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YAMAZAKI et al.(10) **Pub. No.: US 2015/0167678 A1**(43) **Pub. Date: Jun. 18, 2015**(54) **AXIAL FLOW FAN AND SERIES AXIAL
FLOW FAN**(71) Applicant: **SANYO DENKI CO., LTD.**, Tokyo (JP)(72) Inventors: **Tetsuya YAMAZAKI**, Tokyo (JP);
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(2013.01)(57) **ABSTRACT**

An axial flow fan includes: a casing, defining a wind tunnel; a frame having a plurality of spokes extended from the casing to the center in the radial direction of the casing so as to be across the wind tunnel, and a frame hub connecting the plurality of spokes at the center in the radial direction of the casing; a stator supported by the frame hub, in which a winding is wound around the stator; a rotor pivotally supported by the frame hub in a rotatable manner and having a permanent magnet; an impeller fixed to the rotor and having a plurality of rotor blades; and a step part formed in at least one surface of the frame hub.

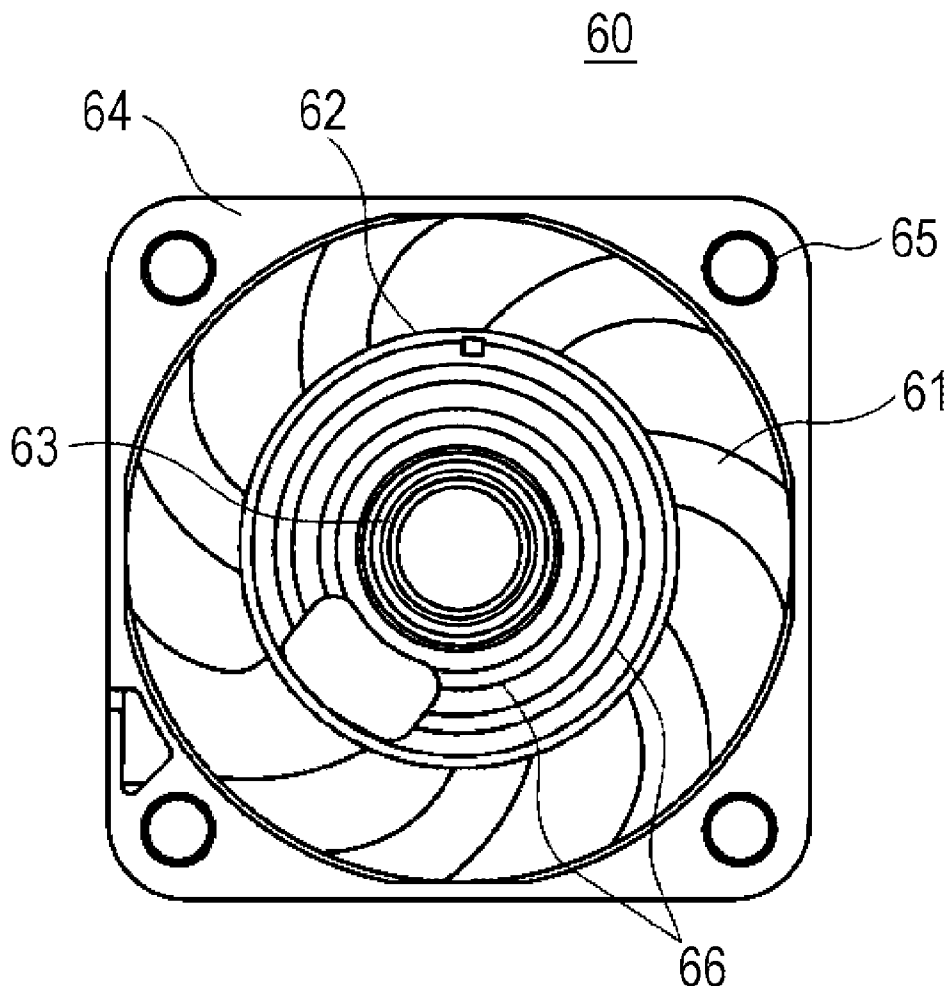


FIG. 1
200

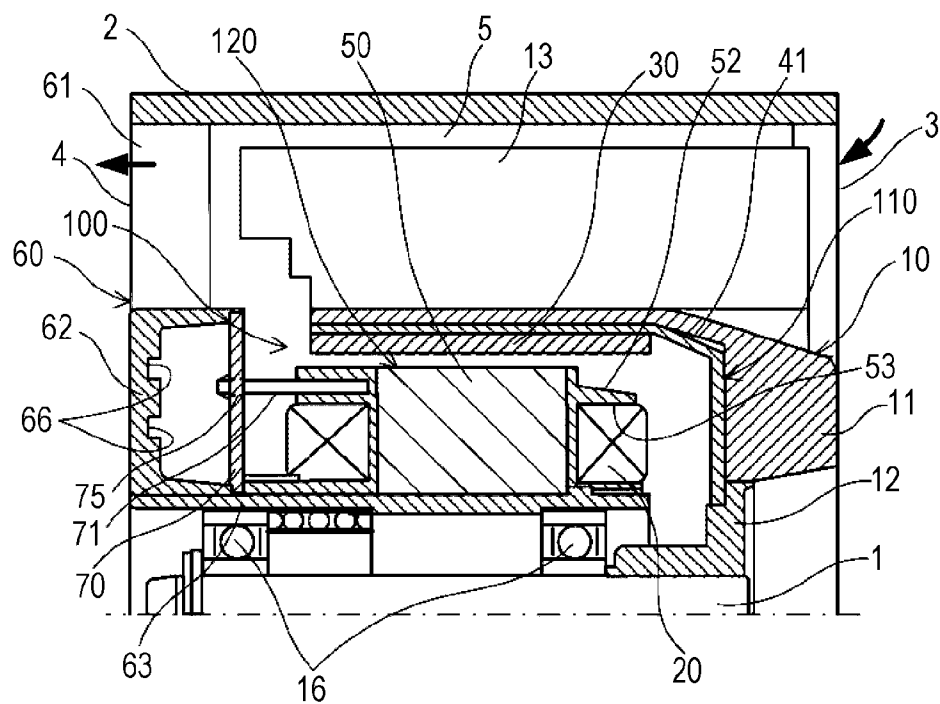


FIG. 2
60

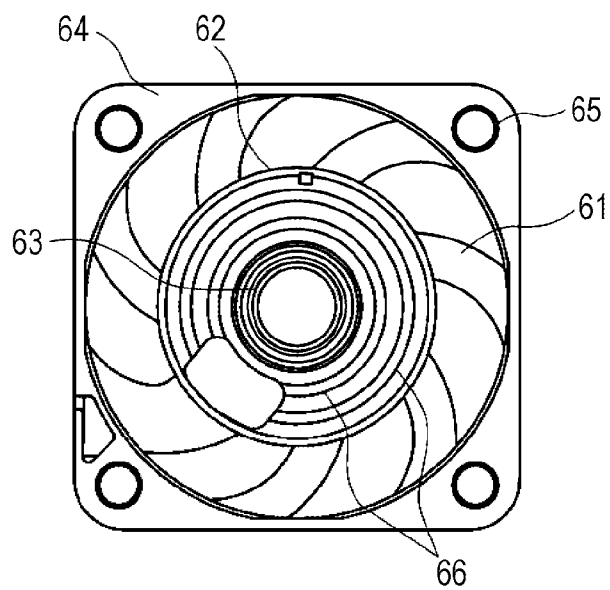


FIG. 3

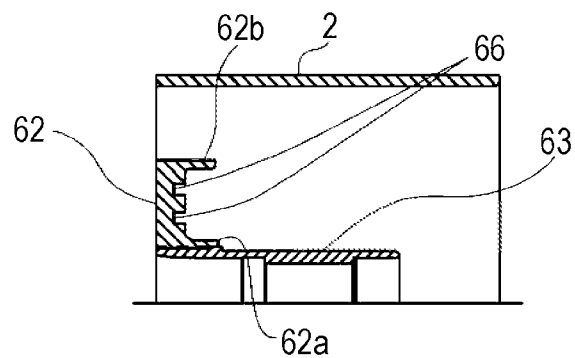


FIG. 4

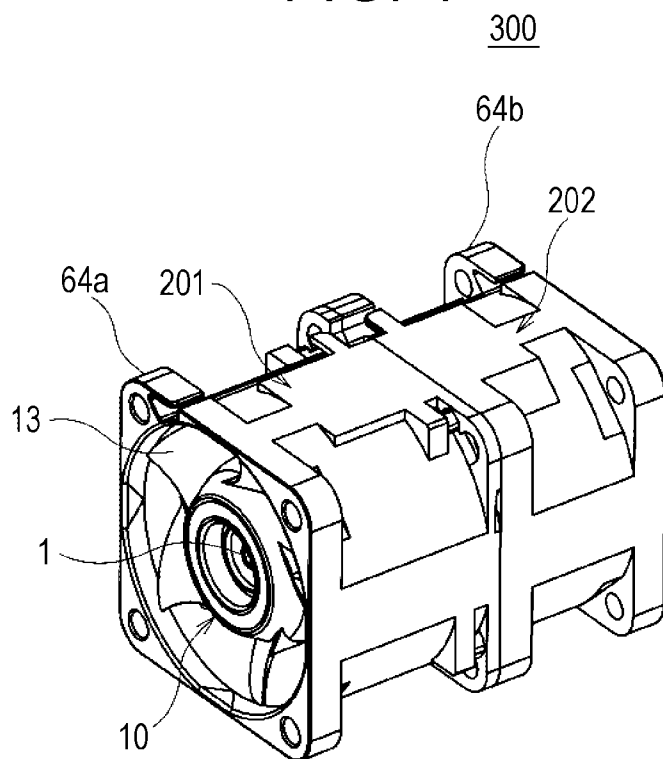


FIG. 5
201

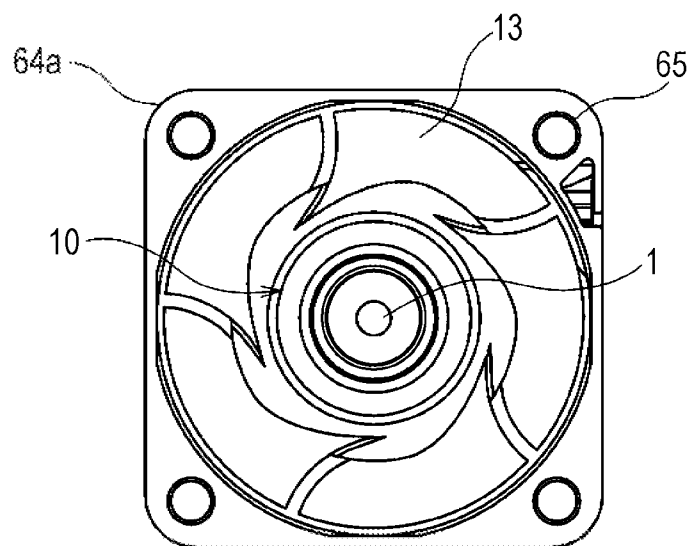


FIG. 6
202

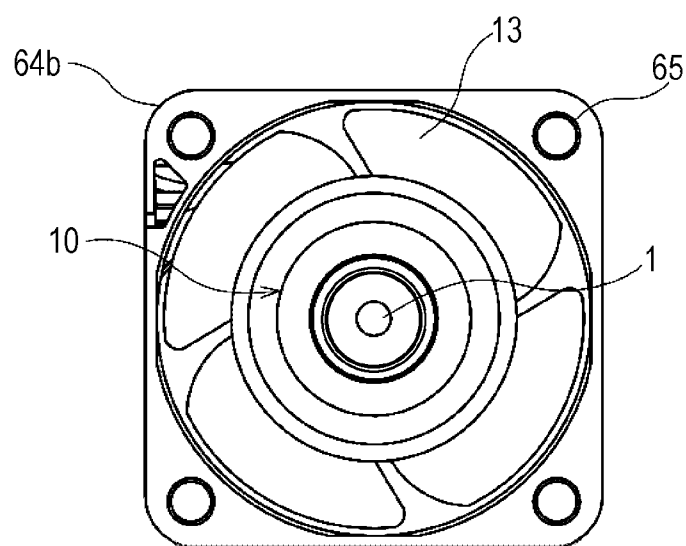


FIG. 7

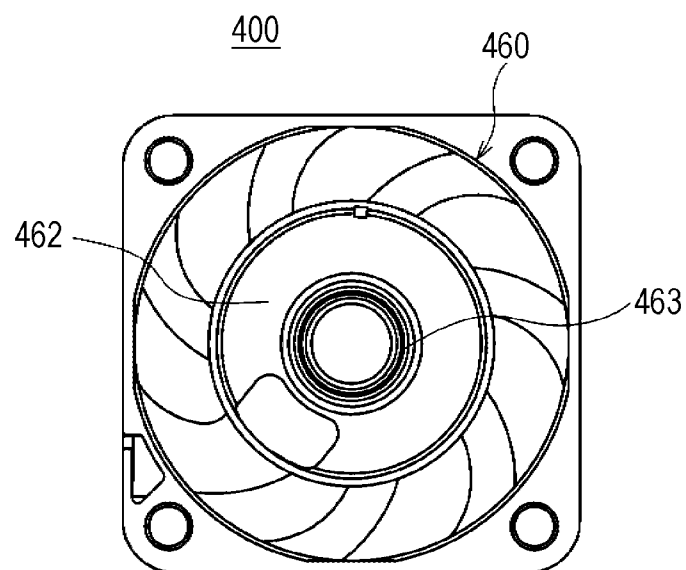


FIG. 8

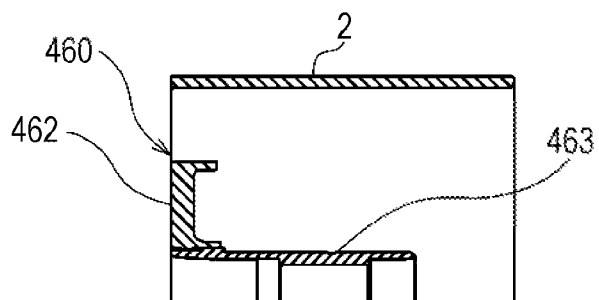
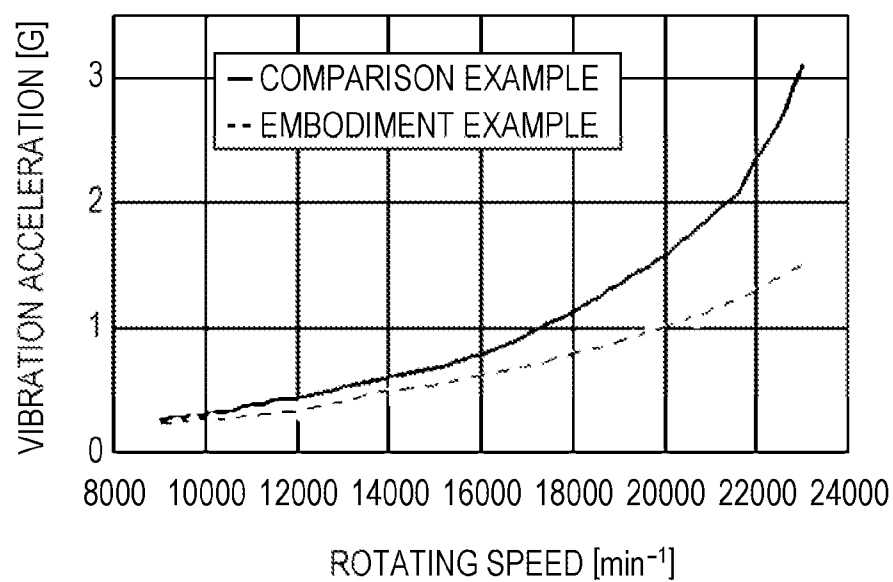


