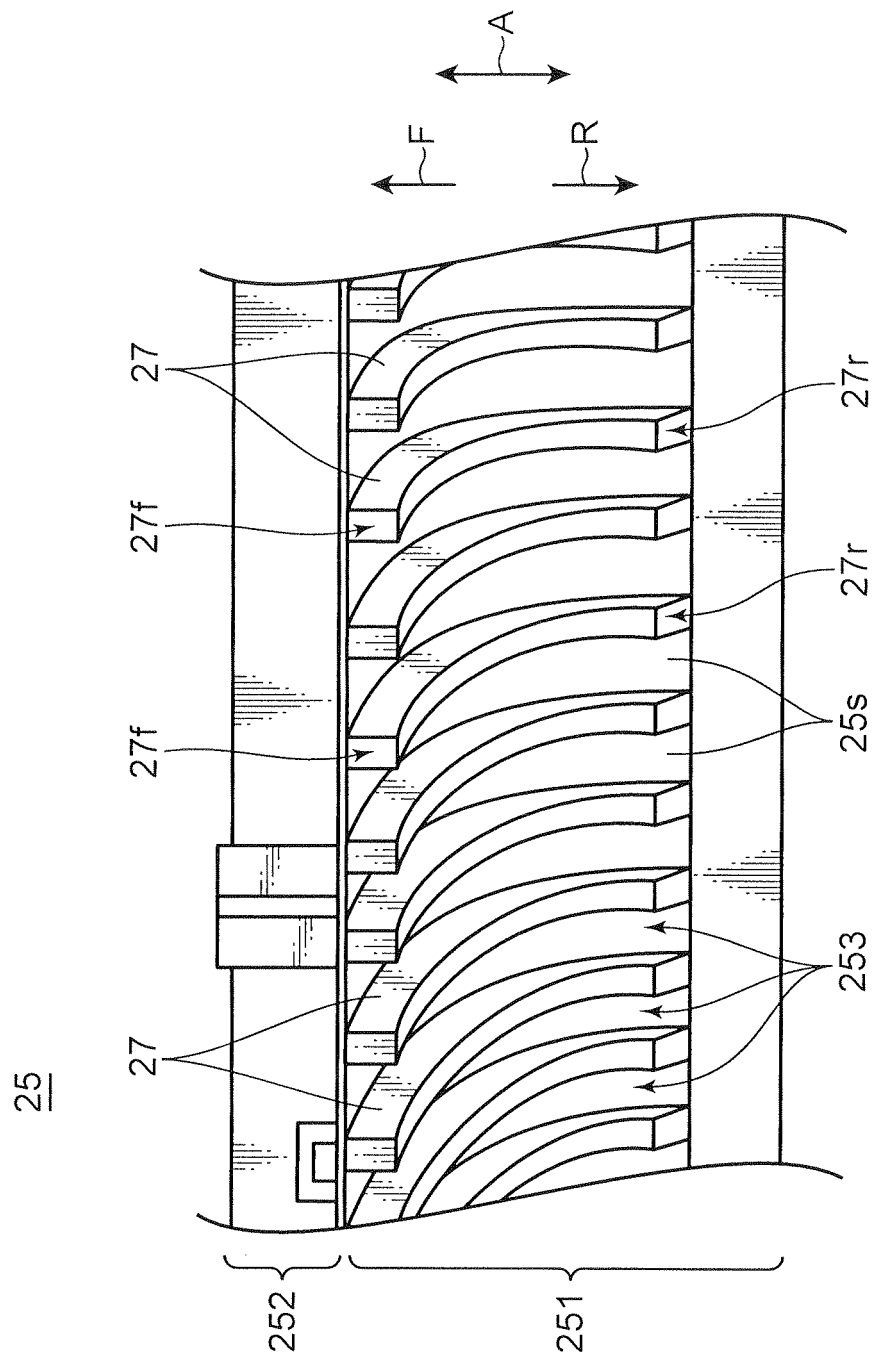
