

(19)



(11)

EP 3 511 575 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
17.07.2019 Bulletin 2019/29

(51) Int Cl.:
F04D 17/06 ^(2006.01) **F04D 25/06** ^(2006.01)
F04D 29/10 ^(2006.01) **F04D 29/28** ^(2006.01)

(21) Application number: **19150210.3**

(22) Date of filing: **03.01.2019**

(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
Designated Validation States:
KH MA MD TN

- **TAKAKI, Hitoshi**
Kyoto, 601-8205 (JP)
- **SHIOZAWA, Kazuhiko**
Kyoto, 601-8205 (JP)
- **HAYAMITSU, Ryosuke**
Kyoto, 601-8205 (JP)

(30) Priority: **12.01.2018 JP 2018003695**

(71) Applicant: **Nidec Corporation**
Kyoto-shi, Kyoto 601-8205 (JP)

(72) Inventors:
• **TATARA, Tatsuya**
Kyoto, 601-8205 (JP)

(74) Representative: **Zimmermann, Tankred Klaus et al**
Schoppe, Zimmermann, Stöckeler
Zinkler, Schenk & Partner mbB
Patentanwälte
Radtkoferstrasse 2
81373 München (DE)

(54) **AIR BLOWER AND CLEANER**

(57) An air blower includes: a motor (10) having a shaft (11); an impeller (20) fixed to the shaft; and a motor housing (30) disposed radially outwardly of the motor. The impeller includes an impeller base (21) that is more extended radially outwardly at an axially lower position. The impeller base includes a boss section (212) fixed to the shaft. The motor housing includes an upper surface cylindrical section (33) that extends axially upward from

a radially inner end of the motor housing upper surface (31). At least part of a radially inner surface of the upper surface cylindrical section is radially opposed to a radially outer surface of the shaft or the boss section, and an axially upper end of the upper surface cylindrical section is disposed over an axially lower end of the impeller base and over an upper end of a bearing (Br1).

EP 3 511 575 A1

Description

Field of the Invention

[0001] The present disclosure relates to an air blower and a cleaner including the air blower.

Description of the Related Art

[0002] An electric air blower in related arts is disclosed in Japanese Unexamined Patent Application Publication No. 11-93892. The electric air blower includes a first bearing housing formed at a central portion of a bottom surface; a motor frame including motor components such as a stator, a rotor, and a commutator; and a bracket which is provided on one end opening side of the motor frame, and in which a second bearing housing is formed at a central portion. The first bearing and the second bearing supported by the first bearing housing and the second bearing housing rotatably support both ends of the shaft of the rotor. The first bearing and the second bearing are bearings in which balls are inserted between an inner ring and an outer ring, and include two seal plates that cover the balls, the inner ring, and the outer ring. In at least one of the first and second bearings, one of the seal

plates is disposed not in contact with the inner ring of the bearing.

[0003] Intrusion of dust into the bearings is reduced by disposing the seal plate in this manner.

[0004] However, the first bearing and the second bearing described in Japanese Unexamined Patent Application Publication No. 11-93892 use a seal plate not in contact with an inner ring, and high dimensional accuracy is required for the seal plate. Thus, an advanced technique is required for manufacturing the seal plate, and the time and effort taken to manufacture increase. Since the other seal plate is in contact with the inner ring, the load is increased by friction between the inner ring and the seal plate, and rotation efficiency may be reduced.

SUMMARY OF THE INVENTION

[0005] An air blower according to an exemplary embodiment of the present disclosure includes: a motor including a shaft disposed along a central axis extending vertically; an impeller that is disposed over the motor and fixed to the shaft; and a motor housing that is disposed outwardly of the motor in a radial direction. The motor includes a bearing that supports the shaft rotatably with respect to the motor housing, and the impeller includes: an impeller base that is more extended outwardly in the radial direction at a lower position in an axial direction; and multiple blades disposed on an upper surface of the impeller base. The impeller base includes: a boss section fixed to the shaft; and a lower surface recessed section on an outer side of the boss section in the radial direction, the lower surface recessed section being included in a lower surface of the impeller base and recessed upwardly

in the axial direction. The motor housing includes: a motor housing upper surface that is disposed under the impeller base, and opposed to the lower surface of the impeller base in the axial direction; and an upper surface cylindrical section in a cylindrical shape, the upper surface cylindrical section extending upward in the axial direction from an inner end of the motor housing upper surface in the radial direction. At least part of a radially inner surface of the upper surface cylindrical section is opposed to a radially outer surface of the shaft or the boss section in the radial direction, and an upper end of the upper surface cylindrical section in the axial direction is disposed over a lower end of the impeller base in the axial direction and over an upper end of the bearing.

[0006] The above and other elements, features, steps, characteristics and advantages of the present disclosure will become more apparent from the following detailed description of the preferred embodiments with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007]

Fig. 1 is a perspective view of a cleaner according to an embodiment;

Fig. 2 is a perspective view of an air blower according to the embodiment;

Fig. 3 is an exploded perspective view of the air blower illustrated in Fig. 2;

Fig. 4 is a vertical cross-sectional view of the air blower illustrated in Fig. 2;

Fig. 5 is a cross-sectional view of an impeller with enlarged upper surface cylindrical section and boss section;

Fig. 6 is a cross-sectional view with an enlarged upper surface cylindrical section in a modification of the air blower;

Fig. 7 is a cross-sectional view with an enlarged upper surface cylindrical section in a modification of the air blower;

Fig. 8 is a cross-sectional view of an impeller with enlarged upper surface cylindrical section and boss section in another example of the air blower according to the present disclosure;

Fig. 9 is a cross-sectional view of an impeller with enlarged upper surface cylindrical section and boss section in another example of the air blower according to the present disclosure;

Fig. 10 is a cross-sectional view of an impeller with enlarged upper surface cylindrical section and boss section in another example of the air blower according to the present disclosure; and

Fig. 11 is a cross-sectional view of an impeller with enlarged upper surface cylindrical section and boss section in another example of the air blower according to the present disclosure.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0008] Hereinafter, an exemplary embodiment of the present disclosure will be described in detail with reference to the drawings. In the present description, in an air blower A, a direction parallel to a central axis Ax of the air blower A is referred to as an "axial direction", a direction perpendicular to the central axis Ax of the air blower A is referred to as a "radial direction", and a direction along the arc centered on the central axis Ax of the air blower A is referred to as a "circumferential direction". Similarly, in a state where an impeller 20 is incorporated in the air blower A, the directions in the impeller 20 corresponding to the axial direction, the radial direction, and the circumferential direction of the air blower A are simply called the "axial direction", the "radial direction", and the "circumferential direction", respectively. In the present description, the geometry of the components and the positional relationship therebetween in the air blower A will be described under the assumption that the axial direction is the vertical direction, and an air inlet 43 of an impeller cover 41 is above the impeller 20. The vertical direction is a name used only for explanation, and does not limit the positional relationship and the direction in a use state of the air blower A. The "upstream" and "downstream" respectively indicate the upstream and downstream of the flow direction of the air sucked through the air inlet 43 when the impeller 20 is rotated.

[0009] In the present description, the geometry of the components and the positional relationship therebetween in a cleaner 100 will be described under the assumption that "downward direction" is the direction closer to a floor surface F (surface to be cleaned) of Fig. 1, and "upward direction" is the direction away from the floor surface F. It is to be noted that these directions are names used only for explanation, and do not limit the positional relationship and the direction in a use state of the cleaner 100. The "upstream" and "downstream" respectively indicate the upstream and downstream of the flow direction of the air sucked through a suction inlet 103 when the air blower A is driven.

[0010] A cleaner according to an exemplary embodiment of the present disclosure will be described below. Fig. 1 is a perspective view of the cleaner according to the embodiment. The cleaner 100 is a so-called stick type vacuum cleaner, and includes a casing 102 having a lower surface and an upper surface in which a suction inlet 103 and an exhaust outlet 104 are respectively opened. A power cord (not illustrated) is led from the rear surface of the casing 102. The power cord is connected to an electrical outlet (not illustrated) provided in a wall surface of a living room to supply electric power to the cleaner 100. It is to be noted that the cleaner 100 may be a so-called robot-type, canister-type, or handy-type electric vacuum cleaner.

[0011] In the casing 102, an air path (not illustrated) is formed, which connects the suction inlet 103 and the ex-

haust outlet 104. In the air path, a dust collector (not illustrated), a filter (not illustrated), and the air blower A are sequentially disposed from the upstream side to the downstream side. Thus, the cleaner 100 includes the air blower A. This makes it possible to implement the cleaner 100 that has a simple configuration and includes the air blower A capable of reducing intrusion of foreign particles into a bearing Br1. Contaminated particles such as dust, dirt contained in the air flowing through the air path are blocked by the filter, and collected by a dust collector which is formed in a container shape. The dust collector and the filter are detachably attached to the casing 102.

[0012] A gripper 105 and an operation interface 106 are provided at the upper portion of the casing 102. A user can move the cleaner 100 by grasping the gripper 105. The operation interface 106 has multiple buttons 106a, and operation settings for the cleaner 100 are made by operating the buttons 106a. For instance, the air blower A is instructed to start driving, stop driving, or change the rotational speed by operating the buttons 106a. A cylindrical suction tube 107 is connected to the suction inlet 103. A suction nozzle 110 is detachably attached to the suction tube 107 at an upstream end of the suction tube 107 (the lower end of Fig. 1).

[0013] Fig. 2 is a perspective view of the air blower according to the embodiment. Fig. 3 is an exploded perspective view of the air blower illustrated in Fig. 2. Fig. 4 is a vertical cross-sectional view of the air blower illustrated in Fig. 2. The air blower A is mounted on the cleaner 100, and sucks air.

[0014] The air blower A includes a motor 10, an impeller 20, and a motor housing 30. In the embodiment, the air blower A further includes a blower housing 40, a cover member 50, and a board Bd.

[0015] The impeller 20 and the motor housing 30 are housed in the blower housing 40. As illustrated in Fig. 4, a flow path 60 is formed in the space between the blower housing 40 and the motor housing 30. The flow path 60 communicates with the later-described impeller cover 41 at the upper end (upstream end), and an exhaust port 61 is formed at the lower end (downstream end) of the flow path 60.

[0016] The motor housing 30 houses the motor 10 connected to the impeller 20. The impeller 20 rotates around a central axis Ax that extends vertically. The motor 10 is disposed under the impeller 20 to rotate the impeller 20. That is, the impeller 20 is rotated around the vertically extending central axis Ax by the rotation of the motor 10. An air current generated by the rotation of the impeller 20 passes through the flow path 60, and is discharged through the exhaust port 61.

[0017] As illustrated in Fig. 3, the motor 10 housed in the motor housing 30 is disposed under the impeller 20. The motor 10 is a so-called inner rotor type brushless motor. The motor 10 includes a shaft 11, a rotor 12, and a stator 13. In other words, the motor housing 30 surrounds the radially outside of the rotor 12 and the stator 13. That is, the motor 10 has the shaft 11 is disposed

along the vertically extending central axis Ax.

[0018] The shaft 11 is cylindrical. The shaft 11 is disposed along the vertically extending central axis Ax, and rotates around the central axis Ax. As illustrated in Fig. 4, the shaft 11 penetrates through a top plate through hole 313 provided in the later-described motor housing upper surface 31 of the motor housing 30. The impeller 20 is fixed to an end which projects from the motor housing upper surface 31 of the shaft 11. In other words, the impeller 20 is disposed over the motor 10, and fixed to the shaft 11. The shaft 11 is rotatably supported by an upper bearing Br1 and a lower bearing Br2.

[0019] The upper bearing Br1 and the lower bearing Br2 are ball bearings. The shaft 11 is fixed to the inner rings of the upper bearing Br1 and the lower bearing Br2. A method, such as adhesive insertion or press fitting, is adopted for fixing. The outer ring of the upper bearing Br1 is fixed to the motor housing 30, and the outer ring of the lower bearing Br2 is fixed to the cover member 50. In other words, the motor 10 includes the bearings Br1 and Br2 that support the shaft 11 rotatably with respect to the motor housing 30. It is to be noted that the upper bearing Br1 and the lower bearing Br2 are not limited to a ball bearing. At least part of the upper bearing Br1 is disposed in the later-described lower surface recessed section 211 of the impeller 20. This makes it possible to increase the axial lengths of the upper bearing Br1 and the lower bearing Br2. In addition, the upper bearing Br1 can be disposed near the later-described boss section 212 of the impeller 20. This makes it possible to reduce the deformation such as bending of the shaft 11 at the time of rotation of the impeller 20. Rotational deflection of the impeller 20 can be reduced by reducing the deformation of the shaft 11. This enables the air blower A to blow air in a stable manner.