FIG. 9

AXIAL FLOW FAN AND SERIES AXIAL FLOW FAN

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority from Japanese Patent Application No. 2013-257089 filed with the Japan Patent Office on Dec. 12, 2013, the entire content of which is hereby incorporated by reference.

BACKGROUND

[0002] 1. Technical Field

[0003] The present disclosure relates to an axial flow fan and a series axial flow fan.

[0004] 2. Related Art

[0005] An axial flow fan has a rotary motor as a rotary driving device, an impeller mounted to the rotating shaft of the rotary motor and having a plurality of rotor blades, and a cylindrical casing forming an axial flow together with the impeller.

[0006] In the axial flow fan, a high cooling performance can be obtained by increasing the rotating speed of the impeller. However, the increase in the rotating speed of the impeller causes a larger individual vibration produced by the axial flow fan. This is because the vibration generated by the rotation of the rotor is transferred to the casing via a bearing support part (a bushing) and a frame having a frame hub and thus the individual vibration of the axial flow fan increases.

[0007] In the known art for reduction in the individual vibration of the axial flow fan motor, the axial flow fan motor has a propeller that rotates to generate an airflow, a motor that drives the propeller, a venturi bottom to which the motor is fixed, and a venturi. The venturi is provided so as to have a gap to the outer circumference of the propeller. The venturi has an outer frame having a substantially square outer circumference and a bell-mouth having a substantially cylindrical inner circumference. The venturi bottom is connected to the outer frame via a leg part. A plurality of openings is formed in the venturi bottom (see, for example, JP-A-2006-161688).

[0008] Further, the known fan in the same art has an impeller that rotates on a center axis, a motor unit that causes the impeller to rotate, a motor support part that supports the motor unit, and a housing that accommodates the impeller and the motor unit therein. The motor support part has a substantially disk-shaped base part and a substantially cylindrical bearing holding part axially extending with the center axis as the center. The whole or a part of the motor support part (at least the base part) is made of a resin. On the surface of the base part, a plurality of recess parts are axially recessed and formed in a mesh pattern. The flat part other than the recess parts of the base part does not include a continuous portion in a radial direction extending from the center of the base part in a radial manner (see, for example, JP-A-2012-184748).

SUMMARY

[0009] An axial flow fan includes: a casing defining a wind tunnel; a frame having a plurality of spokes extended from the casing to the center in the radial direction of the casing so as to be across the wind tunnel, and a frame hub connecting the plurality of spokes at the center in the radial direction of the casing; a stator supported by the frame hub, in which a winding is wound around the stator; a rotor pivotally supported

by the frame hub in a rotatable manner and having a permanent magnet; an impeller fixed to the rotor and having a plurality of rotor blades; and a step part formed in at least one surface of the frame hub.

BRIEF DESCRIPTION OF DRAWINGS

[0010] FIG. 1 is a sectional view of an upper half part of an axial flow fan of a present embodiment;

[0011] FIG. 2 is an inside front view of a frame of the axial flow fan of the present embodiment;

[0012] FIG. 3 is a sectional view of an upper half part of the frame of the axial flow fan of the present embodiment;

[0013] FIG. 4 is a perspective view of a series axial flow fan of the present embodiment;

[0014] FIG. 5 is a left side view illustrating an appearance of an intake side of the series axial flow fan of the present embodiment;

[0015] FIG. 6 is a right side view illustrating an appearance of an exhaust side of the series axial flow fan of the present embodiment;

[0016] FIG. 7 is an inside front view of a frame of an axial flow fan of a comparison form;

[0017] FIG. 8 is a sectional view of an upper half part of the frame of the axial flow fan of the comparison form; and

[0018] FIG. 9 is a diagram used for the illustration of a vibration reduction effect of the axial flow fan of the present embodiment.

DETAILED DESCRIPTION

[0019] In the following detailed description, for purpose of explanation, numerous specific details are set forth in order to provide a thorough understanding of the disclosed embodiments. It will be apparent, however, that one or more embodiments may be practiced without these specific details. In other instances, well-known structures and devices are schematically shown in order to simplify the drawing.

[0020] According to the technique disclosed in JP-A-2006-161688, a plurality of openings is formed in the venturi bottom (the frame hub). However, forming a plurality of openings to the frame hub results in reduction in the strength of the frame hub. This has no small influence on the airflow at the exhaust side.

