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(54) **FAN ASSEMBLY**

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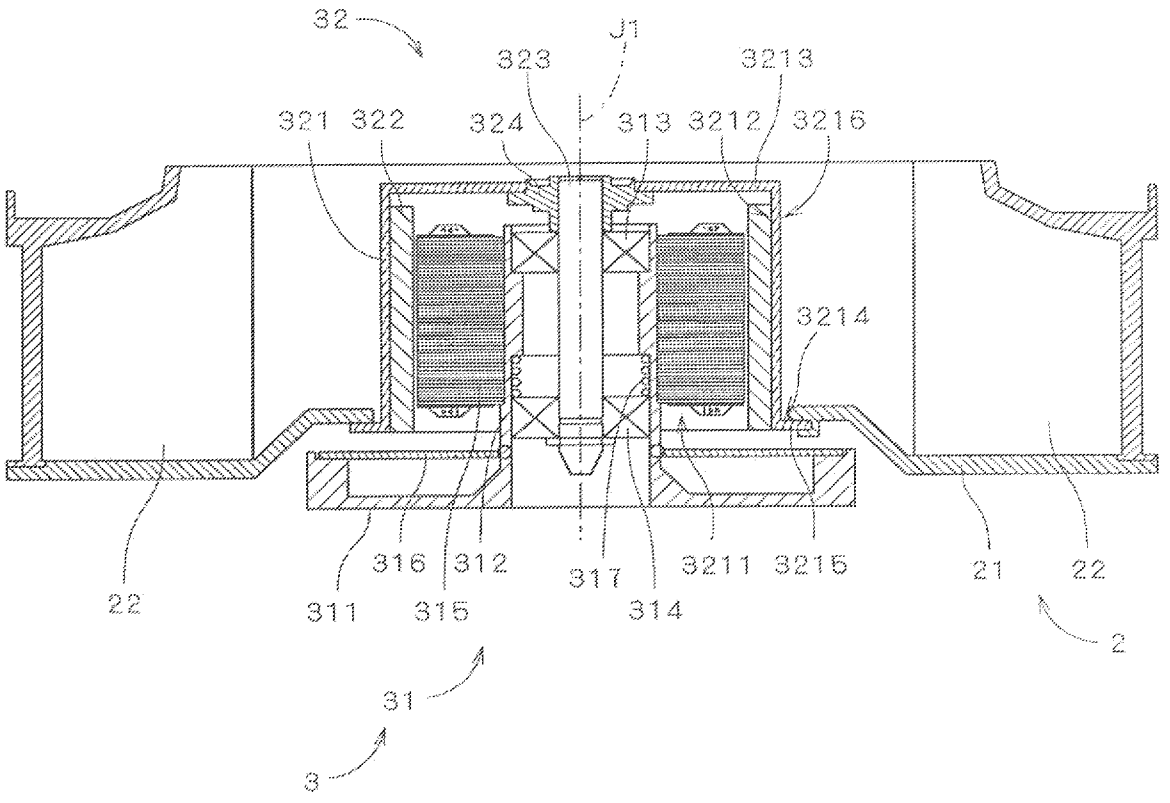
(57) **ABSTRACT**

A fan assembly includes an impeller portion generating an air flow and a motor that rotates the impeller portion about a center axis. The impeller portion is attached to a yoke of a rotor portion of the motor and is rotated with the yoke. A circular portion of the impeller is attached to a bottom opening of the yoke having a cylindrical shape whose top is covered by insert molding. Therefore, the impeller and the yoke may be securely fixed to each other. In addition, an outer side surface of the yoke is exposed to outside air such that the space arranged inward from the plurality of blades may be enlarged.