[0020] The rotor 12 is fixed to the shaft 11. The rotor 12 rotates with the shaft 11. The rotor 12 has multiple magnets (not illustrated). The multiple magnets are disposed in parallel and fixed in the axial direction on the outer circumferential surface of the shaft 11. In each of the multiple magnets, a magnetic pole face of the N pole and a magnetic pole face of the S pole are alternately arranged in the circumferential direction.

[0021] Instead of the multiple magnets, a single circular magnet may be used. In this case, the N pole and the S pole may be alternately magnetized in the circumferential direction in the magnet. Alternatively, the magnet may be integrally made of a resin blended with magnetic material powder.

[0022] The stator 13 is disposed outwardly of the rotor 12 in the radial direction. In other words, the stator 13 is disposed to be opposed to the rotor 12 in the radial direction. The stator 13 includes a stator core 131, an insulator 132, and coils 133. The stator core 131 is a multilayer body in which magnetic steel sheets are layered in the axial direction (the vertical direction in Fig. 3). It is to be noted that the stator core 131 is not limited to a multilayer body in which magnetic steel sheets are lay-

ered, and may be a single member made of calcined powder or cast powder, for instance.

[0023] The stator core 131 has a circular core back 134 and multiple teeth 135. The multiple teeth 135 are formed radially extending inwardly from the inner circumferential surface of the core back 134 to the magnets (not illustrated) of the rotor 12 in the radial direction. In short, the teeth 135 extend inwardly from the core back 134 in the radial direction. Thus, multiple teeth 135 are disposed in the circumferential direction. The coils 133 are formed by winding a conductive wire around each of the teeth 135 with the tooth interposed between the insulator 132. Specifically, the stator 13 includes the circular core back 134, the teeth 135 extending from the core back 134 in the radial direction, and the coils 133 wound around the teeth 135.

[0024] The motor 10 is a brushless motor. A brushless motor is driven by a current which is divided into three branches (hereinafter referred to as three phases) having different supply timings. A current is supplied to the multiple coils 133 at determined timing, thus the coils 133 and the magnets of the rotor 12 attract or repel each other. Consequently, the rotor 12 rotates.

[0025] The motor 10 is a high rotational motor that can revolve at the rate of 100,000 revolutions or greater per minute, for instance. Normally, a motor with less number of coils is advantageous in high speed rotation. As described above, the motor 10 is driven by a current with three phases. Therefore, in the motor 10, the number of the coils 133, and the number of teeth 135 in which the coils 133 are disposed are three. In other words, the motor 10 is a three-phase three-slot motor. In order to rotate the motor 10 with better balance, three teeth 135 are disposed at regular intervals in the circumferential direction.

[0026] In the stator core 131, the inner circumferential surface and the outer circumferential surface of the core back 134 are planar in the root vicinity of the teeth 135. This reduces collapse of coils in the periphery of the outer end of the coils 133 in the radial direction, and makes it possible to effectively utilize a winding space for forming the coils 133. Loss can be reduced by shortening a magnetic path. In the area other than the root vicinity of the teeth 135, the inner circumferential surface and the outer circumferential surface of the core back 134 are curved surfaces.

[0027] A curved surface portion of the core back 134 is in contact with the inner surface of the motor housing 30. The curved surface portion may be press-fitted into the inner surface of the motor housing 30. It is to be noted that the core back 134 may be cylindrical not including a planar surface. In this case, a cylindrical outer surface is press-fitted into the motor housing 30. The core back 134 and the motor housing 30 may be fixed to each other by another method such as adhesive bonding.

[0028] A lead wire (not illustrated) is connected to the coils 133. One end of the lead wire is connected to a drive circuit (not illustrated) on a board Bd arranged under

the blower housing 40. Thus, electric power is supplied to the coils 133.

[0029] The configuration of the motor housing 30 will be described with reference to the drawings. As illustrated in Fig. 4, the motor housing 30 covers the outer side of the motor 10 in the radial direction. In other words, the motor housing 30 is disposed outwardly of the motor 10 in the radial direction. The motor housing 30 includes a motor housing upper surface 31, a motor housing cylindrical section 32, an upper surface cylindrical section 33, and stator vanes 34. The motor housing upper surface 31 and the motor housing cylindrical section 32 are integrally formed. The motor housing 30 may be made of metal or resin.

[0030] The motor housing upper surface 31 extends in a direction perpendicular to the central axis Ax. The motor housing upper surface 31 is circular as viewed in the axial direction. The motor housing cylindrical section 32 extends downward in the axial direction from the outer edge of the motor housing upper surface 31 in the radial direction. The motor housing upper surface 31 is disposed under the impeller base 21, and is opposed to the lower surface of the impeller base 21 in the axial direction.

[0031] Fig. 5 is a cross-sectional view of the impeller with enlarged upper surface cylindrical section and boss section. As illustrated in Figs. 4 and 5, the motor housing upper surface 31 includes a top plate projection section 311 and the upper surface cylindrical section 33. The top plate projection section 311 projects upward in the axial direction from the motor housing upper surface 31. In the top plate projection section 311, the radially outer surface extends more inwardly in the radial direction at an upper position in the axial direction. The axially upper surface of the top plate projection section 311 includes a top plate recessed section 312 that is recessed downward in the axial direction. A top plate through hole 313, which is through in the axial direction, is disposed in the axially bottom surface of the top plate recessed section 312. The centers of the top plate projection section 311, the top plate recessed section 312, and the top plate through hole 313 match the central axis Ax. In other words, the top plate projection section 311, the top plate recessed section 312, and the top plate through hole 313 are concentric. An upper bearing Br1 is disposed under the top plate projection section 311 in the axial direction. The center of the upper bearing Br1 matches the central axis Ax.

[0032] As illustrated in Fig. 5, the motor housing upper surface 31 includes an inner surface projection section 315 that extends inwardly in the radial direction from the top plate through hole 313. The axially lower surface of the inner surface projection section 315 is in contact with the axially upper surface of the upper bearing Br1. In other words, the motor housing 30 includes the inner surface projection section 315 that extends inwardly in the radial direction from the radially inner surface of the motor housing 30. The axially upper surface of the upper bearing Br1 is in contact with the axially lower surface of the

inner surface projection section 315.

[0033] Thus, when the upper bearing Br1 is mounted on the motor housing upper surface 31, the inner surface projection section 315 positions the upper bearing Br1 in the axial direction. In the motor housing upper surface 31 illustrated in Fig. 5, the inner surface projection section 315 is provided at a position overlapping with the outer ring of the upper bearing Br1 in the axial direction. However, without being limited to this, the inner surface projection section 315 may be not in contact with the inner ring and the shaft 11, and may project more inwardly than the state of Fig. 5. In other words, the radially inward front end of the inner surface projection section 315 may be located between the outer ring and the inner ring of the upper bearing Br1 in the axial direction. With this configuration, the inner surface projection section 315 has an effect of reducing intrusion of foreign particles such as dust, dirt from the top plate through hole 313 into the bearing Br1. Consequently, the motor 10 can be driven for a long time in a stable manner.

[0034] In the upper bearing Br1, the shaft 11 is fixed, and the shaft 11 penetrates through the top plate through hole 313. An annular recessed groove 314, which is recessed downwardly in the axial direction, is provided outwardly of the motor housing upper surface 31 in the radial direction. The annular recessed groove 314 is provided adjacent to the outer side of the top plate projection section 311 in the radial direction.

[0035] The upper surface cylindrical section 33 extends upward from the motor housing upper surface 31 in the axial direction. As illustrated in Figs. 4 and 5, the upper surface cylindrical section 33 projects axially upward from the axially upper surface of the inner surface projection section 315 which projects radially inwardly from the top plate through hole 313. That is, the upper surface cylindrical section 33 extends upward in the axial direction from the inner surface projection section 315. Thus, the upper surface cylindrical section 33 can be molded on a radially inner side as much as possible. Consequently, it is possible to reduce the radial gap between the upper surface cylindrical section 33 and the shaft 11 or the boss section 212, and therefore, labyrinth seal characteristics can be improved. The upper surface cylindrical section 33 has a cylindrical shape. Thus, the motor housing 30 includes the cylindrical upper surface cylindrical section 33 that extends upward in the axial direction from the radially inner end of the motor housing upper surface 31.

[0036] In the motor housing upper surface 31, the top plate projection section 311 and the upper surface cylindrical section 33 are integrally formed. The upper surface cylindrical section 33 may not be integrally formed with the motor housing upper surface 31. For instance, the upper surface cylindrical section 33 may be produced separately from the motor housing upper surface 31, and fixed to the motor housing upper surface 31. A method such as welding, screwing may be used as a fixing method, but the fixing method is not limited to these. For in-

stance, a portion extending in the radial direction may be provided in the upper surface cylindrical section 33, and may be press-fitted into the top plate recessed section 312. The details of the upper surface cylindrical section 33 will be described later. The upper surface cylindrical section 33 is disposed radially inwardly of the top plate recessed section 312 formed in the top plate projection section 311. Specifically, the upper end of the upper surface cylindrical section 33 in the axial direction is disposed over the lower end of the impeller base 21 in the axial direction and over the upper end of the bearing Br1.

[0037] The motor housing cylindrical section 32 projects downward in the axial direction from the outer edge of the motor housing upper surface 31 in the radial direction. The motor housing cylindrical section 32 is cylindrical. Specifically, the motor housing 30 has a covered cylindrical shape having an opening at the bottom. Multiple stator vanes 34 are provided in a radially outer surface 300 of the motor housing cylindrical section 32. The stator vanes 34 are formed in a plate shape, and are more inclined to a direction opposite to the rotational direction of the impeller 20 at an upper position. The stator vanes 34 facing the impeller 20 are convexly curved. The outer edge of the multiple stator vanes 34 is in contact with the blower housing 40, that is, the inner surface of a lower cover 42. The stator vanes 34 are installed side by side in the circumferential direction, and guide an air current downward when the air blower A is driven.

[0038] In the embodiment, the stator vanes 34 and the motor housing 30 are an integrated component. However, the stator vanes 34 and the motor housing 30 may be separate components.

[0039] A disc-shaped cover member 50 is disposed under the motor housing 30. The lower surface of the motor housing 30 is covered by mounting the cover member 50. The cover member 50 is fixed to the motor housing 30 using a fastening element, such as a screw, which is not illustrated. As illustrated in Figs. 1 and 4, the board Bd is disposed under the cover member 50.

[0040] Next, the impeller 20 will be described. The impeller 20 is a so-called mixed flow impeller which is formed as a resin-molded article. The impeller 20 includes the impeller base 21 and multiple blades 22. A resin called engineering plastic may be used as the resin of which the impeller 20 is made. The engineering plastic is a resin having a superior mechanical property such as intensity, heat resistance compared with other resins. It is to be noted that the impeller 20 may be made of a material such as metal. The impeller base 21 has a larger diameter at a lower position. Thus, the impeller 20 includes the impeller base 21 that is more extended outwardly in the radial direction at a lower position in the axial direction. In other words, the impeller base 21 has a more increased diameter at a lower position.

[0041] The impeller base 21 includes a lower surface recessed section 211, and a boss section 212. The center (central axis Ax) of the boss section 212 includes a hole 213 into which the shaft 11 of the motor 10 is press-fitted.

In other words, the impeller base 21 includes the boss section 212 fixed to the shaft 11. Thus, the boss section 212 and the shaft 11 are connected, and the impeller 20 rotates around the central axis Ax. The boss section 212 has a cylindrical shape, and the outer diameter of boss section 212 is smaller than the inner diameter of the cylinder body of the upper surface cylindrical section 33. When the shaft 11 is inserted into the hole 213 and the impeller 20 and the shaft 11 are fixed to each other, at least part of the axially lower portion of the radially outer surface of the boss section 212 is opposed to at least part of a radially inner surface 330 of the upper surface cylindrical section 33 in the radial direction. The details of arrangement of the boss section 212 and the upper surface cylindrical section 33 will be described later.

[0042] Multiple blades 22 are disposed on the upper surface 214 of the impeller base 21. Thus, the impeller 20 includes the multiple blades 22 disposed on the upper surface 214 of the impeller base 21. In the impeller 20, the blades 22 are installed side by side on the upper surface 214 of the impeller base 21 at a predetermined period in the circumferential direction, and are integrally formed with the impeller base 21. The upper portion of the blades 22 is arranged forwardly in the rotation direction with respect to the lower portion. The lower surface of the impeller base 21 has an annular projection section 215. The annular projection section 215 has a substantially V-shaped cross section.