[0021] Further, according to the technique disclosed in JP-A-2012-184748, a plurality of recess parts recessed in the axial direction is formed in a mesh pattern on the surface of the base part (the frame hub). However, forming a plurality of recess parts in such a way is complicated. Further, when the frame hub is made of metal, it is difficult to form the recess parts in a mesh pattern on the surface of the frame hub.

[0022] One of the purposes of the present disclosure is to provide the following axial flow fan and series axial flow fan. That is, these axial flow fan and series axial flow fan have simple structure and are able to reduce the individual vibration of the axial flow fan and series axial flow fan even when the rotating speed of the impeller is high, while suppressing the reduction in the strength of the frame hub and the affection on the airflow at the exhaust side.

[0023] The axial flow fan according to one embodiment of the present disclosure (the present axial flow fan) has a casing, a frame, a stator, a rotor, and an impeller.

[0024] The casing defines a wind tunnel. The frame has a plurality of spokes and a frame hub. Each spoke is extended from the casing to the center part in the radial direction of the

casing so as to be across the wind tunnel. The frame hub connects the plurality of spokes at the center part in the radial direction of the casing. The stator is supported by the frame hub. A winding is wound around the stator. The rotor is pivotally supported by the frame hub in a rotatable manner and has a permanent magnet. The impeller is fixed to the rotor and has a plurality of rotor blades.

[0025] A step part is formed in at least one surface of the frame hub.

[0026] In the present axial flow fan, the step part is formed in at least one surface of the frame hub. This step part attenuates the vibration transferred to the frame hub. As a result, this allows for the suppression of the transfer of the vibration to, for example, the casing via the frame hub.

[0027] Therefore, the present axial flow fan has simple structure and allows for the reduction in the vibration even when the rotating speed of the impeller is high, while suppressing the reduction in the strength of the frame hub and the affection on the airflow at the exhaust side.

[0028] The axial flow fan of the present embodiment will be described below by referring to the drawings.

[0029] In the axial flow fan of the present embodiment, the step part is formed in at least one surface of the frame hub of the frame. Thus, the vibration transferred to the frame hub is attenuated. As a result, this allows for the suppression of the transfer of the vibration to, for example, the casing via the frame hub.

[Arrangement of Axial Flow Fan]

[0030] Firstly, the arrangement of the axial flow fan of the present embodiment will be described by referring to FIG. 1 to FIG. 3. FIG. 1 is a sectional view of the upper half part of the axial flow fan of the present embodiment. FIG. 2 is an inside front view of the frame of the axial flow fan of the present embodiment. FIG. 3 is a sectional view of the upper half part of the frame of the axial flow fan of the present embodiment.

[0031] The axial flow fan is a blowing apparatus that is adapted to suck the air from one side in the axial direction of the rotating shaft and discharge the air to the other side in the axial direction by the rotation of the impeller fixed to the rotating shaft of the rotary motor.

[0032] As illustrated in FIG. 1, an axial flow fan 200 has an impeller 10 fixed to a rotating shaft 1, and a cylindrical casing 2. The casing 2 surrounds the outer circumference of the impeller 10 in the radial direction.

[0033] The impeller 10 has a substantially cup-shaped hub 11 at the center. The impeller 10 has a plurality of rotor blades 13 on the outer circumference of the hub 11. The hub 11 is fixed to the rotating shaft 1 via a socket 12.

[0034] Inside the hub 11, a rotary motor 100 is disposed as a rotary driving apparatus for the impeller 10. The rotary motor 100 of the present embodiment is provided by, for example, an outer-rotor type brushless motor. The rotary motor 100 has an inside stator 120 and an outside rotor 110. The inside stator 120 is an armature having a winding 20. The outside rotor 110 is an excitation part having a permanent magnet 30 disposed on the outer circumference of the inside stator 120.

[0035] The plurality of rotor blades 13 is mounted to the circumference of the hub 11 of the impeller 10 in a radial manner. Each rotor blade 13 is provided so as to be inclined with respect to the axial direction of the rotating shaft 1.

[0036] The impeller 10 generates an airflow between the rotor blades 13 and the casing 2 by the rotation of the impeller 10. The rotor blades 13 are formed in such a shape and structure that generates the airflow from the hub 11 side of the impeller 10 to a frame hub 62 side.

[0037] The rotor 110 has a substantially cup-like rotor yoke 41, the rotating shaft 1, the permanent magnet 30, and the like. The rotating shaft 1 is press-fitted to the center part of the rotor yoke 41 by the socket 12.

[0038] The rotor yoke 41 is fitted into the hub 11. The permanent magnet 30 is fixed to the inner circumference surface along the axial direction of the rotor yoke 41. The rotor yoke 41 has a function of closing the line of magnetic force from the excitation part (the outside rotor 110) to maximize electromagnetic induction effect of the permanent magnet 30.

[0039] For the composition material of the rotor yoke 41, an iron-base magnetic material such as an SC material is used, for example. However, the composition material of the rotor yoke 41 is not limited to the exemplified material.

[0040] The rotating shaft 1 is rotatably supported by a bearing 16. The bearing 16 is fixed to the inner surface of a cylindrical bearing support part (a bashing) 63. The bearing support part 63 is fixed to the center of the frame hub 62.