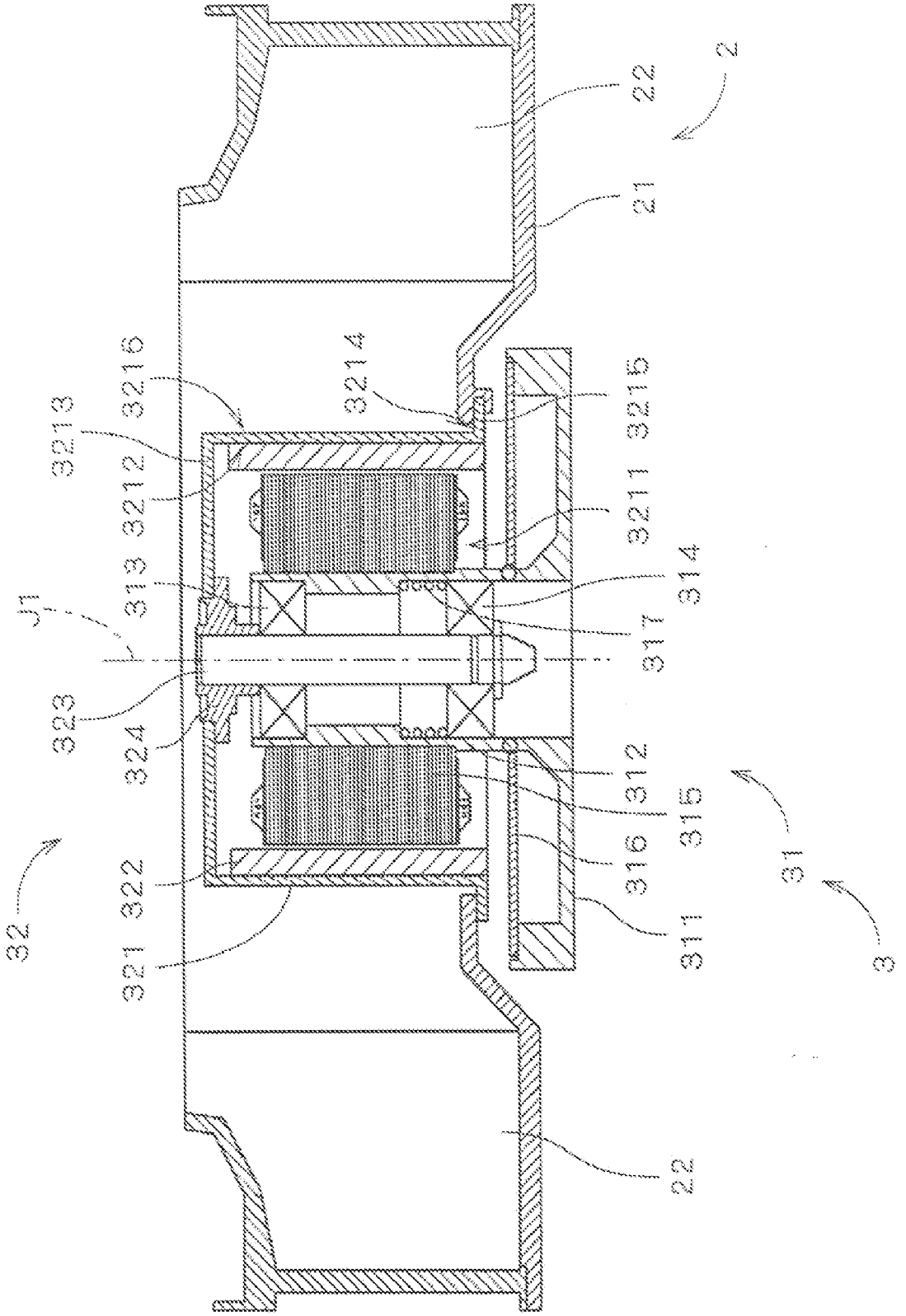

2
22
21
3216
3214
3215
3213
3212
3211
313
314
J1
317
323
324
312
316
315
322
321
32
31
311
3
22

FIG. 1

FIG. 2

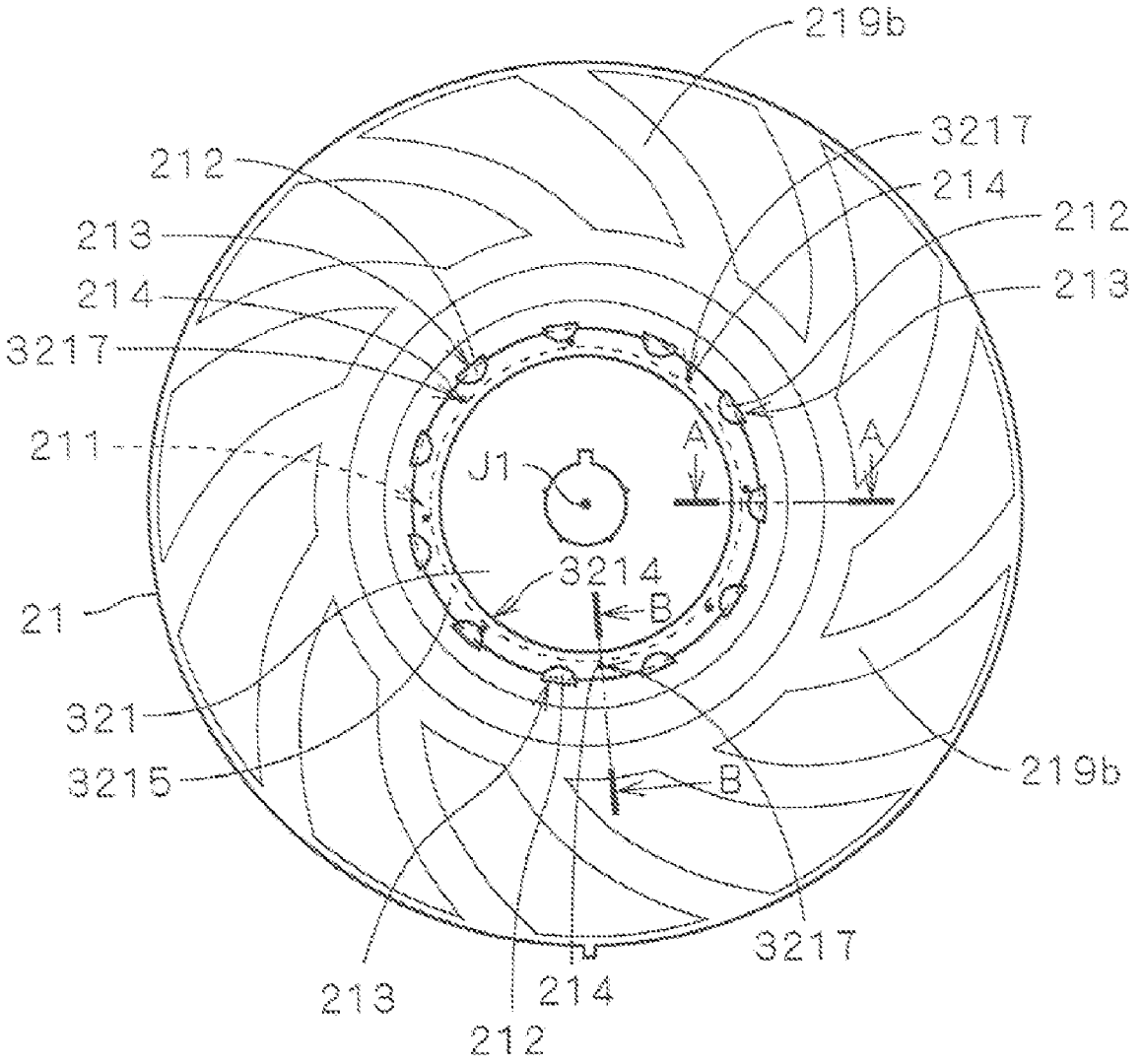

219b
3217
212
214
213
212
214
213
3217
211
J1
A
A
3214
B
21
321
3215
B
219b
3217
213
214
212