[0043] When the impeller 20 is fixed to the shaft 11, the annular projection section 215 of the axially lower end of the impeller base 21 is opposed to the annular recessed groove 314 in the axial direction. Since the impeller 20 is configured to rotate, a gap is formed between the annular projection section 215 and the annular recessed grooves 314. In other words, the annular projection section 215 and the annular recessed groove are not in contact with each other.

[0044] As illustrated in Fig. 4, in the lower surface of the impeller base 21, a lower surface recessed section 211, which is recessed upwardly in the axial direction, is provided outwardly of the boss section 212 in the radial direction. In other words, the impeller base 21 includes the lower surface recessed section 211 on the outer side of the boss section 212 in the radial direction, the lower surface recessed section 211 being included in the lower surface of the impeller base 21 and recessed upwardly in the axial direction. Since the impeller base 21 includes the lower surface recessed section 211, it is possible to reduce the weight of the impeller base 21. Decrease in the weight of the impeller 20 serving as a rotational unit allows power consumption to be reduced, and easily causes high speed rotation. Also, it is possible to reduce sink when the impeller 20 is molded. Also, part of the axially upper portion of the top plate projection section 311 of the motor housing upper surface 31 is housed inside the lower surface recessed section 211. The upper bearing Br1 mounted on the top plate projection section 311 is disposed inwardly of the lower surface recessed

section 211. In other words, the axially upper surface of the bearing Br1 is disposed over the axially lower end of the impeller base 21. Consequently, the bearing Br1 can be brought closer to the axially upper end of the shaft 11, and rotational deflection of the shaft 11 can be reduced.

[0045] Next, the blower housing 40 will be described. The blower housing 40 surrounds the radially outer side of the motor housing 30 with a gap interposed therebetween. The blower housing 40 includes an impeller cover 41 and a lower cover 42.

[0046] The impeller cover 41 is disposed at least outwardly of the impeller 20 in the radial direction. The impeller cover 41 serves as a guide that turns the flow of air current generated by rotation of the impeller 20 in the axial direction. The impeller cover 41 includes the air inlet 43 which is open in the vertical direction (the axial direction). The air inlet 43 has a shape of bell mouse 431 that extends downward from the upper end with inwardly curved. Thus, the diameter of the air inlet 43 is smoothly reduced from an upper position to a lower position. Since the air inlet 43 has the shape of the bell mouse 431, air can be smoothly sucked. Thus, the amount of air sucked through the air inlet 43 at the time of rotation of the impeller 20 is increased. Therefore, it is possible to increase the blowing efficiency of the air blower A.

[0047] In the air blower A in the embodiment, the lower end of the impeller cover 41 is fixed to the lower cover 42. The lower cover 42 has a circular cross-section perpendicular to the central axis Ax, and is in a cylindrical shape extending in the axial direction. The lower cover 42 includes an opening at the upper end and the lower end. The upper end of the lower cover 42 is connected to the lower end of the impeller cover 41. The lower end of the impeller cover 41 is inserted into the inside of the lower cover 42. The inner surface of the impeller cover 41 is smoothly continuous, for instance, differentiable continuous to the inner surface of the lower cover 42. This makes the inner surface of the blower housing 40 smooth, and reduces the disturbance of air current.

[0048] As a method of fixing the impeller cover 41 and the lower cover 42, for instance, a projection section is provided in the outer surface of the lower cover 42, and a beam section extending downward in the axial direction is provided in the inner surface of the front end side in the impeller cover 41, the beam section including a recessed section recessed outwardly in the radial direction. When the impeller cover 41 is moved in the axial direction toward the lower cover 42, the beam section is bent, and the projection section of the lower cover 42 is inserted into and fixed to the recessed section of the beam section of the impeller cover 41. A fixing method is not limited to this, and a fixing method which reduces movement in the axial direction and the circumferential direction, may be widely adopted. Preferably, a fixing method enables positioning in the circumferential direction and easy attachment and detachment. In addition, the impeller cover 41 and the lower cover 42 may be molded as an integrated member.

[0049] The lower cover 42 is disposed outwardly of the motor housing 30 in the radial direction. The multiple stator vanes 34 are disposed side by side in the gap between the lower cover 42 and the motor housing 30 at regular intervals in the circumferential direction. The multiple stator vanes 34 are in contact with the outer surface of the motor housing 30 in the radial direction. In the air blower A in the embodiment, the motor housing 30 and the lower cover 42 may be integrally formed of a resin.

[0050] The contact between the stator vanes 34 and the motor housing 30 includes not only the case where different members are in contact, but also the case where the stator vanes 34 and the motor housing 30 are integrally formed. The stator vanes 34 are disposed on the radially outer surface of the motor housing 30 at regular intervals in the circumferential direction.

[0051] The motor 10 generates heat as it rotates in the coil 133 and its surroundings. The heat is transmitted to the motor housing 30. The stator vanes 34 are disposed inside the flow path 60, and are in contact with the motor housing 30. Thus, the stator vanes 34 control air current, and also serve as radiation fins for escaping the heat of the motor housing 30 to the outside. This increases the efficiency of cooling the air blower A in which heat is generated by the coil 133 and its vicinity.

[0052] In the air blower A in the embodiment, the motor housing 30 and the lower cover 42 are integrally formed. However, without being limited to this, the motor housing 30 and the lower cover 42 may be formed as separate members, for instance. When the lower cover 42 is formed as a separate member from the motor housing 30, the impeller cover 41 and the lower cover 42 may be integrated.

[0053] The impeller 20 is fixed to the axially upper end of the shaft 11 via the boss section 212, the shaft 11 penetrating through the top plate through hole 313 of the motor housing upper surface 31. In this structure, the axially upper end of the upper surface cylindrical section 33 is disposed upward of the axially lower end of the impeller base 21. At least part of the axially lower portion of the boss section 212 is housed inside the upper surface cylindrical section 33. Here, the arrangement of the upper surface cylindrical section 33 and the boss section 212 will be described with reference to the drawings. As illustrated in Fig. 5, the axially lower end of the boss section 212 is located under the axially upper end of the upper surface cylindrical section 33. Thus, part of the axially upper portion of the radially inner surface 330 of the upper surface cylindrical section 33 is opposed to part of the axially lower portion of a radially outer surface 2120 of the boss section 212 in the radial direction.

[0054] The boss section 212 formed in the lower surface of the impeller 20 serving as a rotational body is disposed inside the upper surface cylindrical section 33 with a gap in the radial direction. It is to be noted that in the area where the boss section 212 and the upper surface cylindrical section 33 are opposed to each other in the radial direction, the radial gap between the boss sec-

tion 212 and the upper surface cylindrical section 33 is uniform over the entire area in the axial direction. Consequently, the boss section 212 and the upper surface cylindrical section 33 form a labyrinth seal structure. Due to the labyrinth seal structure, air flow is unlikely to occur in the gap between the radially outer surface 2120 of the boss section 212 and the radially inner surface 330 of the upper surface cylindrical section 33.

[0055] When the impeller 20 is rotated, air flows from a radially outer side to a radially inner side in the lower surface of the impeller base 21. Since the boss section 212 and the upper surface cylindrical section 33 form a labyrinth seal structure, air is unlikely to flow through an opening at the upper end of the upper surface cylindrical section 33 into the motor housing 30 through the gap between the boss section 212 and the upper surface cylindrical section 33.

[0056] The upper bearing Br1 is disposed inside the motor housing 30, specifically, at the back of the labyrinth seal structure formed by the boss section 212 and the upper surface cylindrical section 33. This reduces the flow of the air outside the motor housing 30 toward the upper bearing Br1.

[0057] The air blower A sucks air through the air inlet 43 by rotation of the impeller 20. The air contains the air outside the air blower A, and foreign particles such as dust, dirt may be mixed in the air. Particularly when the air blower A is used for the cleaner 100, foreign particles are likely to be mixed. The labyrinth seal structure reduces the flow of external air toward the upper bearing Br1 as well as intrusion of foreign particles into the bearing Br1, the foreign particles including dust, dirt contained in the external air.

[0058] The formation of a labyrinth seal structure by the upper surface cylindrical section 33 and the boss section 212 reduces intrusion of foreign particles such as dust, dirt from the axially upper end of the upper surface cylindrical section 33 to the upper bearing Br1. Also, in the labyrinth seal structure, the boss section 212 and the upper surface cylindrical section 33, that is, the impeller 20 and the motor housing 30 are not in contact with each other. Therefore, reduction of the rotation efficiency of the shaft 11, that is, motor 10 can be reduced.

[0059] Specifically, in the air blower A, the axially upper end of the upper surface cylindrical section 33 is disposed upward of the axially lower end of the impeller base 21 and upward of the upper end of the bearing Br1.

This makes it possible to reduce mixing of foreign particles such as dust, dirt into the upper bearing Br1 without interfering with the rotation of the shaft 11 (impeller 20). Consequently, the motor 10 can be driven for a long time in a stable manner. When the upper surface cylindrical section 33 and the boss section 212 are opposed to each other in the radial direction as in the embodiment, the upper surface cylindrical section 33 and the boss section 212 form a labyrinth seal structure, thus intrusion of foreign particles such as dust, dirt into the upper bearing Br1 can be further reduced.

[0060] The upper surface cylindrical section 33, which projects upward from the motor housing upper surface 31, is provided, and the upper surface cylindrical section 33 and the boss section 212 of the impeller 20 form a labyrinth seal structure. For this reason, a bearing including special sealing does not have to be used as the upper bearing Br1. Thus, a generally distributed bearing may be used as the upper bearing Br1, and accordingly, the cost of manufacturing the air blower A can be reduced. In addition, when repair or inspection is performed, the bearing is easily available, and the maintenance performance is high accordingly.

[0061] As described above, since the labyrinth seal structure is formed, air flow from the radially outer side to the inner side of the impeller 20 is unlikely to occur. Thus, air current generated in the impeller 20 is unlikely to flow between the impeller 20 and the motor housing upper surfaces 31, and the blowing efficiency is easily maintained. In addition, a force due to air current flowing between the impeller 20 and the motor housing upper surfaces 31 is unlikely to be applied to the impeller 20, and thus the rotation of the impeller 20 is stabilized.

[0062] As illustrated in Fig. 4, in the air blower A in the embodiment, the radially inner surface 330 of the upper surface cylindrical section 33 and the radially outer surface 2120 of the boss section 212 are opposed to each other in the radial direction. However, without limiting to this, for instance, when the boss section 212 is short, the axially lower portion of the radially inner surface 330 of the upper surface cylindrical section 33 is opposed to the shaft 11. The radially inner surface 330 of the upper surface cylindrical section 33 may form a constant gap between the outer surface of the shaft 11 in the radial direction and radially inner surface 330 in the axial direction so that a labyrinth seal structure may be formed. Specifically, at least part of the radially inner surface 330 of the upper surface cylindrical section 33 is opposed to the radially outer surface of the shaft 11 or the boss section 212 in the radial direction. Also, over the entire area in the axial direction, the radially inner surface 330 of the upper surface cylindrical section 33 has a uniform radial distance from the radially outer surface of the shaft 11 or the boss section 212. Consequently, the radially inner surface 330 of the upper surface cylindrical section 33 forms a labyrinth seal structure over the entire area in the axial direction, and thus mixture of foreign particles such as dust, dirt into the upper bearing Br1 can be further reduced.

[0063] Alternatively, a step section, which extends inwardly in the radial direction, may be provided below a portion of the shaft 11 opposed to the boss section 212 of the upper surface cylindrical section 33 in the radial direction, so that the gap between the shaft 11 and the upper surface cylindrical section 33 may be reduced. The step section is not in contact with the shaft 11 as well as the boss section 212. With this configuration, a labyrinth seal structure is formed in the gap between the axially lower end of the boss section 212 and the upper surface

cylindrical section 33, and the gap between the step section of the upper surface cylindrical section 33 and the shaft 11.

[0064] Even with the formation of a labyrinth seal structure as described above, similarly to the case where the labyrinth seal structure is formed by the boss section 212 and the upper surface cylindrical section 33, intrusion of foreign particles into the upper bearing Br1 can be reduced without reducing the rotation efficiency of the motor 10.

[0065] The cleaner 100 includes the air blower A. In the cleaner 100 having the configuration described above, when the motor 10 of the air blower A is driven, the impeller 20 is rotated around the central axis Ax. The impeller 20 is rotated by the motor 10. Thus, the air blower A including the motor 10 with superior assembly workability can be implemented. Moreover, since the cleaner 100 includes the air blower A, the air blower A having the motor 10 with superior assembly workability can be utilized for the cleaner 100.