[0041] The frame hub 62 has a substantially cup-like shape and forms a base part of the stator 120. The frame hub 62 is arranged at one side the axial direction of the rotating shaft 1. The hub 11 of the impeller 10 is located at the opposite side of the frame hub 62 in the axial direction (the other side in the axial direction) of the rotating shaft 1.

[0042] On the other hand, the stator 120 has a stator stack 50, the winding 20, and the like.

[0043] The stator stack 50 is fixed to the outer surface of the bearing support part 63. The stator stack 50 is formed by stacking a plurality of thin metal sheets in the thickness direction of the sheet, in which each of the thin metal sheets has a substantially ring-like shape. The composition as material of the metal sheets of the stator stack 50 may be a silicon steel sheet, for example, for having both good performance and cost. The metal sheets of the stator stack 50 are stacked by a mechanical pressure-welding, for example.

[0044] An insulator 52 is provided recessed in the stator stack 50. A slot 53 as a recess part is defined in the insulator 52. The slot 53 is disposed substantially evenly in the circumferential direction of the stator stack 50. The winding 20 wound around the stator stack 50 is accommodated in the slot 53.

[0045] The frame hub 62 supports a circuit board (a printed board) 70. Wiring patterns for controlling the axial flow fan 200 are formed on the circuit board 70.

[0046] The winding 20 wound around the stator stack 50 and the circuit board 70 are electrically connected to each other via a connection terminal 71. The connection terminal 71 aggregates the connecting wires of the winding 20 and connects them to the circuit board 70.

[0047] In the circuit board 70, a through hole 75 for inserting the connection terminal 71 therein is bored. The protrusion part of the connection terminal 71 inserted in the through hole 75 is soldered to the circuit board 70.

[0048] The casing 2 defines a wind tunnel 5 that guides the airflow and defines an intake port 3 and an exhaust port 4 for the air at both ends. The casing 2 is integrally formed with a frame 60 having a flange part 64 (see FIG. 2). The flange part 64 of the present embodiment is formed in a rectangular

shape. At four corners of the flange part **64** insertion holes **65** for mounting not-shown mounting screws therein are opened.

[0049] As illustrated in FIG. 1 to FIG. 3, the frame **60** has a plurality of spokes **61** and the frame hub **62**.

[0050] The spokes **61** are extended from the casing **2** to the center in the radial direction of the casing **2** so as to be across the wind tunnel **5**. Each spoke **61** is formed bent in a wing shape in substantially the same direction for serving the rectifying function of the exhaust airflow.

[0051] The spokes **61** are connected by the frame hub **62** at the center in the radial direction of the casing **2**. The frame hub **62** is formed in a ring shape. An inner circumference part **62a** and an outer circumference part **62b** of the frame hub **62** are protruded. The bearing support part (the bushing) **63** is fitted into and fixed to the inner circumference part **62a** of the frame hub **62**.

[0052] Step parts **66** are formed in at least one surface of the frame hub **62**. In the present embodiment, two step parts **66** are formed in the inner bottom of the frame hub **62**. The two step parts **66** are concentrically formed.

[0053] Although two step parts **66** are formed in the inner bottom of the frame hub **62** in the present embodiment, the number of the step parts **66** is determined depending on the diameter of the frame hub **62** and thus is not limited to two. Further, the step parts **66** may be formed in the outer surface of the frame hub **62** or both surfaces (that is, the outer surface and the inner bottom) without limited to the inner bottom of the frame hub **62**.

[Arrangement of Series Axial Flow Fan]

[0054] Next, the arrangement of the series axial flow fan of the present embodiment will be described by referring to FIG. 4 to FIG. 6. FIG. 4 is a perspective view of the series axial flow fan of the present embodiment. FIG. 5 is a left side view illustrating the appearance of the intake side of the series axial flow fan of the present embodiment. FIG. 6 is a right side view illustrating the appearance of the exhaust side of the series axial flow fan of the present embodiment.

[0055] As illustrated in FIG. 4 to FIG. 6, in a series axial flow fan **300** of the present embodiment, at least a first axial flow fan **201** and a second axial flow fan **202** are connected in series in the axial direction of the rotating shaft **1** of the rotary motor **100**. The first axial flow fan **201** is arranged at the intake side, while the second axial flow fan **202** is arranged at the exhaust side. It is noted that, although two axial flow fans are connected in series in the present embodiment, three or more axial flow fans may be connected in series without limited to two.

[0056] In the present embodiment, the length of the first axial flow fan **201** in the axial direction is set longer than that of the axial flow fan **202** in the axial direction. The frame **60** is arranged to the exhaust port of the first axial flow fan **201** arranged at the exhaust side (see FIG. 1 and FIG. 2).

[0057] That is, in the series axial flow fan **300** of the present embodiment, the rotor blades **13** of the first axial flow fan **201** (see FIG. 5), the frame **60** as a stator blade, and the rotor blades **13** of the second axial flow fan **202** (see FIG. 6) are sequentially arranged in the airflow direction within the cylindrical casings **2** connected in series. It is noted that the frame may be arranged at the exhaust side of the second axial flow fan **202**.