FIG. 3

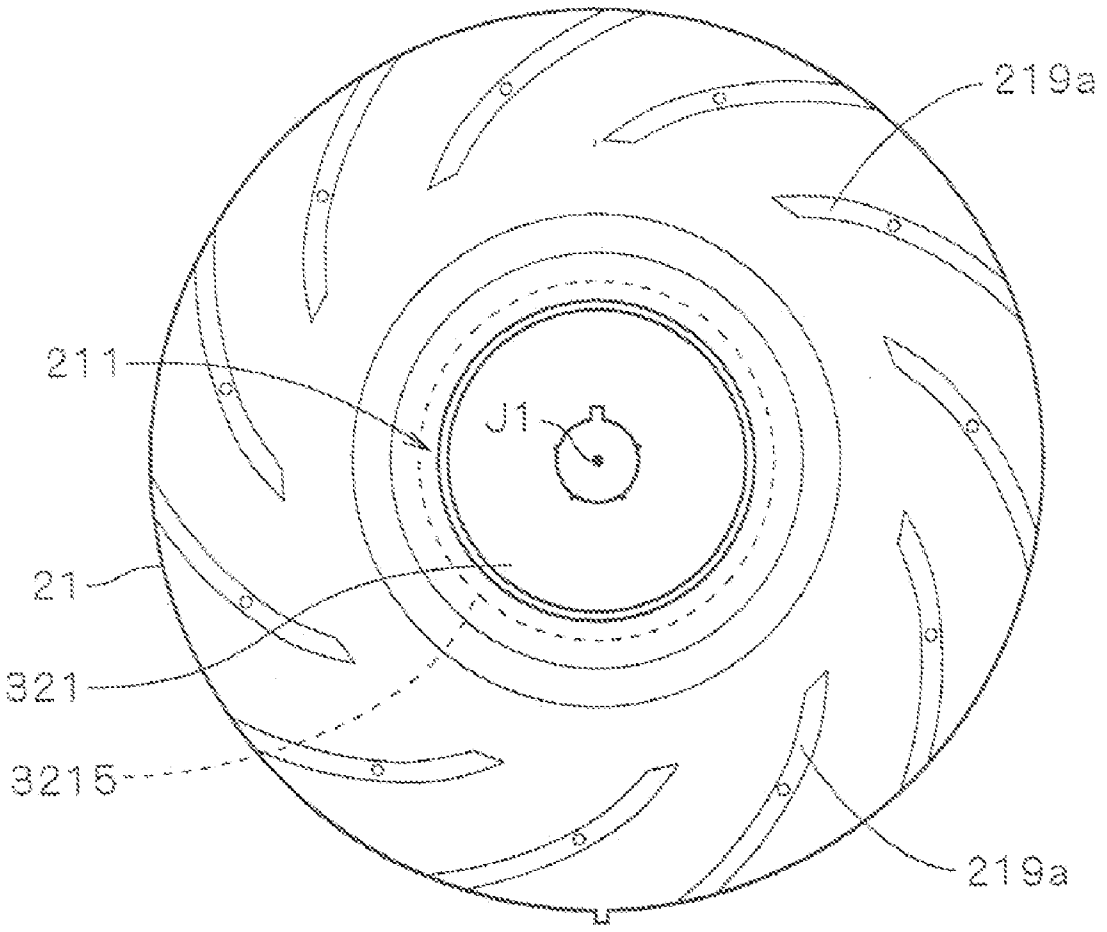


FIG. 4

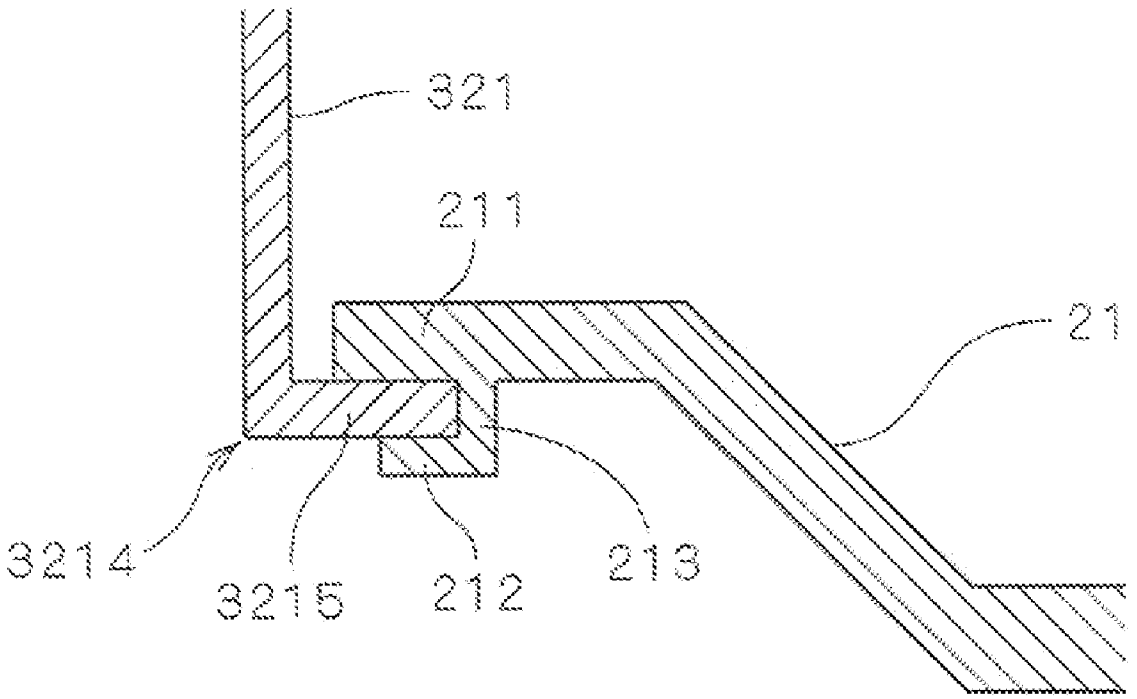


FIG. 5

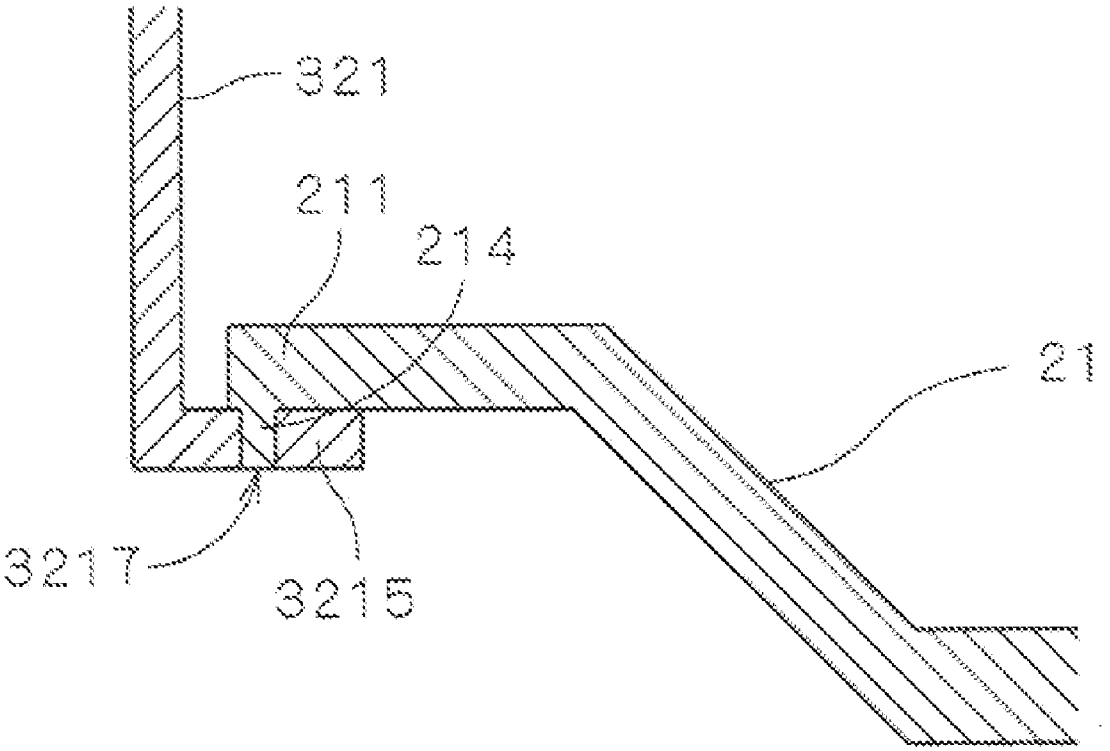


FIG. 6

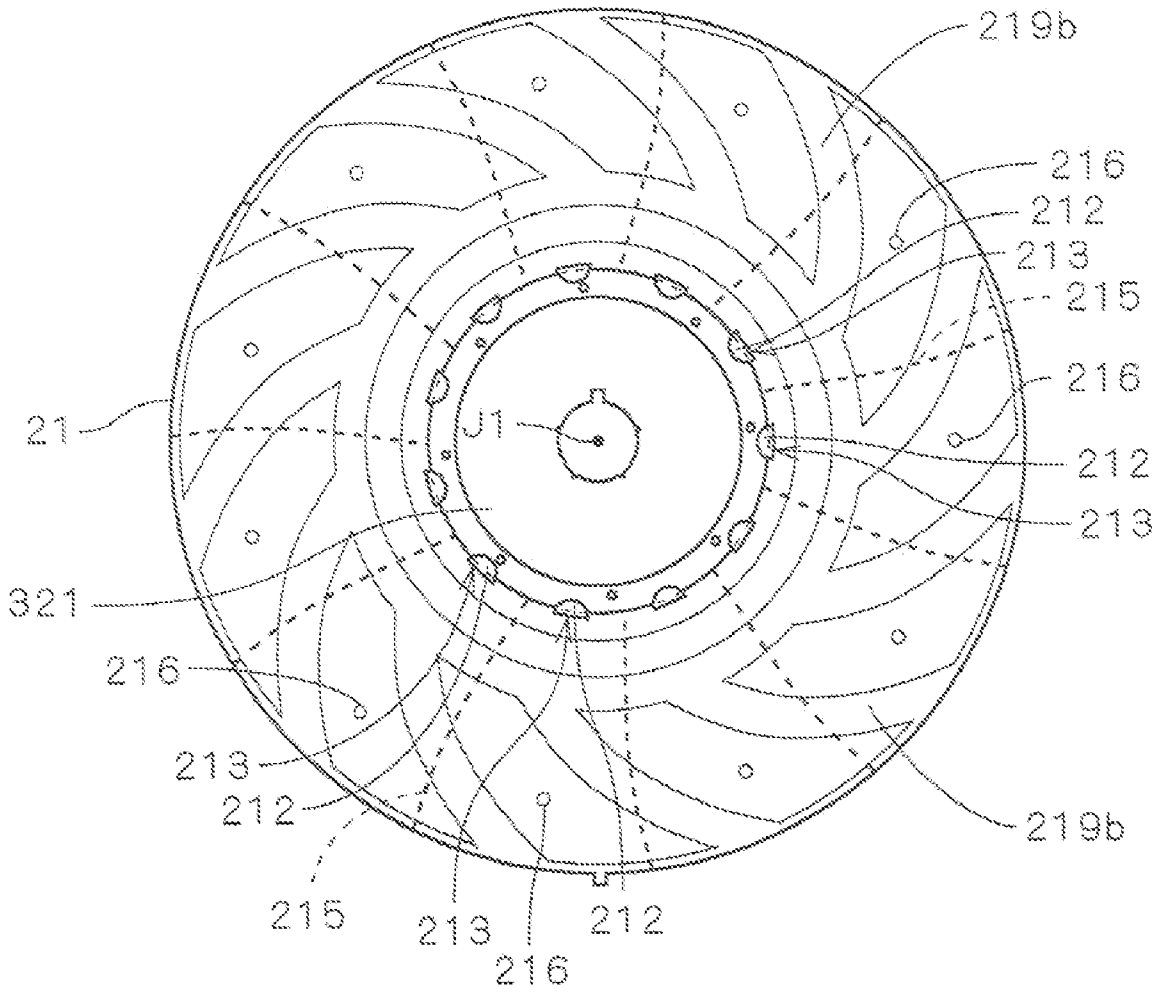

219b
216
212
213
215
216
212
213
219b
21
J1
321
216
213
212
215
213
212
216

FIG. 7