[0066] When the cleaner 100 is driven, air containing contaminated particles such as dust, dirt on a floor surface F flows through the suction nozzle 110, the suction tube 107, the suction inlet 103 (see Fig. 1), the dust collector, and the filter in that order. The air passing the filter is taken in the blower housing 40 through the air inlet 43 of the air blower A. At this point, the amount of air sucked by the bell mouse 431 through the air inlet 43 is increased, and the sucked air is smoothly guided between adjacent blades 22. Therefore, it is possible to improve the blowing efficiency of the air blower A. The cleaner 100 includes the air blower A.

[0067] Although the air which has passed the filter flows into the air blower A, it may be difficult to completely catch dust and dirt by the filter. In other words, foreign particles such as dust, dirt may be slightly mixed in the air which has passed the filter. Since the boss section 212 and the upper surface cylindrical section 33 form a labyrinth seal structure in the air blower A, foreign particles carried by air are unlikely to intrude into the upper bearing Br1.

[0068] The air taken into the inside of the impeller cover 41 flows between adjacent blades 22, and is accelerated downward by the rotating impeller 20 at an outer side in the radial direction. The air accelerated downward at the outer side in the radial direction is blown off downward of the impeller 20. The air blown off downward of the impeller 20 flows in the flow path 60 in the gap between the motor housing upper surface 31 and the lower cover 42. The air (air current) flowed into the flow path 60 flows between adjacent stator vanes 34 in the circumferential direction.

[0069] The air current which has passed the lower end of the stator vanes 34 is exhausted to the outside of the blower housing 40 through the exhaust port 61. The air exhausted to the outside of the blower housing 40 flows through the air path in the casing 102 of the cleaner 100, and is exhausted to the outside of the casing 102 through

the exhaust outlet 104 (see Fig. 1). Thus, the cleaner 100 can clean the floor surface F.

[0070] A modification of the air blower in the embodiment will be described with reference to the drawings. Fig. 6 is a cross-sectional view with an enlarged upper surface cylindrical section in a modification of the air blower. In an air blower A1 illustrated in Fig. 6, the structure of an upper surface cylindrical section 33a is different from the structure of the air blower A. However, the configuration of other components is the same as the configuration of the air blower A. Thus, in the air blower A1, essentially the same component as that of the air blower A is labeled with the same symbol, and a detailed description of the same component is omitted.

[0071] As illustrated in Fig. 6, the upper surface cylindrical section 33a includes a curved section 331 that is more extended outwardly in the radial direction at an upper position of the radially inner surface in the axial direction. In the air blower A1, the impeller 20 is mounted on the end of the shaft 11. Thus, in the shaft 11, rotational deflection may occur at the time rotation. The radially inner surface of the upper surface cylindrical section 33a has a radial distance from the shaft 11 or the boss section 212, the radial distance being larger at an upper position in the axial direction. In the embodiment, the radially inner surface of the upper surface cylindrical section 33a is the curved section 331. Therefore, even when rotational deflection occurs in the shaft 11, the labyrinth seal structure is achieved between the radially outer surface 2120 of the boss section 212 and the radially inner surface of the upper surface cylindrical section 33a. It is to be noted that the same effect is achieved even when the upper surface cylindrical section 33a is opposed to the shaft 11 in the radial direction.

[0072] A modification of the air blower in the embodiment will be described with reference to the drawings. Fig. 7 is a cross-sectional view with an enlarged upper surface cylindrical section in the modification of the air blower. In an air blower A2 illustrated in Fig. 7, the structure of an upper surface cylindrical section 33b is different from the structure of the air blower A. However, the configuration of other components is the same as the configuration of the air blower A. Thus, in the air blower A2, essentially the same component as that of the air blower A is labeled with the same symbol, and a detailed description of the same component is omitted.

[0073] The inner surface of the upper surface cylindrical section 33b of the air blower A2 is divided into a first inner surface section 332 and a second inner surface section 333 in the axial direction. In the area where the first inner surface section 332 is opposed to the boss section 212 in the radial direction, the radial gap between the first inner surface section 332 and the boss section 212 is constant in the axial direction. The second inner surface section 333 is more extended outwardly at an upper position in the axial direction. Specifically, over the entire area in the axial direction, the radially inner surface of the upper surface cylindrical section 33b includes the

first inner surface section 332 which has a uniform radial distance from the shaft 11 or the radially outer surface 2120 of the boss section 212, and the second inner surface section 333 which is connected to the axially upper end of the first inner surface section 332 and has a larger radial distance from the shaft 11 or the boss section 212 at an upper position in the axial direction.

[0074] Since the impeller 20 is mounted on the upper end of the shaft 11, the shaft 11 may be deflected by rotation of the impeller 20. The amount of deformation due to deflection of the shaft 11 is larger on the front end side, in other words, is larger at an upper position than a lower position in the axial direction. The second inner surface section 333 has a curved surface shape which is more extended outwardly in the radial direction at an upper position in the axial direction. Thus, even when the shaft 11 is deflected, in the area where the boss section 212 and the upper surface cylindrical section 33b are opposed to each other in the radial direction, it is possible to maintain a sufficient radial gap between the boss section 212 and the upper surface cylindrical section 33b as well as to achieve the labyrinth seal structure. Also, when the upper surface cylindrical section 33b is opposed to the shaft 11 in the radial direction, it is possible to maintain a sufficient radial gap between the shaft 11 and the upper surface cylindrical section 33b as well as to achieve the labyrinth seal structure.

[0075] In the first inner surface section 332 which has a smaller amount of deformation of the shaft than in an upper side, the radial gap between the boss section 212 and the first inner surface section 332 is constant in the axial direction. Thus, even when the shaft 11 is deflected, it is possible to maintain a sufficient radial gap between the first inner surface section 332 and the boss section 212 as well as to achieve the labyrinth seal structure. In this manner, the sealing effect due to the labyrinth seal structure can be increased. Thus, in the air blower A2, mixture of foreign particles into the upper bearing Br1 can be reduced, and it is possible to maintain a sufficient radial gap between the boss section 212 or the shaft 11 and the upper surface cylindrical section 33b as well as to achieve the labyrinth seal structure. Consequently, the motor 10 can be driven for a long time in a stable manner.

[0076] Another example of the air blower according to the present disclosure will be described with reference to the drawings. Fig. 8 is a cross-sectional view of an impeller with enlarged upper surface cylindrical section and boss section in another example of the air blower according to the present disclosure. An air blower B illustrated in Fig. 8 includes a bearing retainer 35 that retains the upper bearing Br1 and the lower bearing Br2 in the motor housing 30. The components other than these have the same configuration as that of the air blower A. Thus, in the air blower B, essentially the same component as that of the air blower A is labeled with the same symbol, and a detailed description of the same component is omitted.

[0077] As illustrated in Fig. 8, the air blower B includes

the bearing retainer 35 which is fixed to the center of the motor housing 30 in the radial direction. The bearing retainer 35 has a tube shape. The bearing retainer 35 has the center overlapped with the central axis Ax. As illustrated in Fig. 8, the bearing includes the upper bearing Br1 and the lower bearing Br2. The lower bearing Br2 is disposed under the upper bearing Br1 in the axial direction. The radial inner surface of the bearing retainer 35 retains the radial inner surface of the upper bearing Br1 and the lower bearing Br2. That is, the motor housing 30 includes the cylindrical bearing retainer 35 which extends along the central axis Ax. The radial inner surface of the bearing retainer 35 retains the radial outer surface of the bearings Br1 and Br2. The upper surface cylindrical section 36 is connected to the bearing retainer 35. The bearing retainer 35 includes a top plate section through hole 350 in an inner surface in the radial direction. An inner surface projection section 351 is formed from the inner surface of the top plate section through hole 350 toward the inner side in the radial direction. It is to be noted that the radially inner surface of the bearing retainer 35 may retain only one of the radially outer surfaces of the bearing Br1 and the bearing Br2. Also in this case, it is possible to reduce intrusion of foreign particles such as dust, dirt into the bearing Br1.

[0078] The bearing retainer 35 includes the upper surface cylindrical section 36. The upper surface cylindrical section 36 extends axially upward from the axially upper surface of the inner surface projection section 351. The axially lower surface of the inner surface projection section 351 is in contact with the axially upper surface of the upper bearing Br1. The bearing retainer 35 is a member smaller than the motor housing upper surface 31, and can be manufactured with high accuracy and less cost. Since the bearing retainer 35 includes the upper surface cylindrical section 36, it is possible to increase dimensional accuracy of the gap between a radially inner surface 360 of the upper surface cylindrical section 36 and the radially outer surface 2120 of the boss section 212. Consequently, it is possible to reduce intrusion of foreign particles such as dust, dirt while maintaining the rotation of the impeller 20.

[0079] In other words, the rotational accuracy of the shaft 11 can be increased by forming the bearing retainer 35 with high accuracy. In addition, it is possible to increase the accuracy of positioning of the upper surface cylindrical section 36 with respect to the boss section 212, and the effect of reducing intrusion of foreign particles such as dust, dirt into the upper bearing Br1.

[0080] The characteristics other than this are the same as in the first embodiment.

[0081] Another example of the air blower according to the present disclosure will be described with reference to the drawings. Fig. 9 is a cross-sectional view of an impeller with enlarged upper surface cylindrical section and boss section in another example of the air blower according to the present disclosure. An air blower C illustrated in Fig. 9 includes a lower surface projection sec-

tion 23 on the lower surface of the impeller base 21. The components other than this have the same configuration as that of the air blower A in the first embodiment. Thus, in the air blower C, essentially the same component as that of the air blower A is labeled with the same symbol, and a detailed description of the same component is omitted.

[0082] As illustrated in Fig. 9, the lower surface projection section 23 extends from the lower surface of the impeller base 21 downward in the axial direction. The lower surface projection section 23 is formed integrally with the impeller base 21. However, without being limited to this, after the lower surface projection section 23 is manufactured separately from the impeller base 21, the lower surface projection section 23 may be fixed to the lower surface of the impeller base 21. The lower surface projection section 23 has a cylinder body, and is disposed outwardly of the upper surface cylindrical section 33. The axially lower end of the lower surface projection section 23 is disposed under the axially upper end of the upper surface cylindrical section 33. Thus, part of the axially lower portion of a radially inner surface 230 of the lower surface projection section 23 is opposed to part of the axially upper portion of a radially outer surface 3301 of the upper surface cylindrical section 33 in the radial direction. In other words, the impeller base 21 includes the cylindrical lower surface projection section 23 that is disposed outwardly of the upper surface cylindrical section 33 in the radial direction, and extends downward in the axial direction.

[0083] The lower surface projection section 23 formed in the lower surface of the impeller 20 serving as a rotational body is disposed with a gap from the radially outer surface 3301 of the upper surface cylindrical section 33. It is to be noted that in the area where the lower surface projection section 23 and the upper surface cylindrical section 33 are opposed to each other in the radial direction, the radial gap between the lower surface projection section 23 and the upper surface cylindrical section 33 is uniform in the axial direction. Thus, the lower surface projection section 23 and the upper surface cylindrical section 33 form a labyrinth seal structure. Due to the labyrinth seal structure, air flow is unlikely to occur in the gap between the radially inner surface 230 of the lower surface projection section 23 and the radially outer surface 3301 of the upper surface cylindrical section 33.

[0084] In the air blower C in the embodiment, the impeller 20 and the motor housing upper surface 31 have a labyrinth seal structure formed by the radially inner surface 230 of the lower surface projection section 23 and the radially outer surface 3301 of the upper surface cylindrical section 33. In addition, the air blower C has a labyrinth seal structure formed by the radially outer surface 2120 of the boss section 212 and the radially inner surface 330 of the upper surface cylindrical section 33. In other words, the impeller 20 and the motor housing upper surface 31 have a labyrinth seal structure with two stages of recess and projection because of the gap be-

tween the lower surface projection section 23 and the upper surface cylindrical section 33, and the gap between the boss section 212 and the upper surface cylindrical section 33. In this manner, the lower surface projection section 23 is disposed in the impeller 20, and the labyrinth seal structure with two stages of recess and projection is provided, thereby increasing the effect of reducing intrusion of foreign particles into the upper bearing Br1. That is, the number of stages of recess and projection of the labyrinth seal structure is increased to enhance the sealing performance, and intrusion of foreign particles such as dust, dirt into the upper bearing Br1 can be further reduced. Consequently, the motor 10 can be driven for a long time in a stable manner.