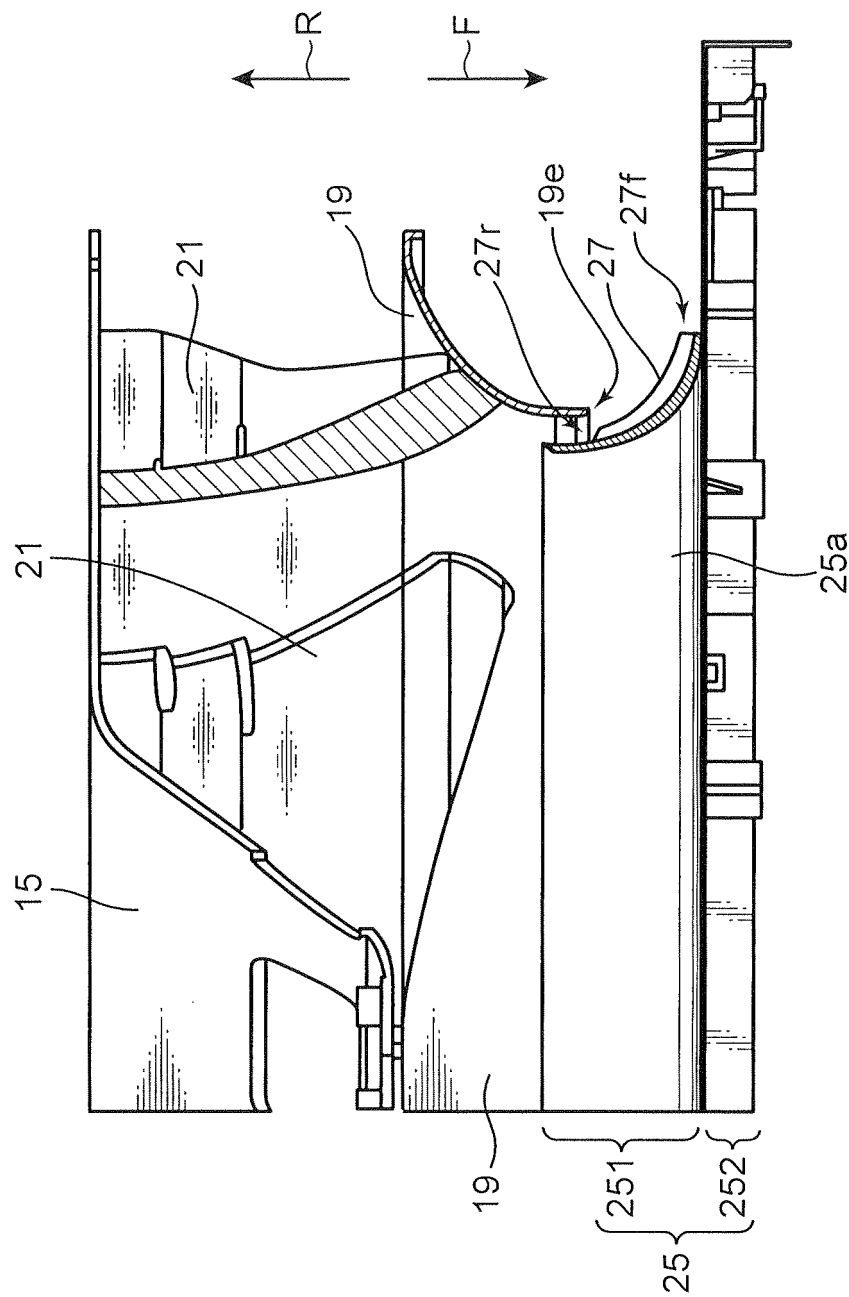