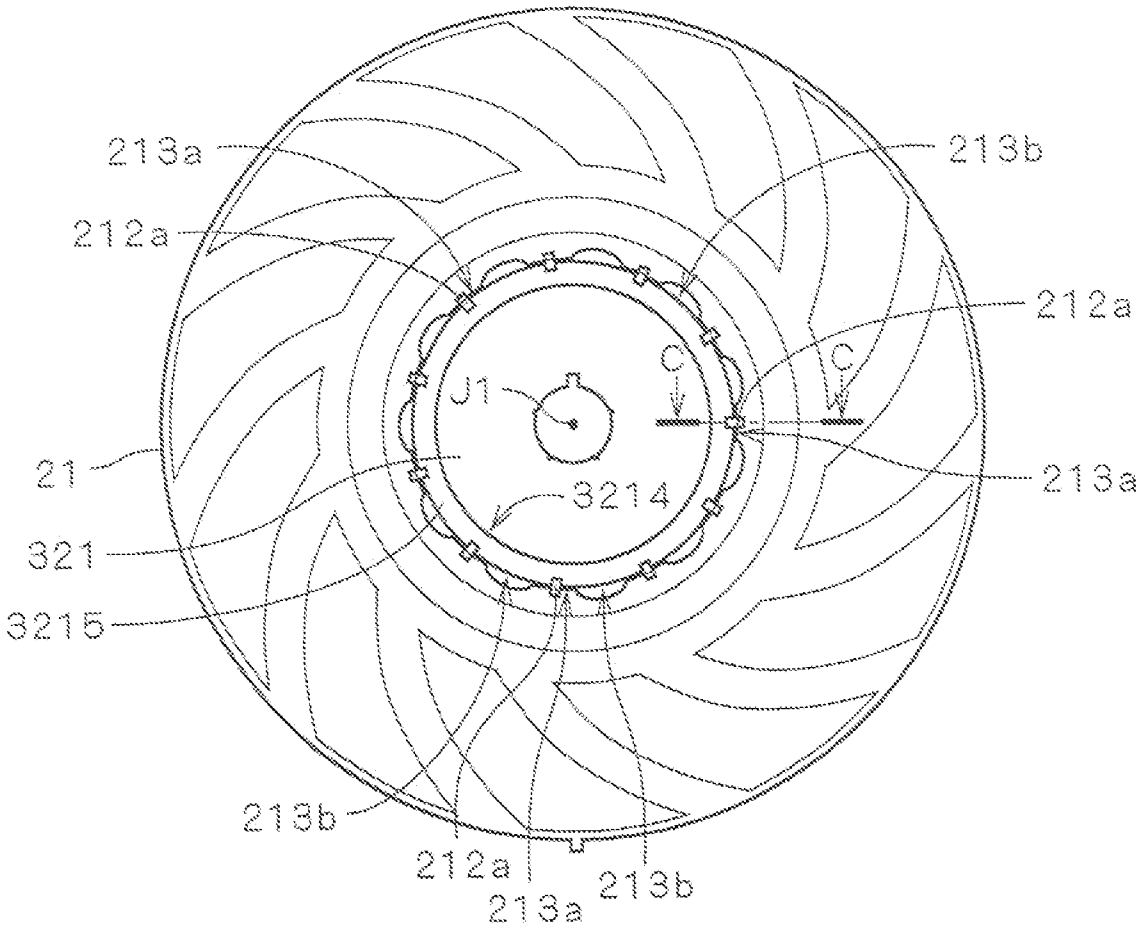

213a
213b
212a
212a
C
C
J1
21
213a
3214
321
3215
213b
212a
213b
213a

FIG. 8

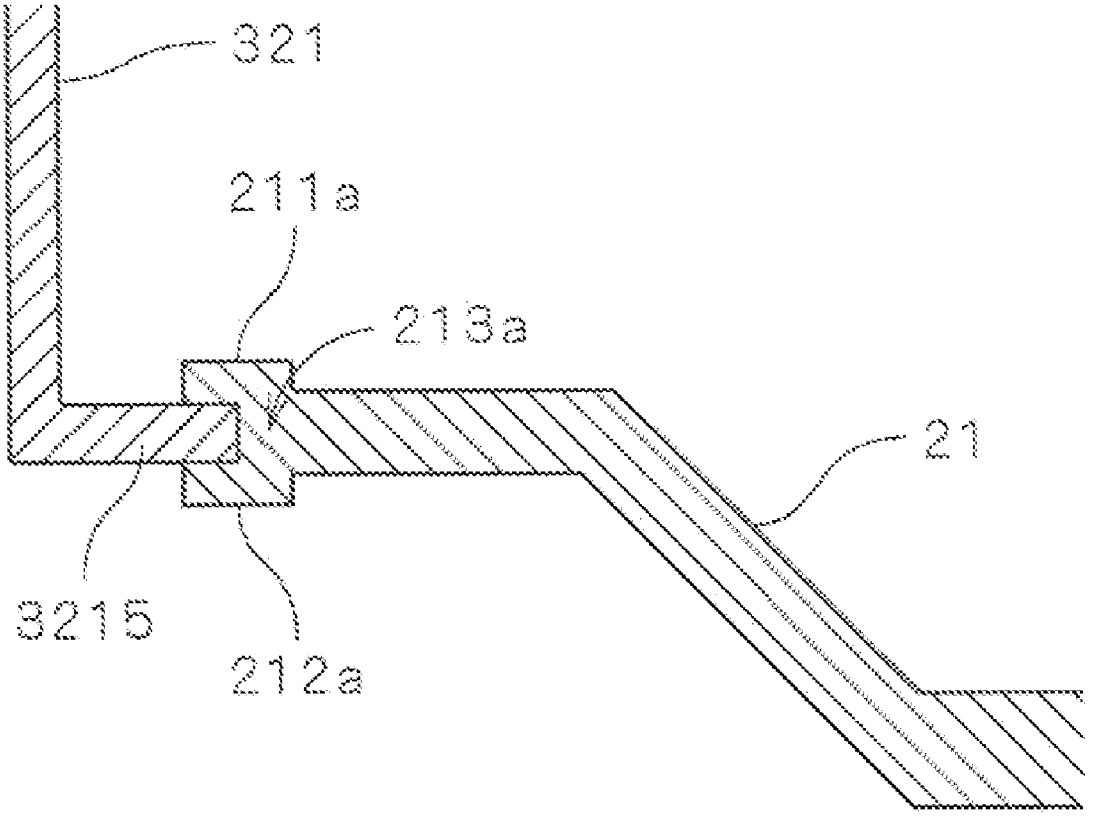


FIG. 9

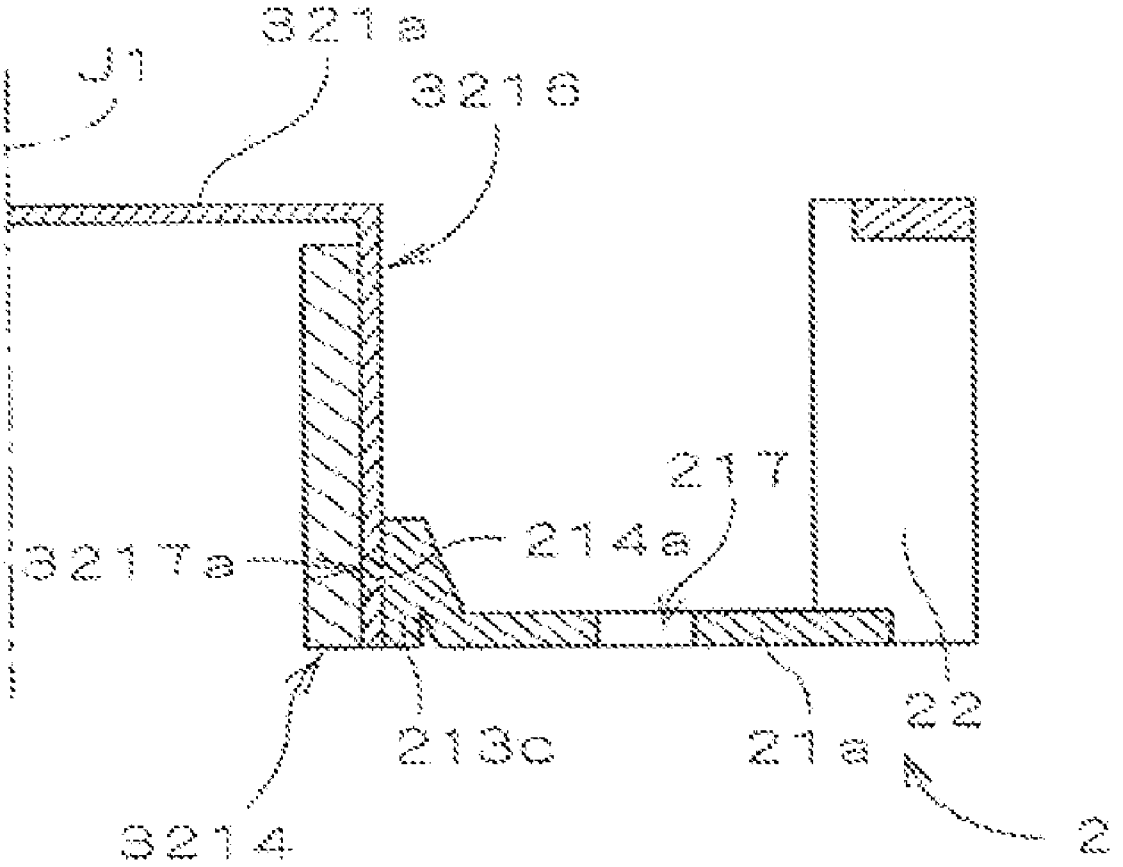


FIG. 10

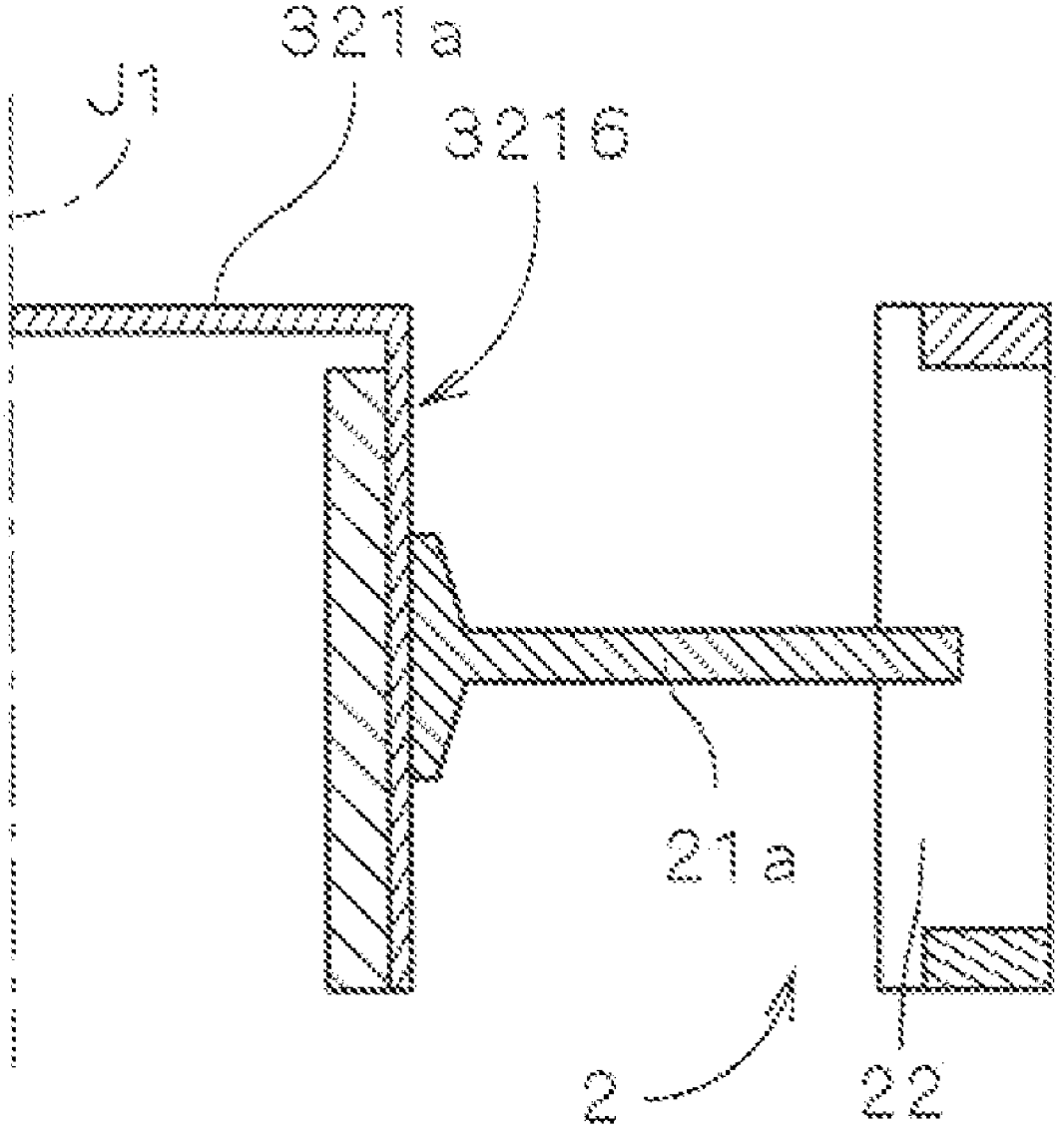
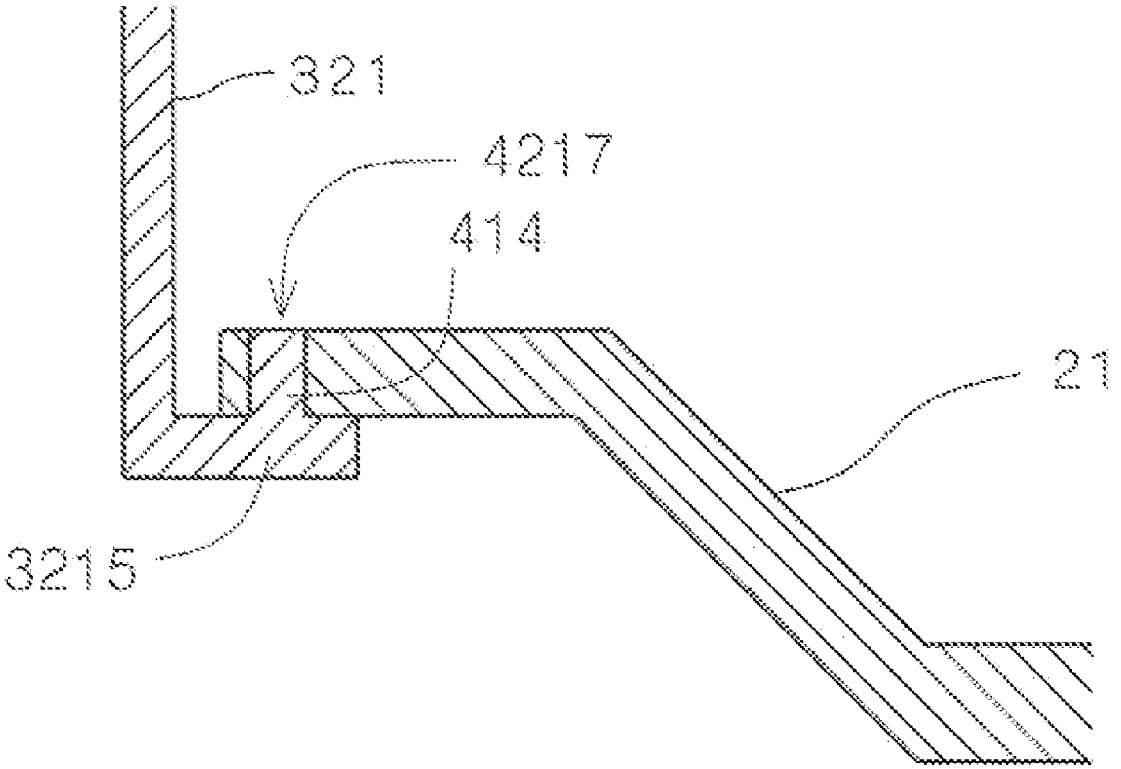