[0085] In addition, the rigidity of the impeller base 21 can be increased by providing the lower surface projection section 23 in a cylindrical shape, which extends from the lower surface of the impeller base 21 downward in the axial direction. Consequently, it is possible to increase the rotational accuracy of the impeller 20 and to increase the blowing efficiency of the air blower C.

[0086] It is to be noted that although the air blower C in the embodiment has a labyrinth seal structure with two stages of recess and projection, the labyrinth seal structure is not limited to this. For instance, the motor housing upper surface 31 may include multiple upper surface cylindrical sections 33, and the lower surface of the impeller base 21 may include multiple lower surface projection sections 23, and thus a labyrinth seal structure with more than two stages of recess and projection may be formed.

[0087] A modification of the air blower in the embodiment will be described with reference to the drawings. Fig. 10 is a cross-sectional view of an impeller with enlarged upper surface cylindrical section and boss section in another example of the air blower according to the present disclosure. As illustrated in Fig. 10, in an air blower C1, the radially inner surface of a lower surface projection section 23a is an inner curved surface section 231 that is more extended outwardly in the radial direction at a lower position in the axial direction. That is, the radially inner surface of the lower surface projection section 23a may be more extended outwardly in the radial direction at a lower position in the axial direction.

[0088] In the air blower C1, the shaft 11 may be deflected when rotating. Since the lower surface projection section 23a includes the inner curved surface section 231, even when the shaft 11 is deflected, it is possible to appropriately maintain the gap between the radially inner surface of the lower surface projection section 23a and the radially outer surface of the upper surface cylindrical section 33. Consequently, the motor 10 can be driven for a long time in a stable manner.

[0089] As illustrated in Fig. 10, the radially outer surface of the lower surface projection section 23a may be an outer curved surface section 232 that is more extended outwardly in the radial direction at an upper position in the axial direction. That is, the radially outer surface of the lower surface projection section 23a may be more

extended outwardly in the radial direction at an upper position in the axial direction.

[0090] With this configuration, the radial width of the portion, of the lower surface projection section 23a, connected to the impeller base 21 can be increased. Thus, the rigidity of the lower surface projection section 23a can be increased. Consequently, the motor 10 can be driven for a long time in a stable manner. In addition, the effect of increasing the rigidity of the impeller base 21 is improved by increasing the rigidity of the lower surface projection section 23a. Thus, the rotation efficiency of the motor 10 is also improved.

[0091] In the air blower C1 in the modification, the lower surface projection section 23a includes the inner curved surface section 231 and the outer curved surface section 232. However, without being limited to this, the lower surface projection section 23a may include one of the inner curved surface section 231 and the outer curved surface section 232.

[0092] The characteristics other than this are the same as in the first embodiment.

[0093] Still another example of the air blower according to the present disclosure will be described with reference to the drawings. Fig. 11 is a cross-sectional view of an impeller with enlarged upper surface cylindrical section and boss section in another example of the air blower according to the present disclosure. An air blower D illustrated in Fig. 11 includes a lower surface projection section 24 on the lower surface of the impeller base 21. The components other than this have the same configuration as that of the air blower A in the first embodiment. Thus, in the air blower D, essentially the same component as that of the air blower A is labeled with the same symbol, and a detailed description of the same component is omitted.

[0094] As illustrated in Fig. 11, the lower surface projection section 24 extends from the lower surface of the impeller base 21 downward in the axial direction. The lower surface projection section 24 is formed integrally with the impeller base 21. However, without being limited to this, after the lower surface projection section 24 is manufactured separately from the impeller base 21, the lower surface projection section 24 may be fixed to the lower surface of the impeller base 21.

[0095] The lower surface projection section 24 includes an inner surface section 240 and a lower surface section 241. The inner surface section 240 has a cylindrical shape, and part of the axially lower portion of the inner surface section 240 is opposed to part of the axially upper portion of the radially outer surface 3301 of the upper surface cylindrical section 33 in the radial direction. The lower surface section 241 is perpendicular to the central axis Ax and opposed to the motor housing upper surface 31 in the axial direction. The radially outer edge of the lower surface section 241 is connected to the lower surface of the impeller base 21. Specifically, the axially lower surface of the lower surface projection section 24 is connected to the lower surface of the impeller base

21, and extends in a direction perpendicular to the central axis. In the embodiment, the axially lower surface of the lower surface projection section 24 is the lower surface section 241.

[0096] The lower surface section 241 of the lower surface projection section 24 is disposed under the axially upper end of the upper surface cylindrical section 33. Thus part of the axially lower portion of the inner surface section 240 of the lower surface projection section 24 is opposed to part of the axially upper portion of the radially outer surface of the upper surface cylindrical section 33 in the radial direction.

[0097] The inner surface section 240 of the lower surface projection section 24 formed in the lower surface of the impeller 20 serving as a rotational body is disposed with a gap on the outside of the upper surface cylindrical section 33. It is to be noted that in the area where the inner surface section 240 and the upper surface cylindrical section 33 are opposed to each other in the radial direction, the radial gap between the inner surface section 240 and the upper surface cylindrical section 33 is uniform. Thus, the lower surface projection section 24 and the upper surface cylindrical section 33 form a labyrinth seal structure. Due to the labyrinth seal structure, air flow is unlikely to occur in the gap between the inner surface section 240 and the radially outer surface 3301 of the upper surface cylindrical section 33.

[0098] In the air blower D in the embodiment, the impeller 20 and the motor housing upper surface 31 have the labyrinth seal structure formed by the lower surface projection section 24 and the upper surface cylindrical section 33, and the labyrinth seal structure formed by the boss section 212 and the upper surface cylindrical section 33. In other words, in the impeller 20 and the motor housing upper surface 31, a labyrinth seal structure with two stages is formed by the radial gap between the lower surface projection section 24 and the radially outer surface 3301 of the upper surface cylindrical section 33, and the radial gap between the radially outer surface 2120 of the boss section 212 and the radially inner surface 330 of the upper surface cylindrical section 33. In this manner, the lower surface projection section 24 is disposed in the impeller 20, and a labyrinth seal structure with two stages is provided, thereby increasing the effect of reducing intrusion of foreign particles into the upper bearing Br1.

[0099] In addition, the rigidity of the impeller base 21 can be increased by providing the lower surface projection section 24 in a cylindrical shape, which extends from the lower surface of the impeller base 21 downward in the axial direction. Consequently, it is possible to increase the rotational accuracy of the impeller 20 and to increase the blowing efficiency of the air blower D. Consequently, the motor 10 can be driven for a long time in a stable manner.

[0100] The characteristics other than this are the same as in the first and third embodiments.

[0101] The present disclosure is applicable, for instance, to an air blower and a cleaner including the air

blower.

[0102] Features of the above-described preferred embodiments and the modifications thereof may be combined appropriately as long as no conflict arises.

[0103] While preferred embodiments of the present disclosure have been described above, it is to be understood that variations and modifications will be apparent to those skilled in the art without departing from the scope and spirit of the present disclosure. The scope of the present disclosure, therefore, is to be determined solely by the following claims.

Claims

1. An air blower comprising:

a motor (10) including a shaft (11) disposed along a central axis (Ax) extending vertically; an impeller (20) that is disposed over the motor and fixed to the shaft; and a motor housing (30) that is disposed outwardly of the motor in a radial direction, the motor including a bearing (Br1) that supports the shaft rotatably with respect to the motor housing, the impeller including:

an impeller base (21) that is more extended outwardly in the radial direction at a lower position in an axial direction; and a plurality of blades (22) disposed on an upper surface of the impeller base, the impeller base including:

a boss section (212) fixed to the shaft; and a lower surface recess on an outer side of the boss section in the radial direction, the lower surface recess being included in a lower surface of the impeller base and recessed upwardly in the axial direction,

the motor housing including:

a motor housing upper surface (31) that is disposed under the impeller base, and opposed to the lower surface of the impeller base in the axial direction; and an upper surface cylindrical section (33) in a cylindrical shape, the upper surface cylindrical section extending upward in the axial direction from an inner end of the motor housing upper surface in the radial direction,

wherein at least part of a radially inner surface

of the upper surface cylindrical section is opposed to a radially outer surface of the shaft or the boss section in the radial direction, and an upper end of the upper surface cylindrical section in the axial direction is disposed over a lower end of the impeller base in the axial direction and over an upper end of the bearing.

2. The air blower according to Claim 1, wherein the radially inner surface of the upper surface cylindrical section has a uniform radial distance from the radially outer surface of the shaft or the boss section over an entire area in the radial direction.

3. The air blower according to Claim 1, wherein the radially inner surface of the upper surface cylindrical section has a larger radial distance from the shaft or the boss section at an upper position in the axial direction.

4. The air blower according to Claim 1, wherein the radially inner surface of the upper surface cylindrical section includes:

a first inner surface section (332) that has a uniform radial distance from the radially outer surface of the shaft or the boss section over an entire area in the radial direction; and a second inner surface section (333) that is connected to an upper end of the first inner surface section in the axial direction, and has a larger radial distance from the shaft or the boss section at an upper position in the axial direction.

5. The air blower according to any one of Claims 1 to 4, wherein the impeller base includes a lower surface projection (24) in a cylindrical shape, the lower surface projection being disposed outwardly of the upper surface cylindrical section in the radial direction, and extending downward in the axial direction.

6. The air blower according to Claim 5, wherein a radially inner surface of the lower surface projection is more extended outwardly in the radial direction at a lower position in the axial direction.

7. The air blower according to Claim 5 or 6, wherein a radially outer surface of the lower surface projection is more extended outwardly in the radial direction at an upper position in the axial direction.

8. The air blower according to Claim 5, wherein an axially lower surface of the lower surface projection is connected to the lower surface of the impeller base and extends in a direction perpendicular to the central axis.

9. The air blower according to any one of Claims 1 to 8,

wherein the motor housing includes an inner surface projection (351) that extends inwardly in the radial direction from a radially inner surface of the motor housing, and

an upper surface of the bearing in the axial direction is in contact with a lower surface of the inner surface projection in the axial direction. 5

10. The air blower according to Claim 9, wherein the upper surface cylindrical section extends upwardly in the axial direction from the inner surface projection. 10

11. The air blower according to any one of Claims 1 to 10, wherein the upper surface of the bearing in the axial direction is disposed over the lower end of the impeller base in the axial direction. 15

12. The air blower according to any one of Claims 1 to 11, wherein the motor housing further includes a bearing retainer (35) in a cylindrical shape, which extends along the central axis, a radially inner surface of the bearing retainer retains a radially outer surface of the bearing, and the upper surface cylindrical section is connected to the bearing retainer. 20 25

13. The air blower according to Claim 12, wherein the bearing includes: 30
an upper bearing (Br1); and
a lower bearing (Br2) that is disposed under the upper bearing in the axial direction, and

the radially inner surface of the bearing retainer retains radially outer surfaces of the upper bearing and the lower bearing. 35