[0058] The first axial flow fan **201** and the second axial flow fan **202** have substantially the same structure except that the first axial flow fan **201** has the frame **60** serving as the stator blade.

[0059] The first axial flow fan **201** may be of the same structure as the above-described axial flow fan **200**. The second axial flow fan **202** may be of the same structure as the above-described axial flow fan **200** except the feature regarding the frame **60**. Accordingly, the detailed description of the internal structure of the second axial flow fan **202** will be omitted.

[0060] In the second axial flow fan **202**, the positions in the axial direction of the rotor **110** and the stator **120** with the circuit board **70** are opposite to those in the first axial flow fan **201** (see FIG. 1). The orientation or the rotation direction of the rotor blades **13** is set so that the axial flow fans **201** and **202** connected in series form the continuous airflow having the same direction in spite of the reversed positions in the internal structure of the first axial flow fan **201** and the second axial flow fan **202** (see FIG. 5 and FIG. 6).

[Effect of Axial Flow Fan and Series Axial Flow Fan]

[0061] Next, the effect of the axial flow fan **200** and the series axial flow fan **300** will be described by referring to FIG. 1 to FIG. 3, FIG. 4, and FIG. 7 to FIG. 9.

[0062] As illustrated in FIG. 4, two of the first axial flow fan **201** and the second axial flow fan **202** of the present embodiment are connected in series, for example, and assembled as the series axial flow fan (the series fan motor) **300**.

[0063] The series axial flow fan **300** is mounted to, for example, a housing of electronic equipment. In mounting the series axial flow fan **300** to the housing, the mounting screws are screwed through the insertion holes **65** of the intake side flange part **64a** or the exhaust side flange part **64b** of the casing **2**. For example, when the series axial flow fan **300** is used as a cooling fan for a server, the intake side flange part **64a** is attached to the fan attachment part on the housing inner surface of the server.

[0064] The impeller **10** of the first axial flow fan **201** and the impeller **10** of the second axial flow fan **202** are rotated in the reverse directions, the example. The rotation of the impellers **10** of the first axial flow fan **201** and the second axial flow fan **202** causes air to be sucked from the intake port **3** of the first axial flow fan **201**.

[0065] The air sucked from the intake port **3** of the first axial flow fan **201** passes through the rotor blades **13** of the first axial flow fan, the frame **60** as the stator blade, and the rotor blades **13** of the second axial flow fan **202** in this order and is discharged from the exhaust port **4** of the second axial flow fan **202**.

[0066] As illustrated in FIG. 1 to FIG. 3, the frame **60** of the axial flow fan **200** (**201**) of the present embodiment has a plurality of spokes **61**. The spokes **61** are extended from the casing **2** to the center in the radial direction of the casing **2** so as to be across the wind tunnel **5**. The spokes **61** are connected by the frame hub **62** at the center in the radial direction of the casing **2**.

[0067] On the other hand, the rotating shaft **1** of the rotor **110** is pivotally supported in a rotatable manner via the bearing support part (the bushing) **63** and the bearing **16** fixed to the frame hub **62**. The impeller **10** is fixed to the rotor **110** and has the plurality of rotor blades **13**.

[0068] Therefore, the attempt to achieve a high cooling performance by increasing the rotating speed of the impeller

10 causes the increased individual vibration generated by the axial flow fan **200**. That is, the vibrancy caused by the rotation of the rotor **110** is transferred to the casing **2** via the bearing support part (the bushing) **63** and the frame **60** having the frame hub **62**. This increases the individual vibration of the axial flow fan **200**.

[0069] In the axial flow fan **200** (**201**) of the present embodiment, however, the step parts **66** are formed in at least one surface of the frame hub **62**. In the present embodiment, the step parts **66** are formed in the inner bottom of the frame hub **62**. According to the axial flow fan **200** (**201**) of the present embodiment, the step parts **66** formed in the inner bottom of the frame hub **62** allow for the attenuation of the vibration transferred to the frame hub **62**. Therefore, the vibration transferred to the frame hub **62** is unlikely to be transferred to the casing **2**.

[0070] Further, the two step parts **66** are formed in the inner bottom of the frame hub **62** of the present embodiment. Since these two step parts **66** are concentrically formed, the vibration can be attenuated without unevenness.

[0071] Furthermore, the step parts **66** are formed in one surface of the frame hub **62** and thus are not openings. Therefore, the step parts **66** do not affect the airflow at the exhaust side. It is noted that the number of the step parts **66** is determined depending on the diameter of the frame hub **62**.

<Comparison Form>

[0072] Next, by referring to FIG. 7 to FIG. 9, the advantageous effects of the axial flow fan **200** of the present embodiment will be examined in comparison with the axial flow fan having the frame of the known structure as a comparison form. FIG. 7 is an inside front view of the frame of the axial flow fan of the comparison form. FIG. 8 is a sectional view of the upper half part of the frame of the axial flow fan of the comparison form. FIG. 9 is a diagram used for the illustration of the vibration reduction effect of the axial flow fan of the present embodiment.

[0073] As illustrated in FIG. 7 and FIG. 8, in an axial flow fan **400** of the comparison form, the inner bottom surface of a frame hub **462** of a frame **460** is formed flat. The surface of the frame hub **462** is also formed flat.