FIG. 11



FAN ASSEMBLY

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention generally relates to an electrically powered fan assembly used to blow air.

[0003] 2. Description of the Related Art

[0004] Conventionally, a centrifugal type fan assembly, taking air in an axial direction and exhausting the air in a radial direction, has the following configuration. Specifically, the conventional fan assembly includes an impeller having a plurality of blades arranged in a circumferential direction centered about a center axis, and a substantially cup-shaped portion arranged at the middle of the impeller into which a substantially cylindrical yoke made of magnetic material is press-fitted. In addition, a field magnet is attached to an inner side surface of the yoke. By virtue of this configuration, the impeller is rotatably supported around the center axis. The blades of the impeller are arranged on radially outer positions of the cup-shaped portion, and the cup-shaped portion and the blades are unitarily formed of synthetic resin, both of which are connected via a joint portion. By virtue of this configuration, a circular space is provided between the plurality of blades and the outer side surface of the cup-shaped portion.

[0005] In terms of a centrifugal fan assembly, it may be preferable to enlarge the space provided at an inner side of the plurality of blades (in other words, the space between radially inner end portions of the blades and the outer side surface of the cup-shaped portion, to which the yoke is press-fitted, is made wider). With the wider space, the fan assembly may take more air therein, which results in improved blower efficiency of the fan assembly. However, upon making a diameter of the yoke smaller to enlarge the space, a magnetic circuit will be decreased in size. As a result, the motor efficiency is degraded. Upon making a diameter of the circular space bigger while fixing an outer diameter of the impeller, a blade-area will be decreased in size, which results in degraded blower efficiency. Upon making a diameter of the circular space bigger while keeping the blade-area of the impeller constant, the impeller will be enlarged.

[0006] In order to enlarge the circular space without expanding the outer diameter of the impeller or degrading the blower efficiency, it is preferable to omit the cup shaped portion of the impeller covering the outer side surface of the yoke.

[0007] In publicly available examples, a portion of the outer side surface around the opening of the permanent-magnet rotor having a cylindrical shape whose top is covered, and an inner side surface of the cylindrical portion provided at a middle of the impeller are fixed by, for example, press-fitting, bonding, and crimp-fixing. In another publicly available example, a flange portion is provided around the outer side surface of the opening of the permanent-magnet rotor, and the flange portion is fixed to the base plate of the centrifugal fan by crimp-fixing.

[0008] However, in case that the permanent-magnet rotor and the cylindrical portion arranged at the middle portion of the impeller are press-fitted or bonded, an axial length of an affixing area at which the outer side surface of the permanent-magnet rotor is abutted against the impeller is short. Therefore, the impeller may not be fixed securely to the permanent-magnet rotor by press-fitting or bonding. For crimp-fixing, forming the engaging portion and crimping processes are required, which may deteriorate the work efficiency.

[0009] Furthermore, the cup shaped portion of the impeller, which is made of resin, may be broken or cracked by the stress generated upon press-fitting the permanent magnet rotator (i.e., the cylindrical yoke made of metallic material with the field magnet attached to the inner side surface thereof) into the cup-shaped portion. Especially in a large-size fan, it is highly probable that the impeller is damaged or cracked. On the other hand, if the press-fit pressure is reduced, the permanent-magnet rotor may not be securely fixed to the impeller. As a result, the permanent-magnet rotor may detach from the impeller.

[0010] In case that such a fan assembly is utilized in a low temperature environment, the impeller made of resin shrinks more than the yoke made of metallic material does, which results in breaking or cracking of the attaching portion of the impeller and the yoke.

SUMMARY OF THE INVENTION

[0011] In order to overcome the problems described above, preferred embodiments of the present invention provide an impeller portion securely fixed to the yoke while improving the blower efficiency of a fan assembly, and the breaking or the cracking of the impeller portion caused by thermal deformation is prevented.

[0012] According to one preferred embodiment of the present invention, a fan assembly includes a yoke having a cylindrical shape whose top is covered and an impeller portion attached to the outer surface or around the bottom opening of the yoke. The impeller portion and the yoke are fixed by insert molding, and the two members are securely fixed to each other while the outer side surface of the yoke is exposed. In the fan assembly mentioned above, an outer side surface of the yoke may be exposed to outside air of the fan assembly. As a result, the impeller portion and the yoke are securely fixed while improving the blower efficiency of the fan assembly.

[0013] A fan assembly according to another preferred embodiment of the present invention further includes a flange portion extending radially outwardly from the bottom opening of the yoke, and an impeller portion attached to the outer surface or a bottom portion around the opening of the yoke. In addition, a portion of the impeller portion may be formed concurrently with the insert molding for fixing the circular portion and the yoke. Upon forming the impeller portion, each of a plurality of weld lines passes between the two adjacent affixing portions. According to another preferred embodiment of the present invention, a plurality of gate marks are arranged on a portion of the discoid circular portion which is attached to the flange portion. By virtue of the configurations mentioned above, damages or cracks of the impeller portion caused by thermal deformation may be prevented.

[0014] It should be understood that in the explanation of the present invention, when positional relationships among

and orientations of the different components are described as being up/down or left/right, positional relationships and orientations that are in the drawings are indicated, however, positional relationships among and orientations of the components once having been assembled into an actual device are not indicated.

[0015] Other features, elements, processes, steps, characteristics and advantages of the present invention will become more apparent from the following detailed description of preferred embodiments of the present invention with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] FIG. **1** is a cross sectional view illustrating a configuration of a fan assembly according to a first preferred embodiment of the present invention.

[0017] FIG. **2** is a bottom plan view illustrating a yoke and a circular portion.

[0018] FIG. **3** is a plan view illustrating the yoke and the circular portion.

[0019] FIG. **4** is a partial sectional view illustrating a yoke and a circular portion.

[0020] FIG. **5** is a partial sectional view illustrating a yoke and a circular portion.

[0021] FIG. **6** is a bottom plan view illustrating a yoke and a circular portion.

[0022] FIG. **7** is a bottom plan view illustrating another example of the yoke and the circular portion.

[0023] FIG. **8** is a partial sectional view illustrating another example of the yoke and the circular portion according to another preferred embodiment of the present invention.