14. A cleaner comprising the air blower according to any one of Claims 1 to 13. 40

45

50

55

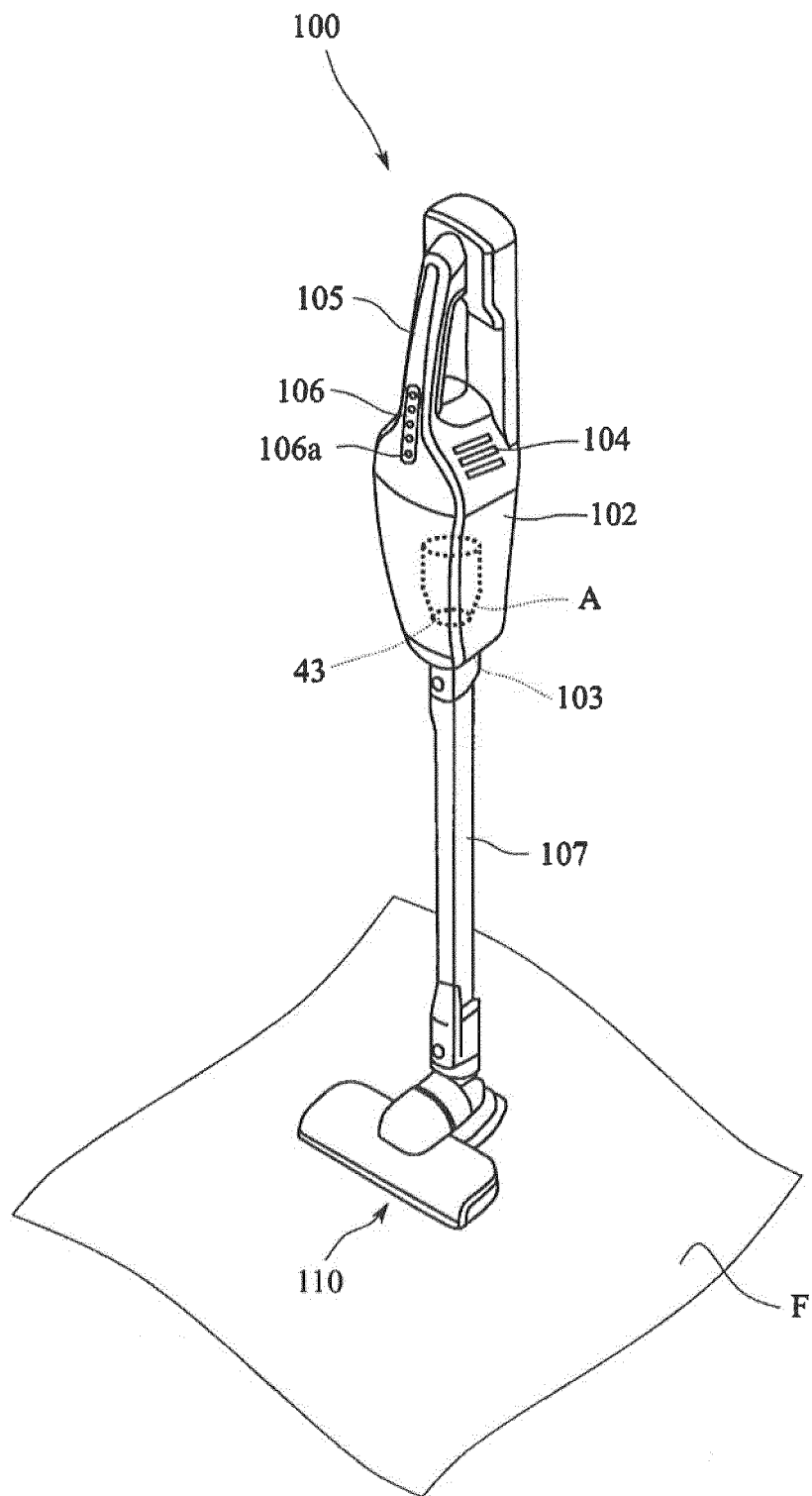


Fig. 1

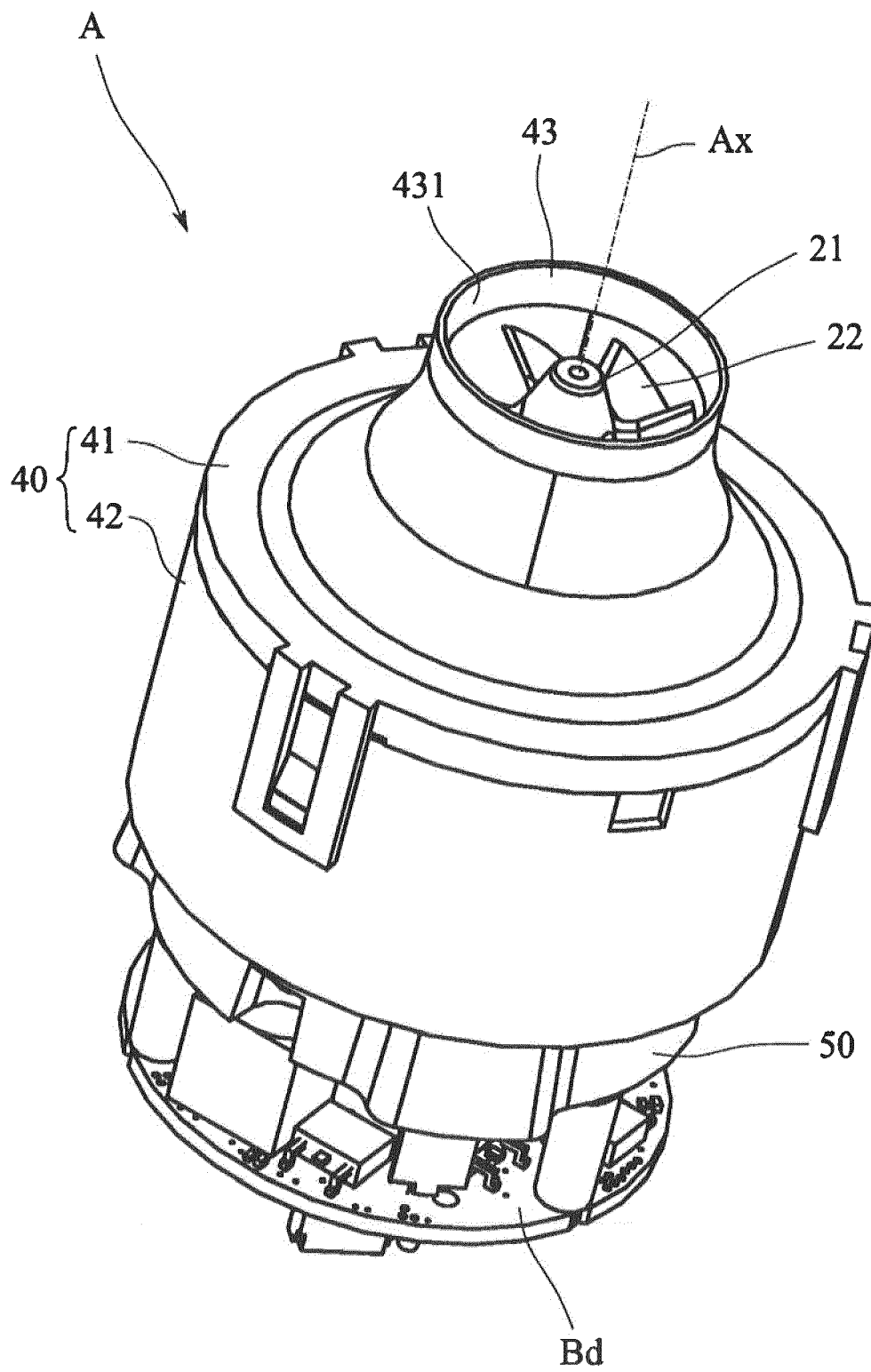


Fig. 2

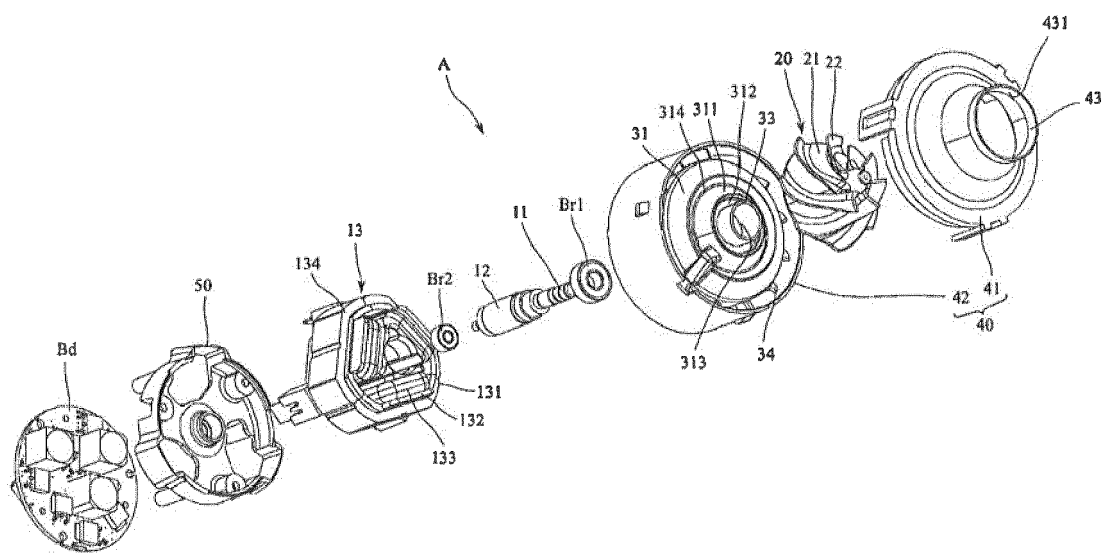


Fig. 3

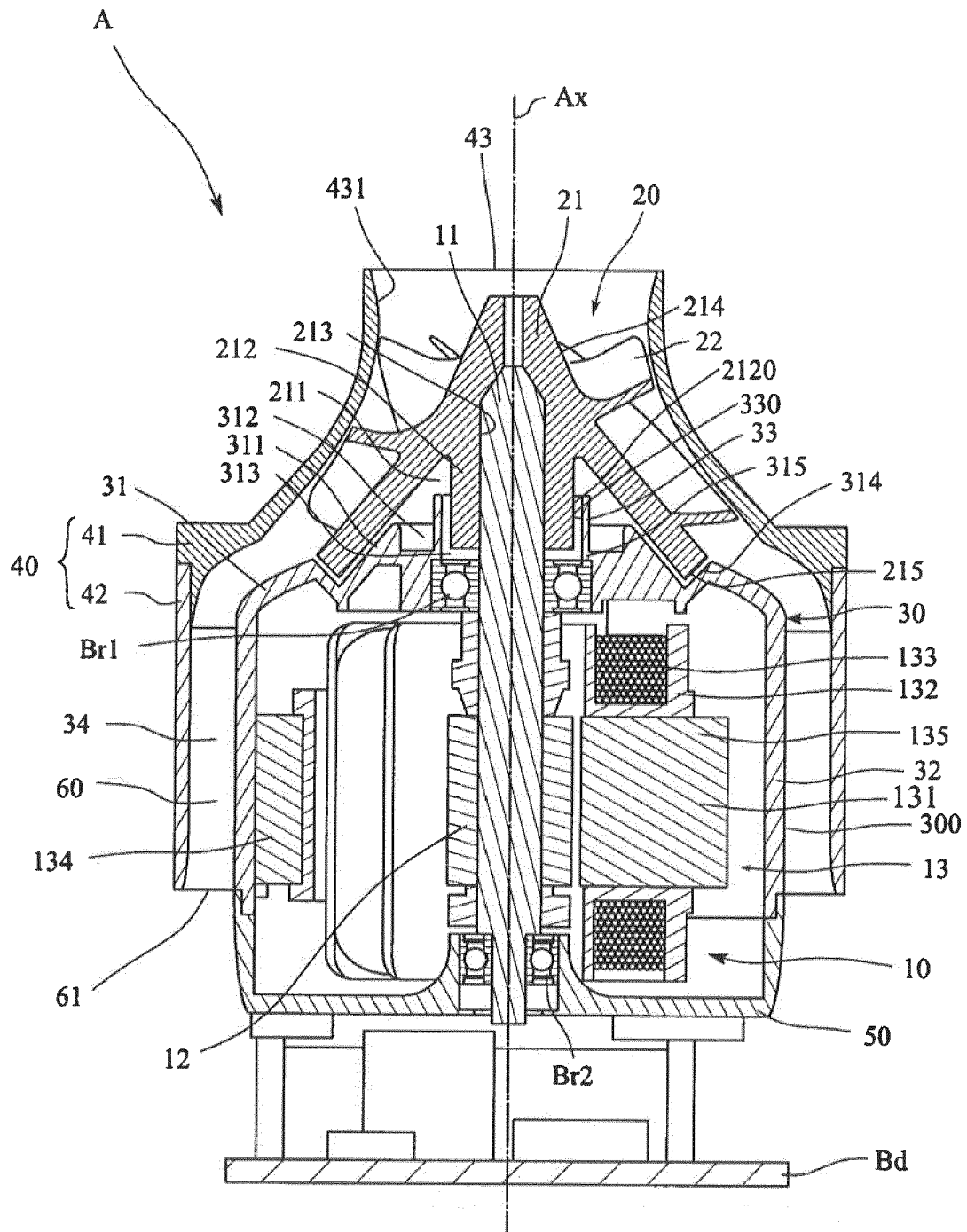


Fig. 4

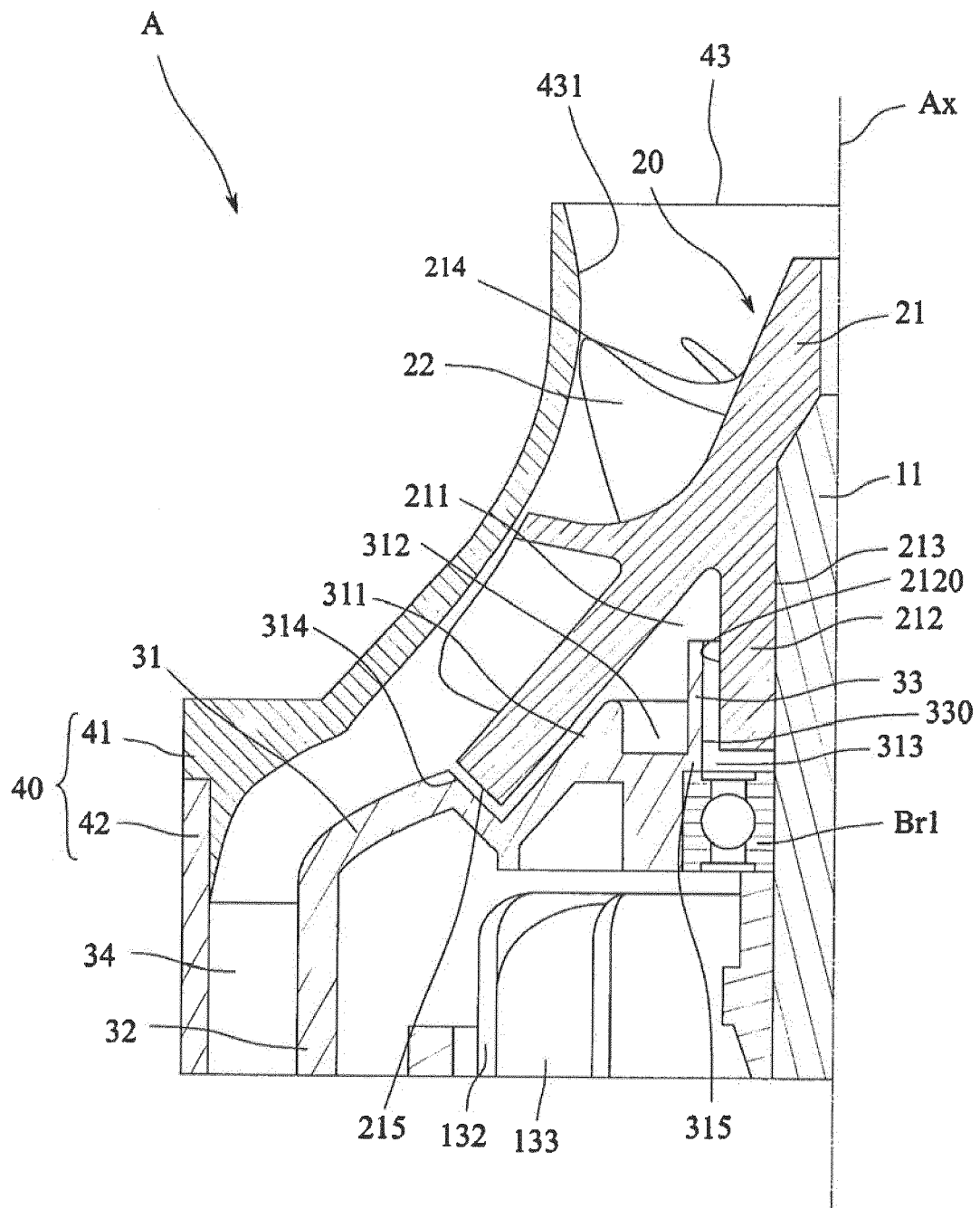


Fig. 5

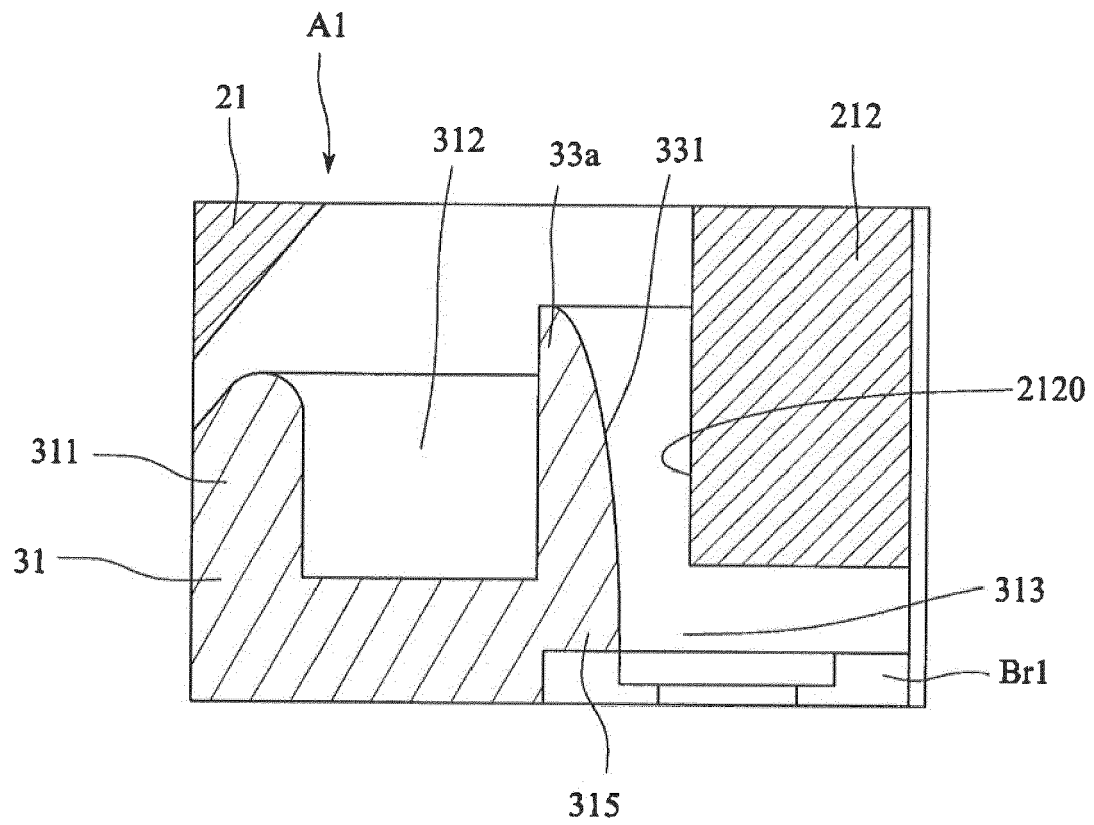


Fig. 6

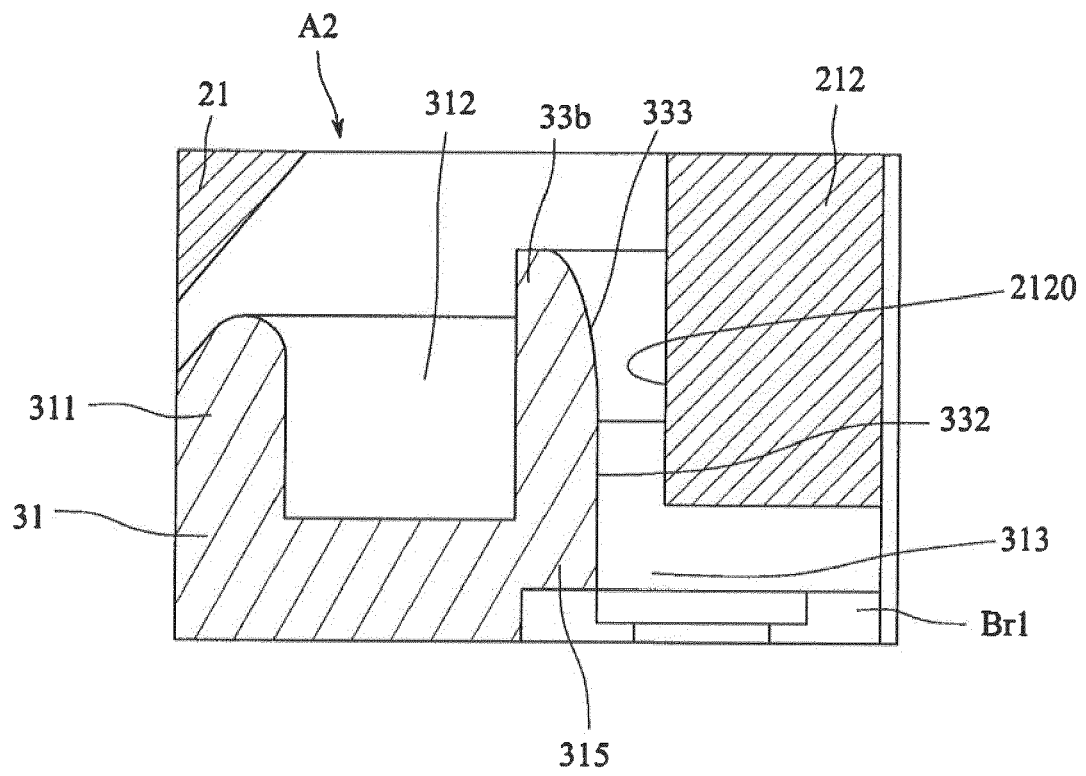


Fig. 7

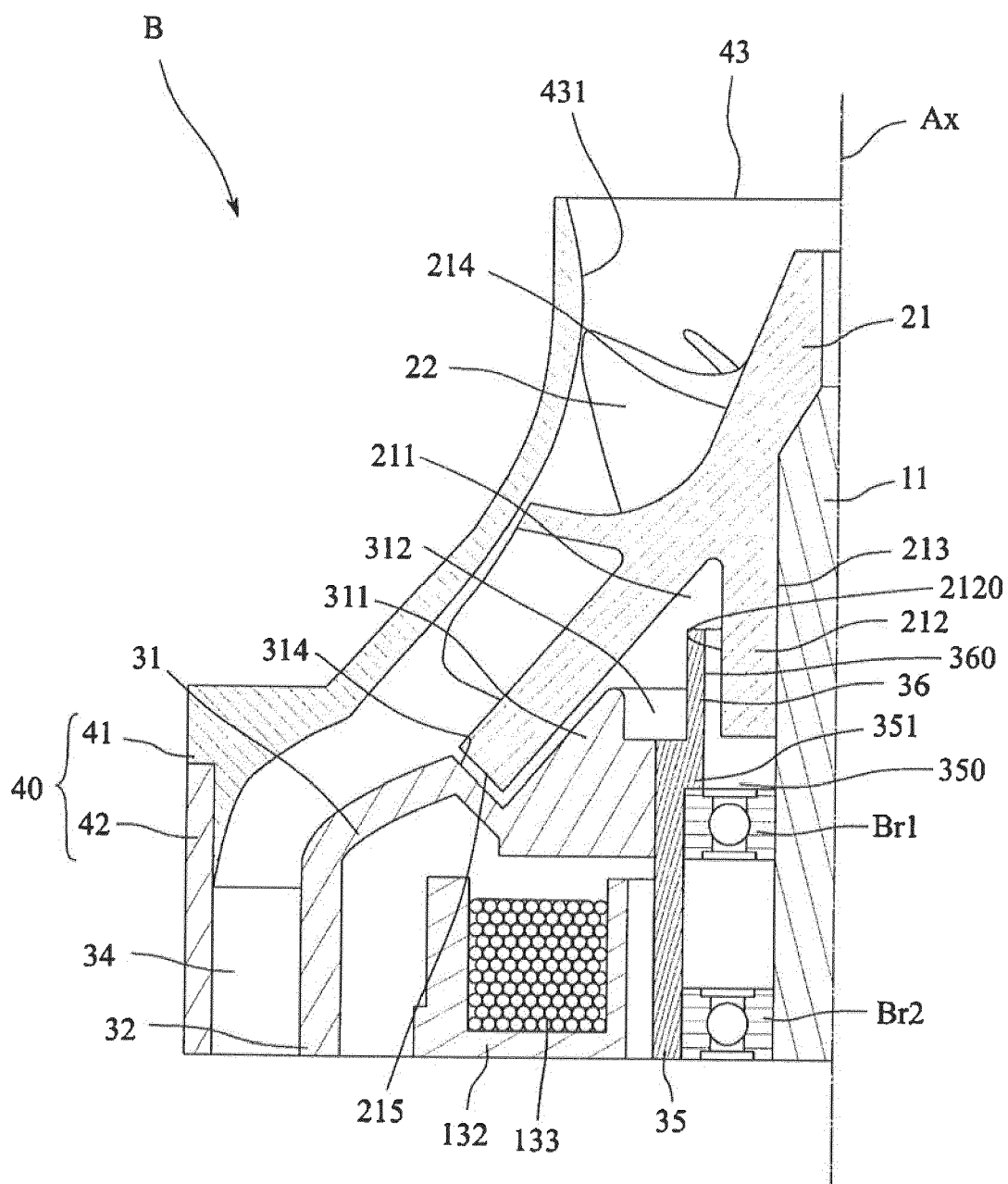


Fig. 8

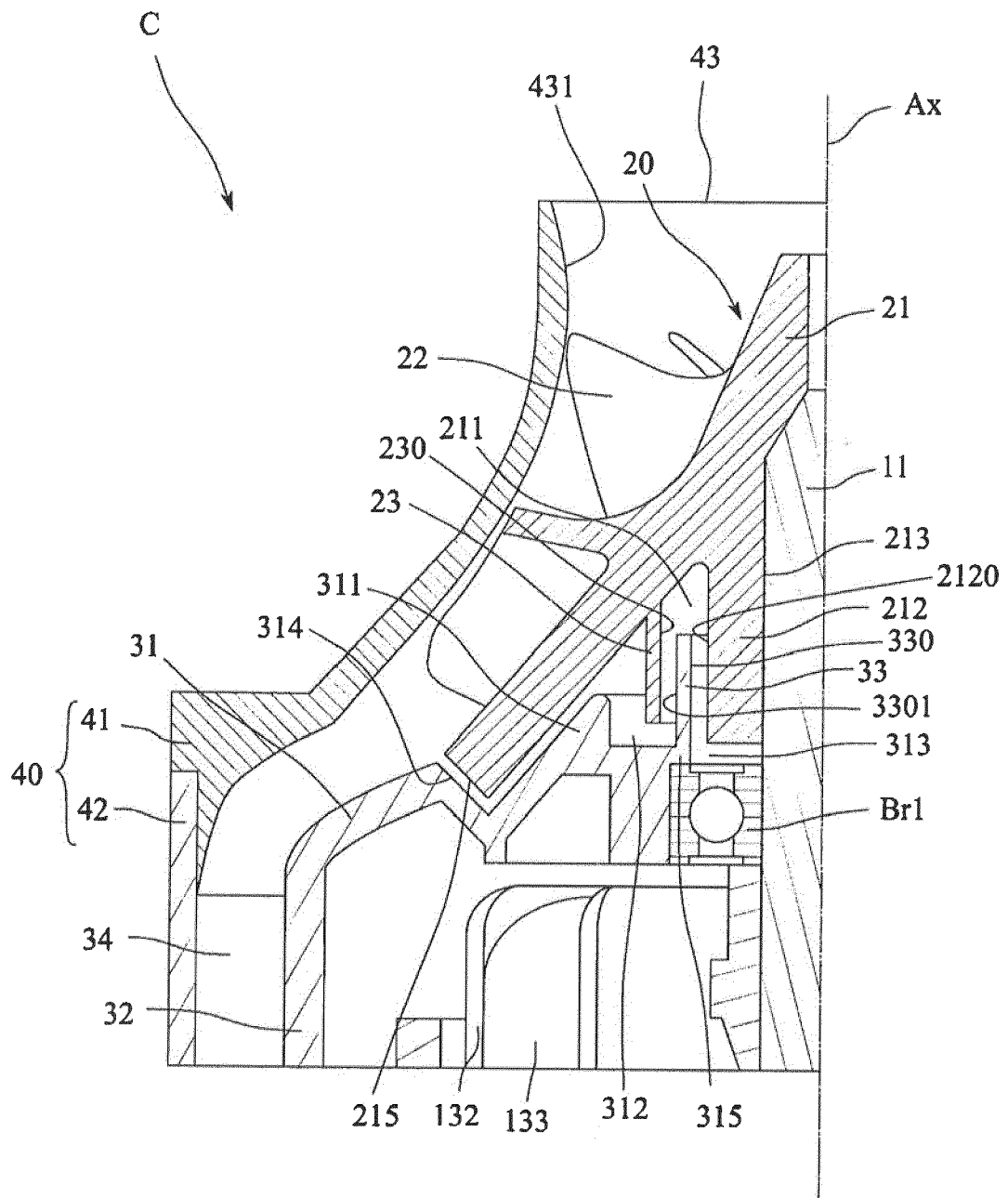


Fig. 9

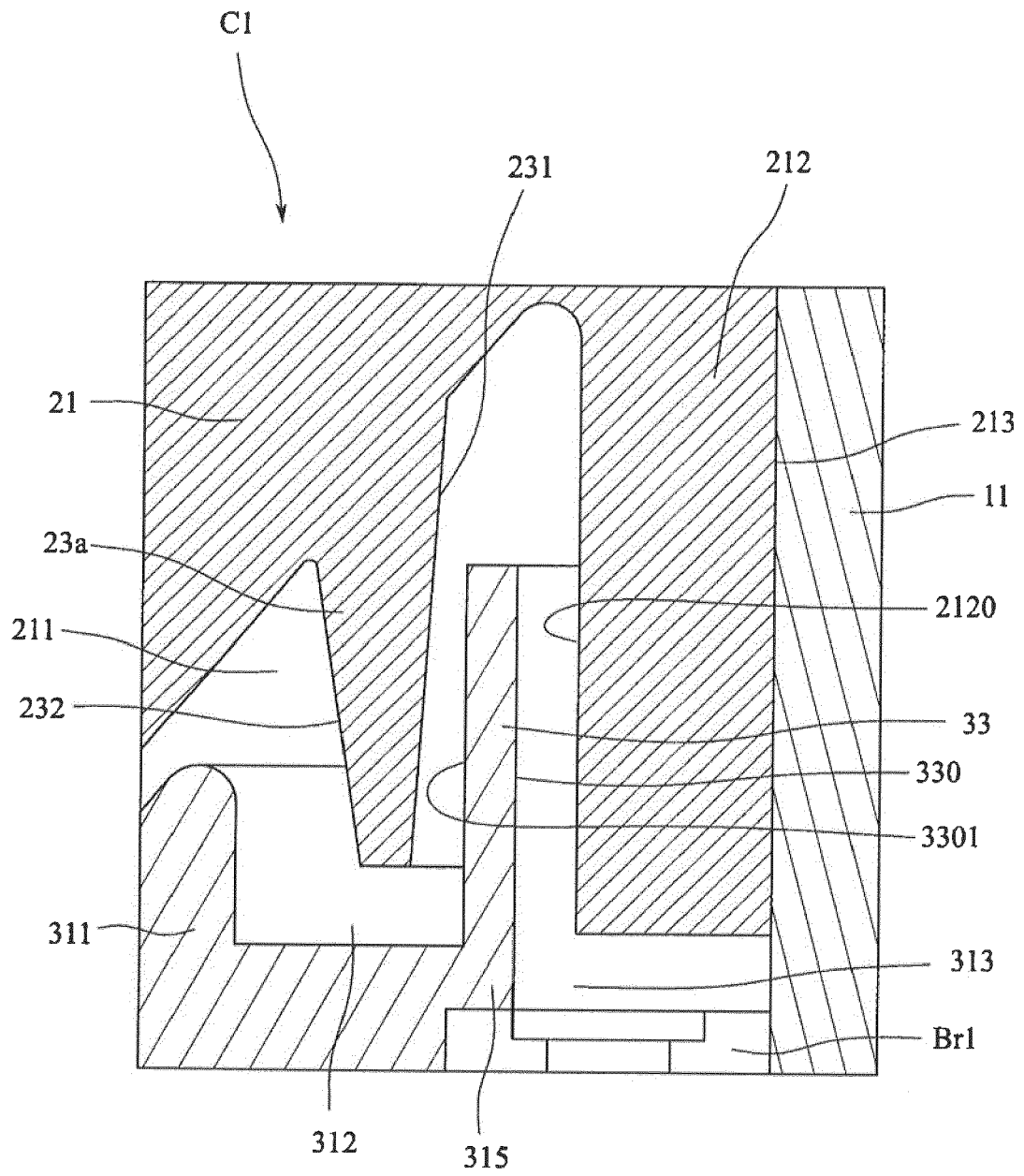