<Vibration Measurement Result>

[0074] The individual vibration was measured for both of the axial flow fan **200** of the present embodiment and the axial flow fan **400** of the comparison form. The measurement result is shown in FIG. 9.

[0075] As illustrated in FIG. 9, in the axial flow fan (the embodiment example) **200** of the present embodiment, the vibration reduction effect of approximately 50% was obtained compared to the axial flow fan (the comparison example) **400** of the comparison form.

[0076] This is considered as follows. In the axial flow fan (the comparison example) **400** of the comparison form, both surfaces of the frame hub **462** are flat. Thus, the vibration generated by the rotation of the rotor is easily transferred to the casing **2** via the bearing, support part (the bushing) **463** and the frame **460** having the frame hub **462**. This resulted in a larger individual vibration of the axial flow fan **400**.

[0077] As having been described above, in the axial flow fan **200** and the series axial flow fan **300** of the present embodiment, the step parts **66** are formed in at least one surface of the frame hub **62**. These step parts **66** allow for the

attenuation of the vibration transferred to the frame hub from the rotor **110** via the bearing support part (the bushing) **63**. As a result, the vibration is unlikely to be transferred to the casing **2**.

[0078] Therefore, the axial flow fan **200** and the series axial flow fan **300** of the present embodiment have the simple structure and are able to reduce the individual vibration of the axial flow fan **200** and the series axial flow fan **300** even when the rotating speed of the impeller **10** is high, while suppressing the reduction in the strength of the frame hub **62** and the affection on the airflow at the exhaust side.

[0079] As set forth, the preferable embodiments of the present disclosure have been described. They are mere examples for the purpose of illustration of the technique of the present disclosure and do not limit the scope of the present disclosure. The technique of the present disclosure can be implemented in various ways which are different from the above-described embodiments as long as not departing from its spirit.

[0080] It is noted that the present disclosure can relate to the improvement of the frame structure of the axial flow fan in which the rotary motor is incorporated in the impeller having a plurality of rotor blades, and the frame structure of the series axial flow fan. The frame **60** of the axial flow fan **200** and the series axial flow fan **300** of the present embodiment has the simple structure and is able to reduce the individual vibration of the axial flow fan **200** and the series axial flow fan **300** even when the rotating speed of the impeller **10** is high, while suppressing the reduction in the strength of the frame hub **62** and the affection on the airflow in the exhaust side.

[0081] The step part **66** may be expressed as a groove part or a ring-like groove part.

[0082] Another purpose of the present disclosure is to provide the axial flow fan and the series axial flow fan having the frame with the simple structure that does not reduce the strength of the frame hub not affect the an flow at the exhaust side and allows for the reduction of the individual vibration even under a high rotating speed.

[0083] Further, the axial flow fan of the embodiment of the present disclosure may be as follows. This axial flow fan has: a casing defining a wind tunnel; a frame having a plurality of spokes extended from the casing to the center in the radial direction of the casing so as to be across the wind tunnel, and a frame hub connecting the plurality of spokes at the center; a stator supported by the frame hub, in which a winding is wound around the stator; a rotor pivotally supported by the frame hub in a rotatable manner and having a permanent magnet; and an impeller fixed to the rotor and having a plurality of rotor blades, wherein a step part is formed in at least one surface of the frame hub.

[0084] In this axial flow fan, the step part may be concentrically formed in the inner bottom surface of the frame hub.

[0085] Further, in the series axial flow fan of the present disclosure, a plurality of the above-described axial flow fans may be connected in series in the axial direction of the rotating shaft of the rotor.

[0086] The foregoing detailed description has been presented for the purposes of illustration and description. Many modifications and variations are possible in light of the above teaching. It is not intended to be exhaustive or to limit the subject matter described herein to the precise form disclosed. Although the subject matter has been described in language specific to structural features and/or methodological acts, it is to be understood that the subject matter defined in the

appended claims is not necessarily limited to the specific features or acts described above. Rather, the specific features and acts described above are disclosed as example forms of implementing the claims appended hereto.

What is claimed is:

1. An axial flow fan comprising:
 - a casing defining a wind tunnel;
 - a frame having a plurality of spokes extended from the casing to the center in a radial direction of the casing so as to be across the wind tunnel, and a frame hub connecting the plurality of spokes at the center in the radial direction of the casing;
 - a stator supported by the frame hub, wherein a winding is wound around the stator;
 - a rotor pivotally supported by the frame hub in a rotatable manner and having a permanent magnet;
 - an impeller fixed to the rotor and having a plurality of rotor blades; and
 - a step part formed in at least one surface of the frame hub.
2. The axial flow fan according to claim 1, wherein a plurality of the step parts are concentrically formed in an inner bottom surface of the frame hub.
3. A series axial flow fan comprising a plurality of axial flow fans according to claim 1,
 - wherein the axial flow fans are connected in series in an axial direction of a rotating shaft of the rotor.
4. A series axial flow fan comprising a plurality of axial flow fans according to claim 2,
 - wherein the axial flow fans are connected in series in an axial direction of a rotating shaft of the rotor.

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