FIG. 7



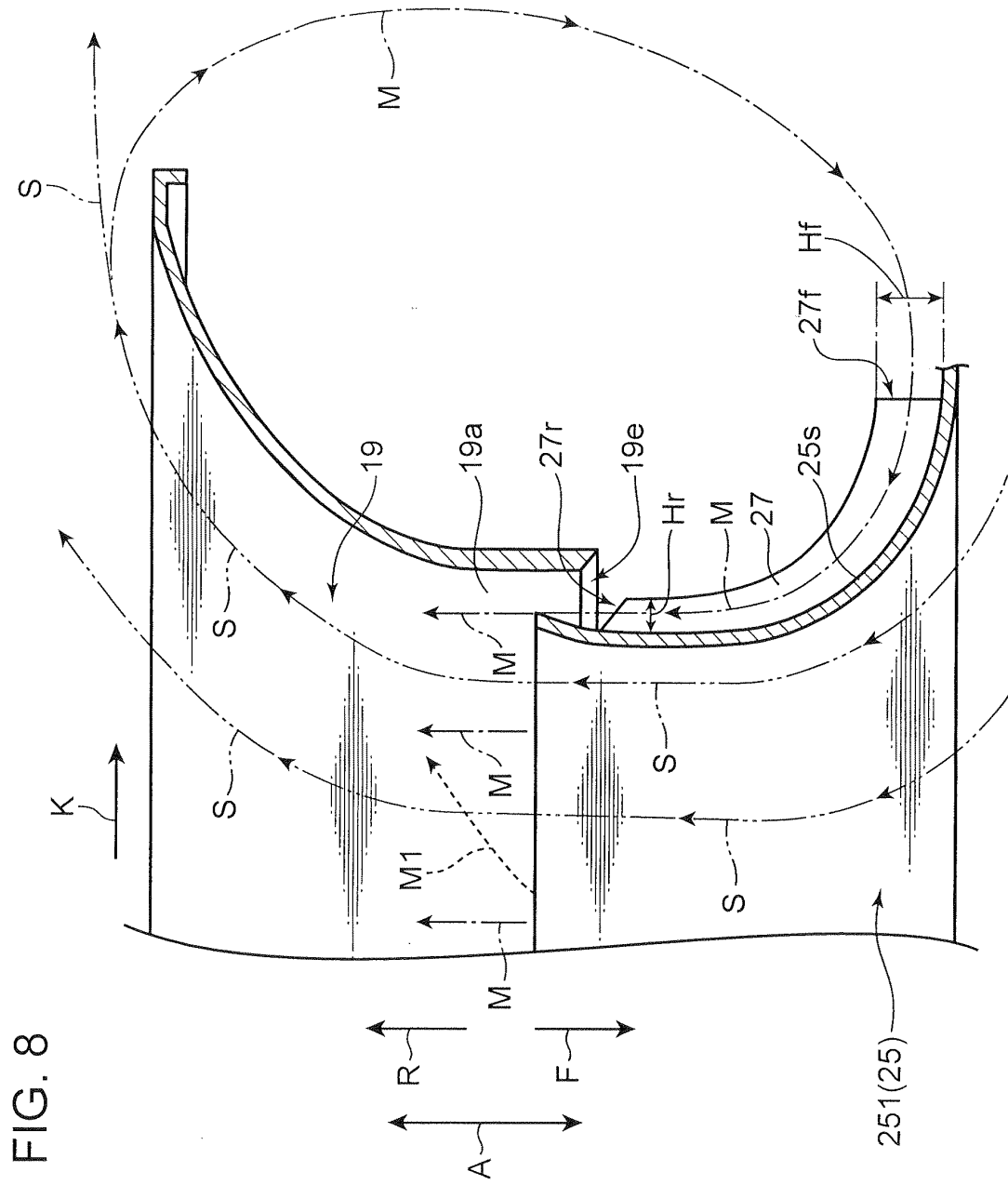


FIG. 9

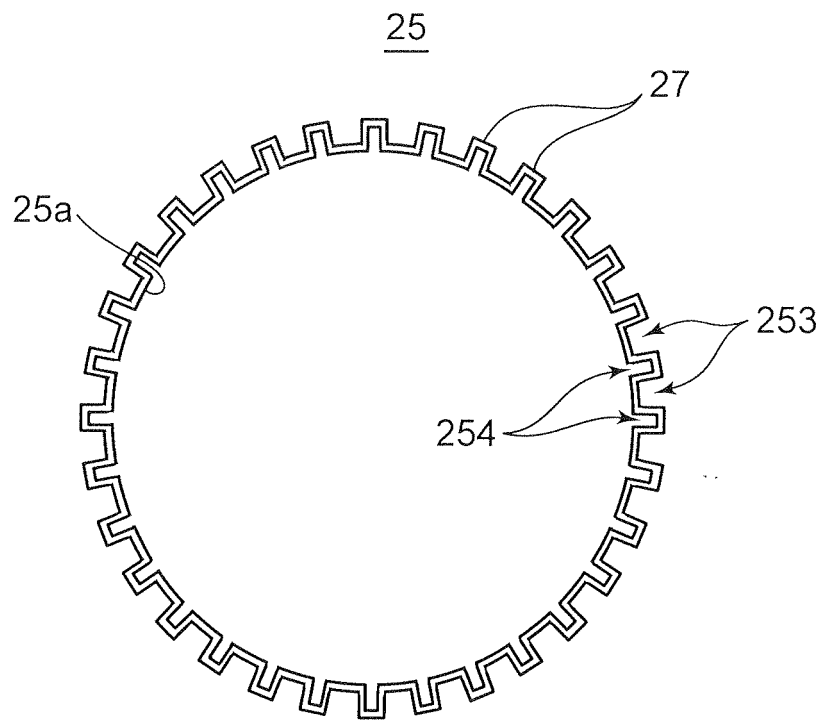


FIG. 10

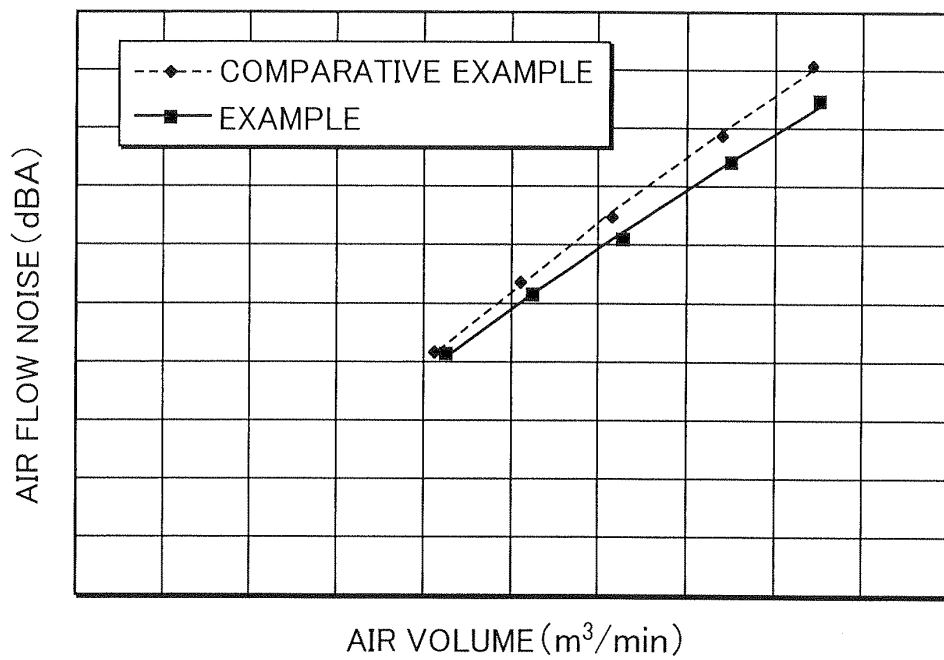
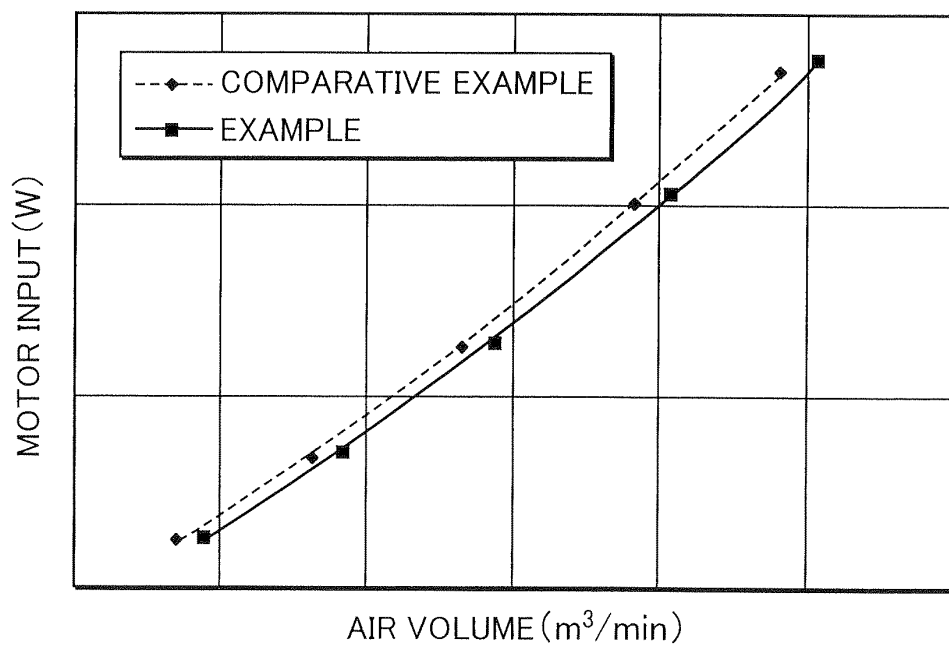


FIG. 11



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2011/000734

A. CLASSIFICATION OF SUBJECT MATTER

F04D29/44 (2006.01) i, F04D29/16 (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)

F04D29/44, F04D29/16

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	1996-2011
Kokai Jitsuyo Shinan Koho	1971-2011	Toroku Jitsuyo Shinan Koho	1994-2011

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 08-004684 A (Mitsubishi Heavy Industries, Ltd.), 09 January 1996 (09.01.1996), paragraphs [0019] to [0022]; fig. 1, 2 (Family: none)	1 2-4
Y A	JP 09-126193 A (Denso Corp.), 13 May 1997 (13.05.1997), paragraphs [0014], [0035]; fig. 2, 6 (Family: none)	1 2-4
Y A	JP 2008-138536 A (Matsushita Electric Industrial Co., Ltd.), 19 June 2008 (19.06.2008), paragraphs [0088], [0125], [0126]; fig. 1, 15, 16 (Family: none)	1 2-4

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

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03 March, 2011 (03.03.11)Date of mailing of the international search report
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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. 119105/1978 (Laid-open No. 036946/1980) (Hitachi, Ltd.), 10 March 1980 (10.03.1980), page 2, line 11 to page 3, line 10; fig. 2, 3 (Family: none)	1-4

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2001003899 A [0007]