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(54) **AXIAL FAN**

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(52) **U.S. Cl.**

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(57) **ABSTRACT**

An axial fan includes: an impeller cup including a blade extending in a radial direction; a motor configured to rotate the impeller cup; and a housing accommodating the impeller cup and the motor. The housing includes: a casing portion covering an outer periphery of the impeller cup; a base portion supporting the motor; and a spoke portion connecting the base portion and the casing portion. The casing portion includes an inlet surface where air is drawn in, and an outlet surface where air is discharged. The casing portion is provided with a level difference portion at least partially in an inner peripheral surface of the casing portion on the outlet surface side.

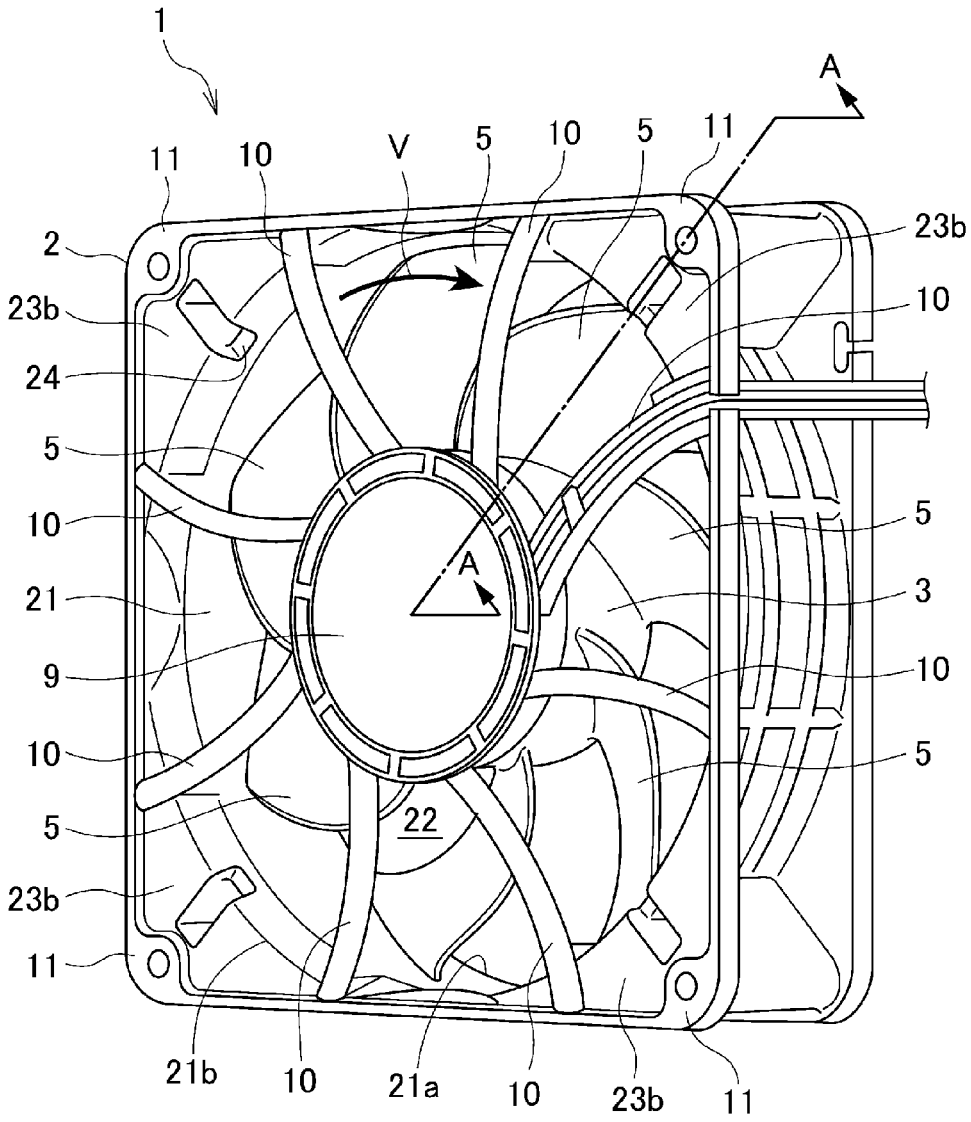

FIG. 1

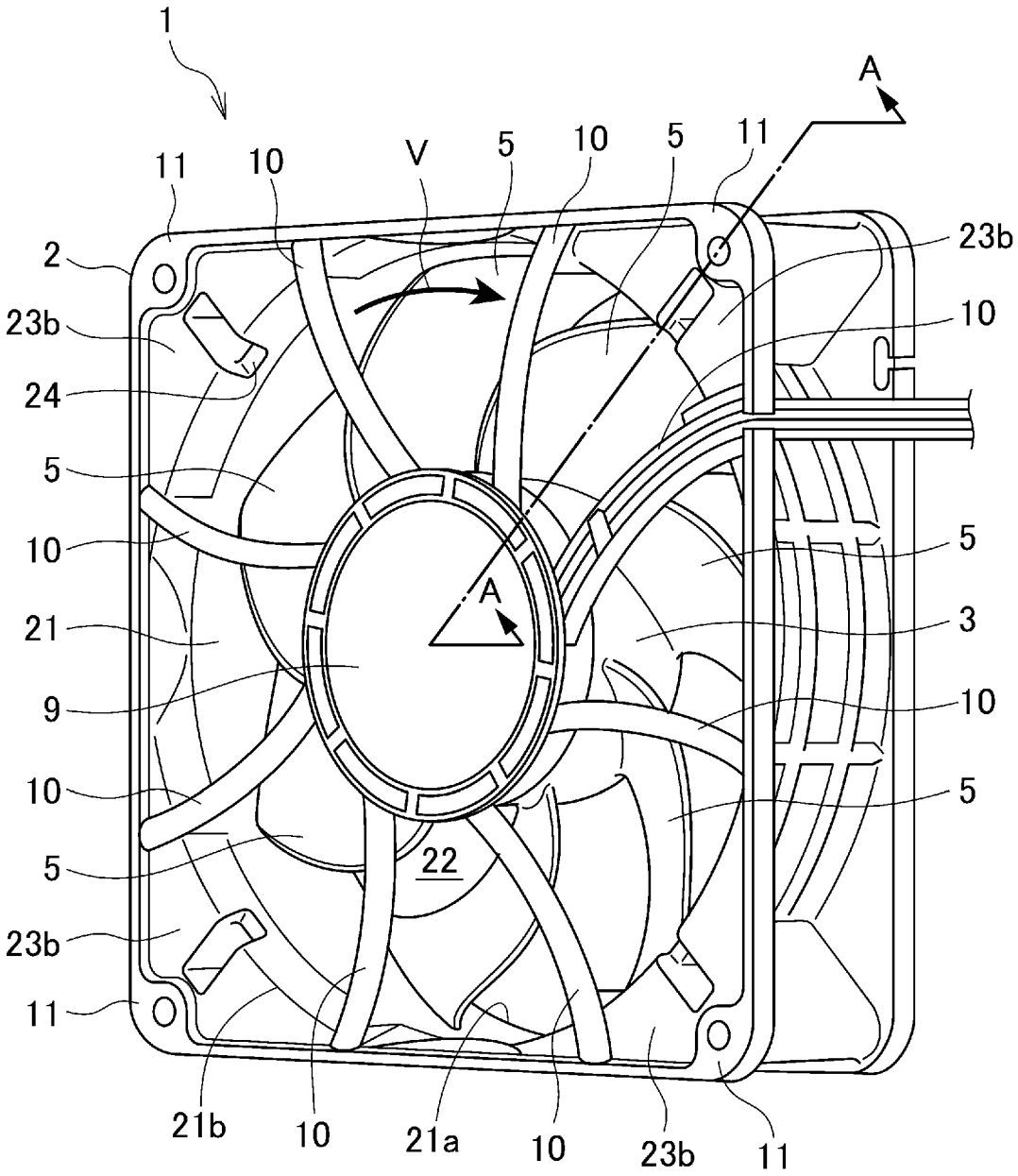
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FIG. 2