[0024] FIG. **9** is a cross sectional view illustrating a configuration of a fan assembly according to a second preferred embodiment of the present invention.

[0025] FIG. **10** is a partial sectional view illustrating another example of the yoke and the impeller portion.

[0026] FIG. **11** is a partial sectional view illustrating a yoke and a circular portion according to another preferred embodiment.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0027] FIG. **1** is a vertical sectional view of a fan assembly **1** along a plane including a center axis J**1**, illustrating a configuration of the centrifugal type fan assembly **1** according to a first preferred embodiment of the present invention. As shown in FIG. **1**, the fan assembly **1** includes an impeller portion **2** and a motor **3**. The impeller portion **2** is attached to the motor **3** and generates air flow by rotation thereof. The motor **3** rotates impeller **2** about a center axis J**1**. The fan assembly **1** is accommodated within a housing (not shown) which defines a passage of air flow. In other words, the housing controls the air flow generated by the rotation of the impeller and sends the air outside of the housing. The fan assembly **1** is, for example, used as an air cooling fan for an electronic device.

[0028] The motor **3** is an outer rotor type motor, including a stator portion **31** which is a stationary assembly and a rotor portion **32** which is a rotary assembly. The rotor portion **32** is supported rotatably on the stator portion **31** with the center axis J**1** as a center by a bearing mechanism **312** explained below. For convenience in the following explanation, the rotor portion **32** side along the center axis J**1** will be described as an upper side and the stator portion **31** side as a bottom end, but the center axis J**1** need not necessarily coincide with the direction of gravity.

[0029] The stator portion **31** includes a base portion **311** which retains the different parts of the stator portion **31**. The base portion **311** includes a bearing supporting portion having a substantially cylindrical shape centered on the center axis J**1**. The bearing supporting portion protrudes in the upward direction (i.e., toward the rotor portion **32** side) from the base portion **311**. Ball bearings **313** and **314** are arranged at positions within the bearing supporting portion at an axially upper portion and an axially bottom portion, respectively. Moreover, a preloaded spring **317** is provided at a bottom side of bearing mechanism **312**.

[0030] The stator **31** also includes an armature **315** which is attached to an outer side surface of the bearing mechanism **312** (i.e., the armature **315** is attached to the base portion **311** near the bearing supporting portion) and a circuit board **316** which is arranged on the base portion **311** below the armature **315** and is electrically connected to the armature **315**.

[0031] The rotor portion **32** includes a covered cylindrical yoke **321** which is made of metallic material and has an opening **3211** on the bottom side thereof (i.e., the stator **31** side), a field magnet **322** which is attached to an inner side surface **3212** of the yoke **321** so as to face the armature **315**, and a shaft **323** which downwardly protrudes from an upper portion **3213** of the yoke **321** (i.e., a substantially disk-shaped portion arranged on the upper end portion of the yoke **321**).

[0032] The yoke **321** includes a substantially annular flange portion **3215** which extends in a direction that is substantially perpendicular to the center axis J**1** and is arranged around the opening **3211** (i.e., the bottom end portion of the yoke **321** facing the armature **315**, and hereinafter referred to as an opening portion **3214**).

[0033] As shown in FIG. **1**, in the fan assembly **1**, an outer side surface **3216** of the yoke **321** is not covered by a portion of the impeller **2** (i.e., an outer side surface **3216** is exposed to outside air). It should be noted that a state in which the outer side surface **3216** of the yoke **321** is exposed to the outside air includes a state in which the yoke **321** is covered with a thin layer to protect the surface thereof and exposes an outer surface of the thin layer to the outside air. In other words, in the fan assembly **1**, an outer side surface of a member which is normally recognized as the yoke **321** is not covered with the impeller portion and is exposed to the outside air.

[0034] A bushing **324** is crimp-fitted to the upper portion **3213** of the yoke **321**, and the shaft **323** is fixed to the bushing **324** by press-fitting. Then the shaft **323** is inserted into the bearing supporting portion **312** such that the shaft **323** is rotatably supported by the ball bearings **313** and **314**. In the fan assembly **1**, the shaft **323**, the ball bearing **313**, and the ball bearing **314** define the bearing mechanism **312**

which supports the yoke **321** about center axis J1 in a manner rotatable relative to the base portion **311**. Then, torque (i.e., rotation force) centered on the center axis J1 is generated between the field magnet **322** and the armature **315** by controlling power input to the armature **315** through a circuit board **316**. The torque rotates the yoke **321**, shaft **323**, and the impeller **2** attached to the yoke **321** with the center axis J1 as the center. Meanwhile, the shaft **323** may be directly attached to the yoke **321**, in which case the bushing **324** would be omitted.

[**0035**] The impeller portion **2** includes a discoid circular portion **21** extending in a radially outward direction (i.e., the direction away from the center axis J1) from the opening portion **3214** of the yoke **321**, and a plurality of blades **22** (for example, 11 blades in this preferred embodiment of the present invention) arranged in an equally spaced manner in the circumferential direction centered about the center axis J1 with a space maintained on an inner side of the blades.

[**0036**] The circular portion **21** firstly extends in the radially outward direction on a plane that is substantially the same plane where the flange portion **3215** is arranged, secondly inclines in the axially downward direction near the outer circumference of the base portion **311**, and then, thirdly extends in the radially outward direction from inner end portions (i.e., the center axis J1 side portions) of the blades **22** on a plane that is substantially the same plane where the circuit board **316** is arranged. As shown in FIG. **3**, a plurality of shallow grooves **219***a* having circular arc shapes (11 grooves in this preferred embodiment) are provided on an upper surface of a radially outward portion of the circular portion **21**. As shown in FIG. **2**, a plurality of convex portions **219***b* having circular arc shapes arranged in a spiral manner are provided on a bottom surface of the radially outward portion of the circular portion **21**, a position of each convex portion corresponding to that of each shallow groove **219***a*, respectively.

[**0037**] Each of the plurality of blades **22** extends upwardly from the upper surface of the circular portion **21** (i.e., a yoke **321** side surface of the circular portion **21**) substantially parallel to the center axis J1. The plurality of blades **22** are unitarily formed by connecting upper end portions thereof with an annular connecting portion having an outer side surface in a circular truncated cone shape. The plurality of unitary blades **22** are arranged in the grooves **219***a* of the circular portion **21** and are fixed to the circular portion **21** preferably by ultrasonic welding. In the centrifugal fan assembly **1**, the air is taken into the fan assembly **1** from the upper side thereof (i.e., the upper portion **3213** side of the yoke **321**) and the air taken into the fan assembly is exhausted in the radial direction away from the center axis J1 by rotating impeller portion **2** and the yoke **321**.

[**0038**] FIGS. **2** and **3** are plan views showing the yoke **321** of the rotor portion **32** and the circular portion **21** of the impeller portion **2** attached to the yoke **321**. FIGS. **4** and **5** are partial sectional views illustrating sections of the yoke **321** and the circular portion **21** along section A-A and section B-B shown in FIG. **2**, respectively.

[**0039**] As shown in FIGS. **2** to **5**, an upper affixing portion **211** of an inner peripheral side of the circular portion **21** is abutted against the upper surface of the flange portion **3215** of the yoke **321** along the entire circumference and centered about the center axis J1. As shown in FIGS. **2** to **4**, the circular portion **21** includes a plurality of bottom affixing portions **212** (11 portions in this preferred embodiment), at which the circular portion **21** is abutted against a bottom surface of the flange portion **3215**, wherein the plurality of bottom affixing portions **212** are arranged in a circumferential direction centered about the center axis J1. By virtue of the configuration mentioned above, the flange portion **3215** is sandwiched by the upper affixing portions **211** and the bottom affixing portions **212** of the circular portion **21**.

[**0040**] The bottom affixing portions **212** include a plurality of side affixing portions **213** (for example, 11 portions in this preferred embodiment) at which the circular portion **21** is abutted against an outer circumferential surface of the flange portion **3215**, wherein the plurality of side affixing portions **213** are arranged in a circumferential direction centered about the center axis J1 and connect the plurality of bottom affixing portions **212** and the upper affixing portions **211**. In the circular portion **21**, the bottom affixing portions **212** and the side affixing portions **213** are arranged in an equally spaced manner in the circumferential direction.

[**0041**] As shown in FIGS. **2** to **5**, the flange portion **3215** of the yoke **321** includes a plurality of through holes **3217** (for example, 8 through holes in this preferred embodiment), which axially penetrate the flange portion **3215** and are arranged in an equally spaced manner in the circumferential direction centered about the center axis J1. Moreover, the through holes **3217** are arranged at positions facing the upper affixing portions **211** of the circular portion **21**. The circular portion **21** includes a plurality of convex portions **214** (for example, 8 convex portions in this preferred embodiment), each of which is inserted into a through hole **3217** to prevent relative movement in the circumferential direction about the center axis J1 between the yoke **321** and the impeller portion **2**.

[**0042**] As described above, the circular portion of the impeller **2** is fixed to the yoke **321** of the flange portion **3215** by insert molding. Upon insert molding of the circular portion **21**, the yoke **321** is arranged within a die having an internal space in a predetermined shape, and a melted resin material is injected from a plurality of gates arranged on the die to fill the internal space of the die. Then, the resin material is solidified by cooling the die. As a result, the circular portion **21** is formed while the circular portion **21** is fixed to the flange portion **3215** of the yoke **321** by injection molding.