Fig. 10

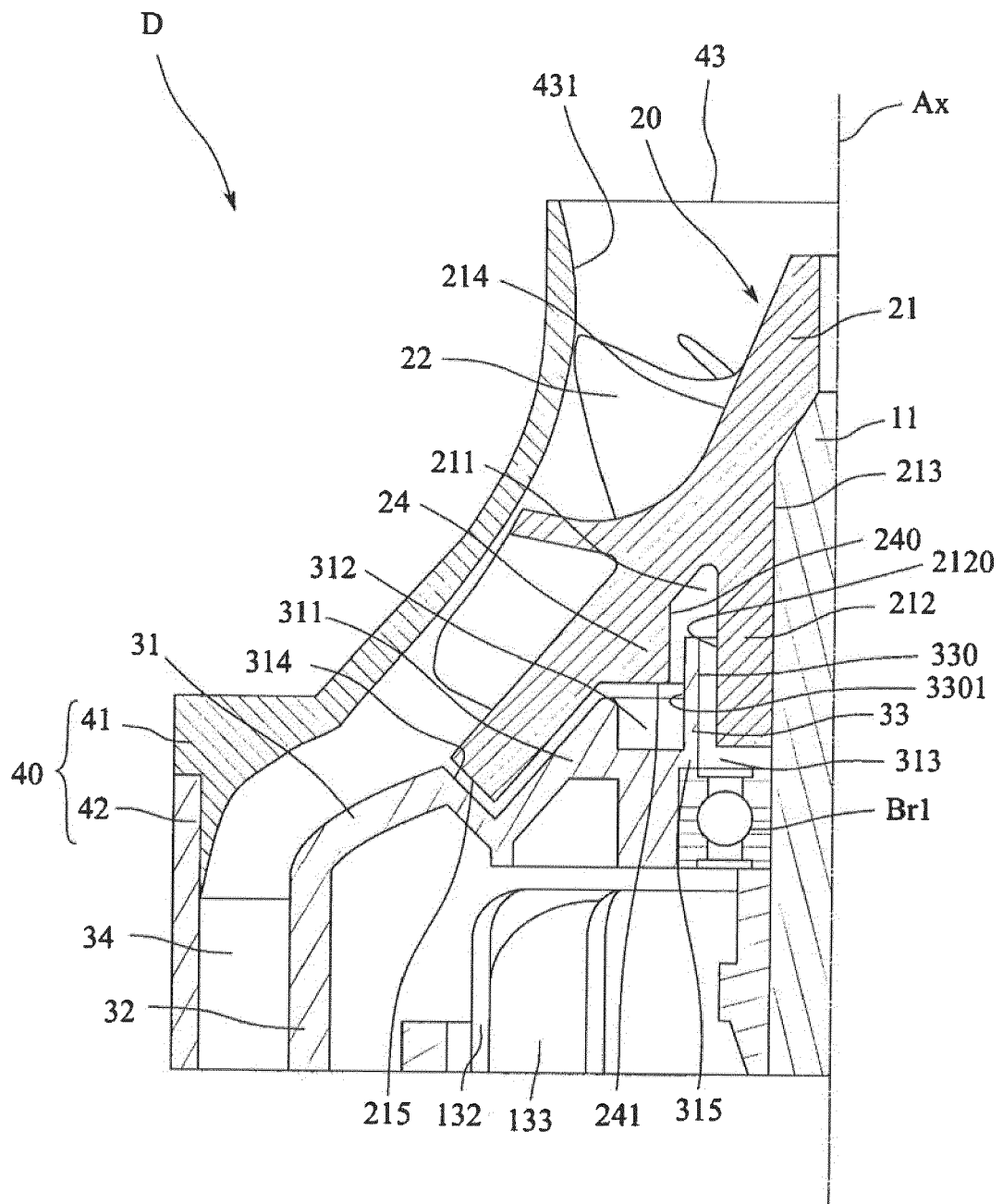


Fig. 11



EUROPEAN SEARCH REPORT

Application Number
EP 19 15 0210

5

10

15

20

25

30

35

40

45

50

55

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X A	US 2013/302156 A1 (NURZYNSKI MICHAL RAFAL [GB]) 14 November 2013 (2013-11-14) * figure 6 * -----	1,2,9-14 3-8	INV. F04D17/06 F04D25/06 F04D29/10 F04D29/28
			TECHNICAL FIELDS SEARCHED (IPC)
			F04D
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 14 May 2019	Examiner Ingelbrecht, Peter
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

 1
EPO FORM 1503 03.02 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 19 15 0210

5

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

14-05-2019

10

15

20

25

30

35

40

45

50

55

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2013302156 A1	14-11-2013	CN 102562652 A	11-07-2012
		CN 202326401 U	11-07-2012
		GB 2486019 A	06-06-2012
		JP 5592024 B2	17-09-2014
		JP 2014501873 A	23-01-2014
		TW M428255 U	01-05-2012
		US 2013302156 A1	14-11-2013
		WO 2012072996 A1	07-06-2012

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 11093892 A [0002] [0004]