[**0043**] Upon forming the circular portion **21**, weld lines are formed at portions in which a melted resin material injected from the different gates flow together. Specifically, the weld line is formed at the intersection of two confronting-flow fronts of the melted resin which temperature is relatively lower than other portions of the resin-flow. As explained above, the condition of the molding material at the molding line is different from that at the other portions, which normally results in degrading the strength at the portion where the welding line is formed.

[**0044**] FIG. **6** is a bottom plan view illustrating the yoke **321** and the circular portion **21**. A plurality of weld lines **215** formed on the circular portion **21** are illustrated by broken lines. Gate marks **216** formed at positions corresponding to those of the gates arranged on the die are also illustrated in FIG. **6**. In the die used for molding the circular portion **21**, each gate is arranged at a position outside that of the

corresponding side affixing portion **213** and bottom affixing portion **212** (i.e., the positions of the gates correspond to gate marks **216** formed between the adjacent convex portions **219***b*, and are on the lines connecting the center axis J**1** and each side affixing portion **213**). The resin material is injected from each of the gates with substantially the same injection pressure, which results in forming the weld line **215** at a substantially middle portion between adjacent gates. By virtue of this configuration, the plurality of weld lines **215** extend radially on the circular portion **21** about the center axis J**1**, and each weld line **215** passes between two adjacent side affixing portions **213**.

[**0045**] As explained above, in the fan assembly **1** according to the present preferred embodiment of the present invention, the circular portion **21** of the impeller portion **2** is attached to the opening portion **3214** of the yoke **321** by insert molding. Therefore, the impeller portion **2** is securely fixed to the yoke **321** even in the case that the affixing area of the impeller portion **2** and the yoke **321** is relatively small. Moreover, the impeller portion **2** may be attached to the yoke **321** when molding the impeller portion **2**.

[**0046**] In terms of the fan assembly **1**, the outer side surface **3216** of the yoke **321** is not covered by a portion of the impeller portion **2** (i.e., the outer side surface **3216** of the yoke **321** directly faces the plurality of blades **22**), the space arranged inside the plurality of blades **22** of the impeller portion **2** may be enlarged in the radial direction about the center axis J**1** compared with a fan assembly in which the outer side surface of the yoke is covered with a portion of the impeller (i.e., the distance between the inner side end portion of the blade **22** and the portion of the member facing thereto (the outer side surface **3216** of the yoke in this preferred embodiment) may be enlarged). As a result, the blower efficiency of the fan assembly **1** may be improved.

[**0047**] In addition, the heat generated by a member arranged within the yoke **321**, such as the armature **315**, may be easily diffused to outside of the yoke **321**. As a result, the temperature of the fan assembly **1** may be easily controlled.

[**0048**] In the fan assembly **1** according to the present preferred embodiment of the present invention, the circular portion **21** of the impeller portion **2** is fixed to the flange portion **3215** extending in a radially outward direction perpendicular to the center axis J**1**. By virtue of this configuration, an attaching portion of the impeller portion **2** may be simplified. Moreover, the flange portion **3215** is axially sandwiched between the upper affixing portion **211** and the bottom affixing portion **212** according to the present preferred embodiment of the present invention. By virtue of this configuration, the impeller portion **2** is securely fixed to the yoke **321** while simplifying the structure of the attaching portion of the impeller portion **2**. Furthermore, by inserting the convex portions **214** of the circular portion **21** into the through holes **3217** of the flange portion **3215**, it is possible to prevent relative movement in the circumferential direction between the impeller portion **2** and the yoke **321**. Additionally, by inserting the convex portions **214** into the through holes **3217**, an affixing area of the circular portion **21** to the yoke **321** is enlarged, which results in fixing the circular portion **21** and the yoke **321** more securely.

[**0049**] In terms of the impeller **2**, the plurality of side affixing portions **213** of the circular portion **21** are intermittently fixed to the outer circumferential surface of the flange portion **3215** along the outer circumferential surface around the opening portion **3214** of the yoke **321**. Therefore, even if the fan assembly **1** is placed in a low temperature environment and the circular portion **21** made of resin shrinks more than the yoke **321** made of metallic material, it is possible to prevent the impeller portion **2** from being damaged or cracked by thermal deformation because each side affixing area **213** includes a clearance in the circumferential direction (i.e., deformable space), which reduces the stress circumferentially applied to the circular portion **21**.

[**0050**] Furthermore, according to this preferred embodiment, the circular portion **21** is formed by insert molding such that each of the plurality of weld lines **215** passes between the adjacent side affixing portions **213** (i.e., a radially inward end portion of each weld line **215** does not overlap the side affixing portions **213**). By virtue of this configuration, the stress caused by thermal deformation (specifically, the thermal shrinkage) is not forcefully applied to the weld lines **215**, and it is possible to prevent the impeller portion **2** from being damaged or cracked by the thermal deformation.

[**0051**] FIG. **7** is a bottom plan view illustrating the circular portion **21** attached to the yoke **321** according to another preferred embodiment of the present invention. FIG. **8** is a partial sectional view illustrating the yoke **321** and the circular portion **21** along section C-C shown in FIG. **7**. In the present preferred embodiment, the circular portion **21** may extend in a radially outward direction perpendicular to the center axis J**1**.

[**0052**] In the preferred embodiment shown in FIGS. **7** and **8**, a plurality of notched portions **213***b* are arranged on an inner side portion of the circular portion **21**, and an inner side surface of an affixing portion **213***a* arranged between two adjacent notched portions **213***b* is abutted against the outer side surface of the flange portion **3215**. In other words, the inner side surface of the plurality of affixing portions **213***a* arranged in the circumferential direction about the center axis J**1** are intermittently abutted against the outer side surface around the opening portion **3214** of the yoke **321**.

[**0053**] As shown in FIGS. **7** and **8**, an upper affixing portion **211***a* and a bottom affixing portion **212***a* are provided on an upper surface and a bottom surface of the affixing portion **213***a*. The upper affixing portion **211***a* and the bottom affixing portion **212***a* abut against an upper surface and a bottom surface of the flange portion **3215** of the circular portion **21** respectively, such that the upper and the bottom affixing portions sandwich the flange portion **3215**. The circular portion **21** is fixed to the yoke near the opening portion **3214** by insert molding. The notched portions **213***b* arranged between the affixing portions **213***a* are formed concurrently with the insert molding of the circular portion **21** by providing a plurality of convex portions within the die. The weld lines (not shown in FIGS. **7** and **8**) extend radially outward from positions corresponding to the notched portions **213***b*.

[**0054**] In the preferred embodiment shown in FIGS. **7** and **8**, even in the case that the fan assembly **1** is placed in a low temperature environment and the circular portion **21** made of resin shrinks more than the yoke **321** made of metallic material does, it is possible to prevent the impeller portion

2 from being damaged or cracked by thermal deformation because each side affixing area **213***a* includes a clearance in the circumferential direction (i.e., notched portions **213***b* as deformable spaces), which reduces the stress circumferentially applied to the circular portion **21**. In case that the thermal shrinkage ratios of the circular portion **21** and the yoke **321** are substantially the same, it is even less likely that the impeller portion **2** is damaged or cracked by the thermal deformation. In such case, the circular portion **21** may include an affixing portion whose inner side surface abuts against the flange portion **3215** along the entire circumference of the flange portion **3215**.

[**0055**] Next, a fan assembly according to a second preferred embodiment of the present invention will be explained. FIG. **9** is a cross sectional view illustrating a yoke **321***a* and the impeller portion **2** of a fan assembly according to a second preferred embodiment of the present invention. Unlike the fan assembly **1** shown in FIG. **1**, the fan assembly according to the second preferred embodiment does not include a flange portion around the opening portion **3214** of the yoke **321***a*.

[**0056**] As shown in FIG. **9**, in the fan assembly according to the second preferred embodiment, a circular portion **21***a* of the impeller portion **2** is fixed to the outer side surface **3216** around a bottom end portion (i.e., opening portion **3214**) of the yoke **321***a* by insert molding. An affixing portion **213***c* of the circular portion **21***a* which abuts against the yoke **321***a* on the inner side of the circular portion **21***a* covers a portion of the outer side surface **3216** of the yoke **321***a*. Other portions of the outer side surface **3216** are not covered with the impeller portion **2**. Therefore, like the first preferred embodiment, the impeller portion **2** is securely fixed to the yoke **321***a* while improving the blower efficiency of the fan assembly.

[**0057**] On a bottom side surface of the yoke **321***a*, a plurality of holes **3217***a* are intermittently arranged in the circumferential direction. In addition, a plurality of convex portions **214***a* to be inserted into the holes **3217***a* are formed on the affixing portion **213***c* of the circular portion **21***a* by insert molding. By this configuration, like the first preferred embodiment of the present invention, it is possible to prevent relative movement in the circumferential direction between the impeller portion **2** and the yoke **321***a* when the impeller portion **2** rotates.

[**0058**] The affixing portion **213***c* may be intermittently abutted against the outer side surface **3216** of the yoke **321***a* in the circumferential direction centered about the center axis J**1**. In other words, the circular portion **21***a* may include a plurality of affixing portions which are arranged in the circumferential direction and intermittently abut against the outer side surface **3216** of the yoke **321***a*. Therefore, like the first preferred embodiment, it is possible to prevent the impeller portion **2** from being damaged or cracked by thermal deformation even in the case that the fan assembly **1** is placed in a low temperature environment and the circular portion **21***a* made of resin shrinks more than the yoke **321***a* made of metallic material does.

[**0059**] In the fan assembly according to the second preferred embodiment of the present invention, the circular portion **21***a* and the plurality of blades **22** are unitarily formed. The circular portion **21***a* includes a plurality of through holes **217** which are circumferentially arranged between the affixing portions **213***c* and the blades **22**. Upon rotating the impeller portion **2**, air is taken via the through holes **217** arranged on the bottom side of the circular portion **21***a* and is fed to the blades **22**. If needed, the fan assembly may take the configuration in which the air is taken from the upper side of the circular portion **21***a* via the through holes **217** and is fed to the bottom side of the circular portion **21***a*.

[**0060**] The fan assembly may take the configuration in which the air is taken from both axially upper and bottom sides by rotating the impeller portion **2**. FIG. **10** is a partial sectional view illustrating another preferred embodiment of the circular portion **21***a* fixed to the yoke **321***a*. In the preferred embodiment of the present invention shown in FIG. **10**, the circular portion **21***a* is securely fixed to a substantially axially middle position of the outer side surface **3216** of the yoke **321***a* by insert molding. In this case, the air taken from axially upper and bottom sides of the impeller portion **2** is smoothly guided to the blades **22** by the circular portion **21***a*. In the preferred embodiment of the present invention shown in FIG. **10**, most of the outer side surface **3216** of the yoke **321***a* is exposed, and the blower efficiency of the fan assembly may be improved.

[**0061**] While embodiments of the present invention have been described in the foregoing, the present invention is not limited to the preferred embodiments detailed above, and various modifications are possible.

[**0062**] For example, in the viewpoint of preventing relative movement between the impeller portion **2** and the yoke **321**, the fan assembly **1** according to the first preferred embodiment of the present invention may include concave portions engaging with the convex portions **214** of the circular portion **21**, instead of the through holes **3217** on the upper surface of the flange portion **3215**. Alternatively, concave portions may be formed on the flange portion **3215** by notching the outer circumference thereof, and the concave portions may be engaged with convex portions which are formed on the circular portion **21**. Alternatively, relative movement between the impeller portion **2** and the yoke **321** in the circumferential direction may be prevented by engaging the side affixing portion **213** of the circular portion **21** and concave portions arranged on the outer circumferential surface of the flange portion **3215**. Alternatively, as shown in FIG. **11**, in the fan assembly **1**, a convex portion **414** may be formed on the flange portion **3215**, and a hole **4217** into which the convex portion **414** is inserted (or a concave portion which engages with the convex portion) may be formed on the circular portion **21**.

[**0063**] Similarly, in the fan assembly according to the second preferred embodiment of the present invention, the convex portions (the notched portions) instead of the holes **3217***a* may be formed on the outer side surface **3216** of the yoke **321***a*. Alternatively, the holes (or the concave portions) may be formed on the affixing portion **213***c* of the circular portion **21***a*, and the convex portions which are inserted into the holes may be formed on the outer side surface **3216** of the yoke **321***a*.

[**0064**] While preferred embodiments of the present invention have been described above, it is to be understood that variations and modifications will be apparent to those skilled in the art without departing the scope and spirit of the present invention. The scope of the present invention, therefore, is to be determined solely by the following claims.

What is claimed is:

1. A fan assembly comprising:

a base portion;

an armature arranged on the base portion;

a field magnet generating a torque centered about a center axis by interacting with the armature;

a yoke having a substantially cylindrical shape centered about the center axis and including an outer side surface, a closed top, and an open bottom directed toward the armature, the field magnet being accommodated inside of and fixed to the yoke;

a bearing mechanism supporting the yoke in a rotatable manner relative to the base portion; and

an impeller portion including a substantially circular portion extending radially outwardly from the open bottom or the outer side surface of the yoke, and a plurality of blades arranged around the center axis and fixed to the substantially circular portion; wherein

the substantially circular portion of the impeller portion is insert molded to the yoke; and

the impeller portion blows air from a bottom side or an upper side thereof in a direction away from the center axis.

2. The fan assembly as set forth in claim 1, wherein a portion of the outer side surface of the yoke is exposed to an inner edge of the blades in the radial direction.

3. The fan assembly as set forth in claim 2, wherein the substantially circular portion includes a plurality of radial affixing portions arranged around the center axis and an axial affixing portion having a surface or an edge extending in the radial direction, each radial affixing portion has a surface or an edge which constrains the radial position of the substantially circular portion against the yoke, and the axial affixing portion constrains the axial position of the circular portion against the yoke.

4. The fan assembly as set forth in claim 3, wherein the substantially circular portion is insert molded, a plurality of weld lines extend radially on the substantially circular portion from the center axis, and each of the weld lines passes between two adjacent radial affixing portions.

5. The fan assembly as set forth in claim 3, wherein the substantially circular portion includes a plurality of gate marks at positions radially outward from the radial affixing portions, and each gate mark is arranged substantially on an extension of a line connecting each radial affixing portion and the center axis in a plan view.

6. The fan assembly as set forth in claim 2, wherein the yoke includes a flange portion at the open bottom, the flange portion extends in a radially outward direction, and the substantially circular portion of the impeller is fastened thereto.

7. The fan assembly as set forth in claim 2, wherein the yoke includes a convex portion and the impeller portion includes a hole portion or a concave portion, and the convex portion is inserted into the hole portion or the concave portion so as to prevent a relative movement between the yoke and the impeller portion in the circumferential direction.

8. The fan assembly as set forth in claim 2, wherein the yoke includes a hole portion or a concave portion and the impeller portion includes a convex portion, and the convex portion is inserted into the hole portion or the concave portion so as to prevent a relative movement between the yoke and the impeller portion in the circumferential direction.

9. The fan assembly as set forth in claim 1, wherein the substantially circular portion of the impeller portion includes a plurality of radial affixing portions arranged around the center axis and an axial affixing portion having a surface or an edge extending in the radial direction, each radial affixing portion has a surface or an edge which constrains the radial position of the substantially circular portion against the yoke, and the axial affixing portion constrains the axial position of the circular portion against the yoke.

10. The fan assembly as set forth in claim 9, wherein the substantially circular portion is insert molded, a plurality of weld lines extend radially on the circular portion from the center axis, and each of the weld lines passes between two adjacent radial affixing portions.

11. The fan assembly as set forth in claim 10, wherein the yoke includes a hole portion or a concave portion and the impeller portion includes a convex portion, and the convex portion is inserted into the hole portion or the concave portion so as to prevent a relative movement between the yoke and the impeller portion in the substantially circumferential direction.

12. The fan assembly as set forth in claim 10, wherein the yoke includes a flange portion at the open bottom, the flange portion extends in a radially outward direction, and the substantially circular portion of the impeller is fastened thereto.

13. The fan assembly as set forth in claim 12, wherein gate marks are arranged on a portion of the substantially circular portion which axially overlaps with the flange portion.

14. The fan assembly as set forth in claim 10, wherein the yoke includes a convex portion and the impeller portion includes a hole portion or a concave portion, and the convex portion is inserted into the hole portion or the concave portion so as to prevent a relative movement between the yoke and the impeller portion in the circumferential direction.

15. The fan assembly as set forth in claim 9, wherein the substantially circular portion includes a plurality of gate marks at positions radially outward from those of the radial affixing portions, each gate mark is arranged substantially on an extension of a line connecting each radial affixing portion and the center axis in a plan view.

16. The fan assembly as set forth in claim 15, wherein the yoke includes a flange portion at the open bottom, the flange portion extends in a radially outward direction, and the substantially circular portion of the impeller is fastened thereto.

17. The fan assembly as set forth in claim 16, wherein the gate marks are arranged on a portion of the substantially circular portion which axially overlaps with the flange portion.

18. The fan assembly as set forth in claim 15, wherein the yoke includes a hole portion or a concave portion and the impeller portion includes a convex portion, and the convex portion is inserted into the hole portion or the concave portion so as to prevent a relative movement between the yoke and the impeller portion in the circumferential direction.

19. The fan assembly as set forth in claim 15, wherein the yoke includes a convex portion and the impeller portion includes a hole portion or a concave portion, and the convex portion is inserted into the hole portion or the concave portion so as to prevent a relative movement between the yoke and the impeller portion in the circumferential direction.

20. The fan assembly as set forth in claim 9, wherein the yoke includes a flange portion at the open bottom, the flange portion extends in a radially outward direction, and the substantially circular portion of the impeller is fastened thereto.

21. The fan assembly as set forth in claim 1, wherein the yoke includes a flange portion at the open bottom, the flange portion extends in a radially outward direction, and the substantially circular portion of the impeller is fastened thereto.

22. The fan assembly as set forth in claim 1, wherein the yoke includes a hole portion or a concave portion and the impeller portion includes a convex portion, and the convex portion is inserted into the hole portion or the concave portion so as to prevent a relative movement between the yoke and the impeller portion in the circumferential direction.

23. The fan assembly as set forth in claim 1, wherein the yoke includes a convex portion and the impeller portion includes a hole portion or a concave portion, and the convex portion is inserted into the hole portion or the concave portion so as to prevent a relative movement between the yoke and the impeller portion in the circumferential direction.

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