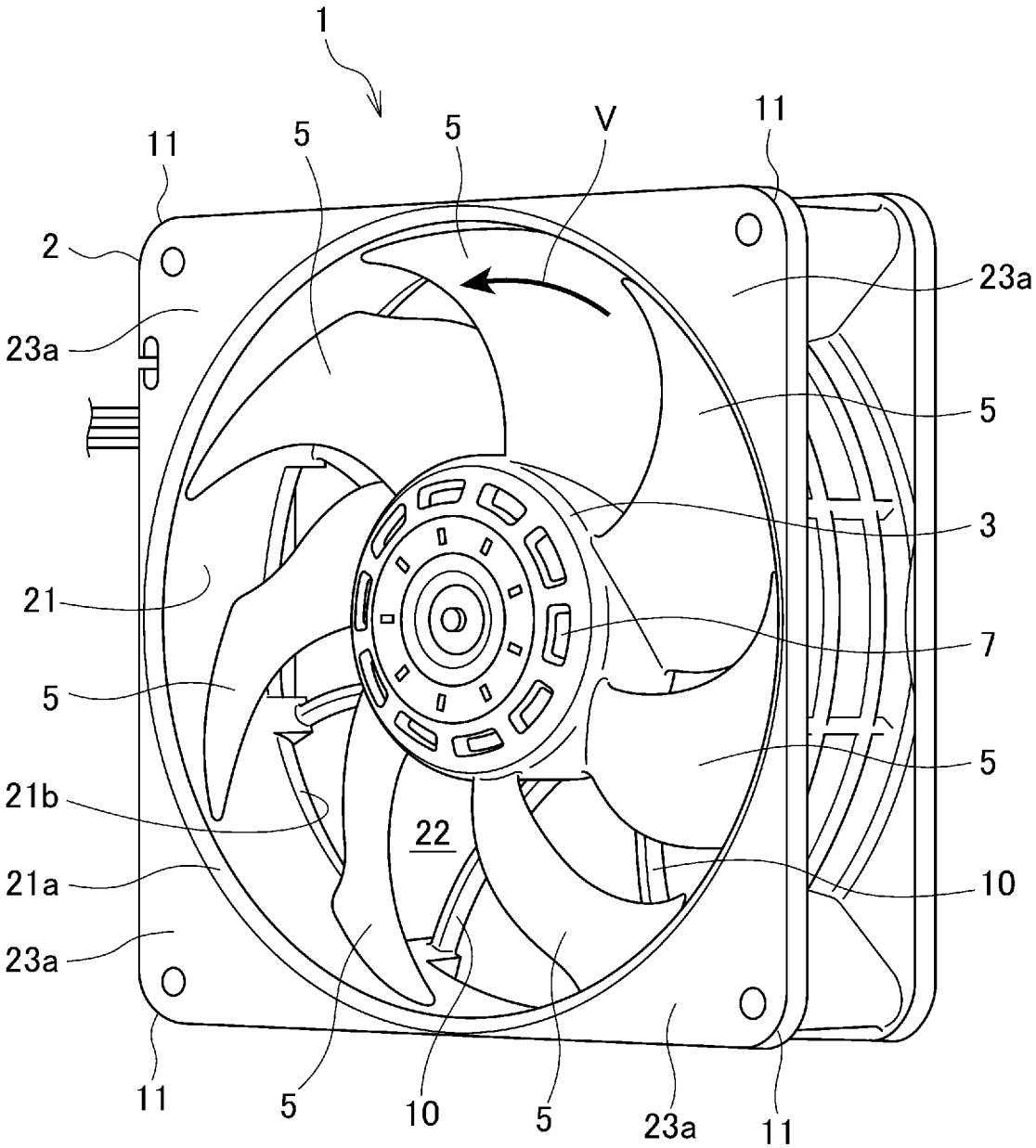
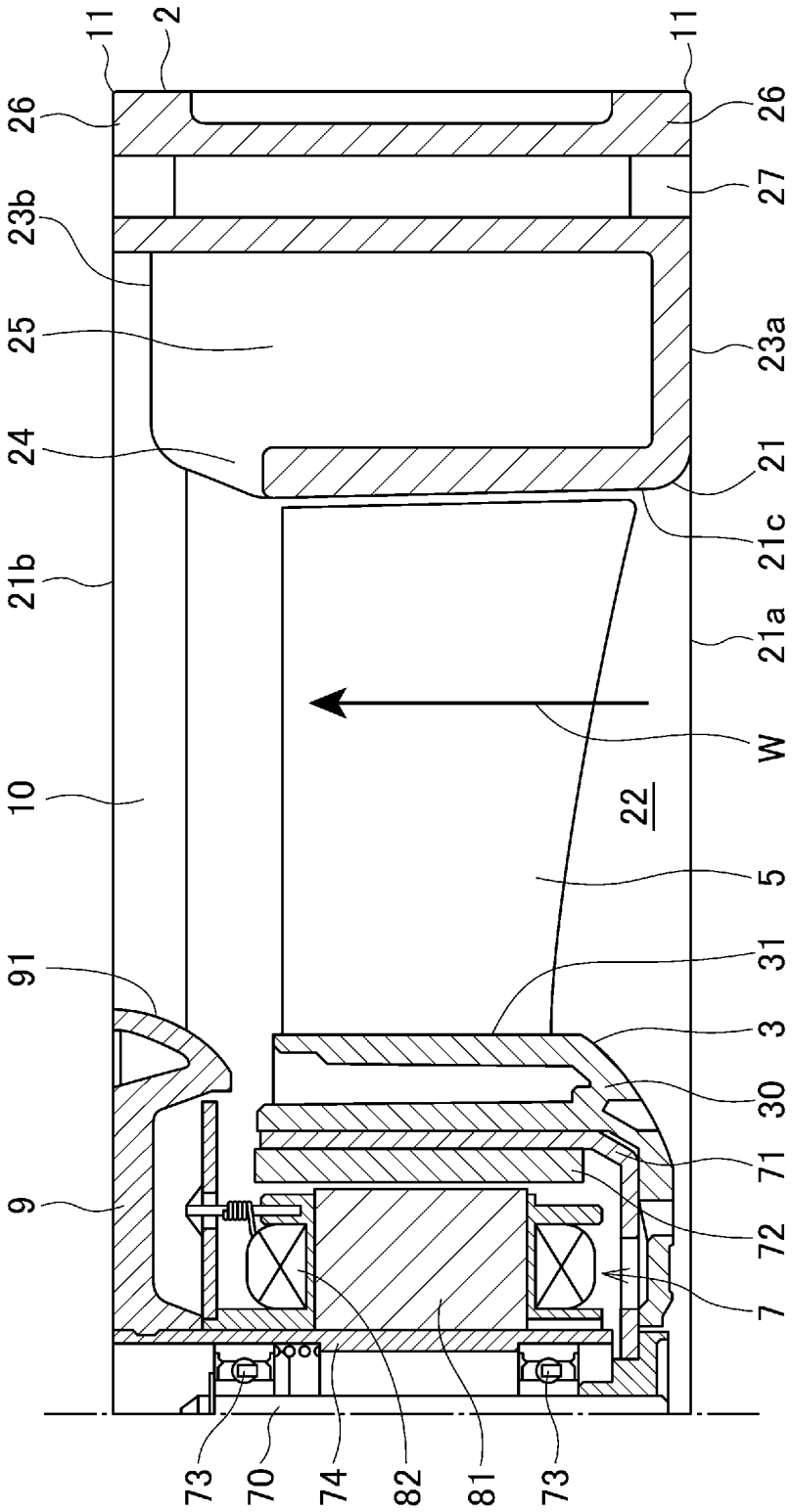


FIG. 3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26
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27
23b
25
23a
24
21
21c
21b
21a
W
22
10
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82
81
73

FIG. 4

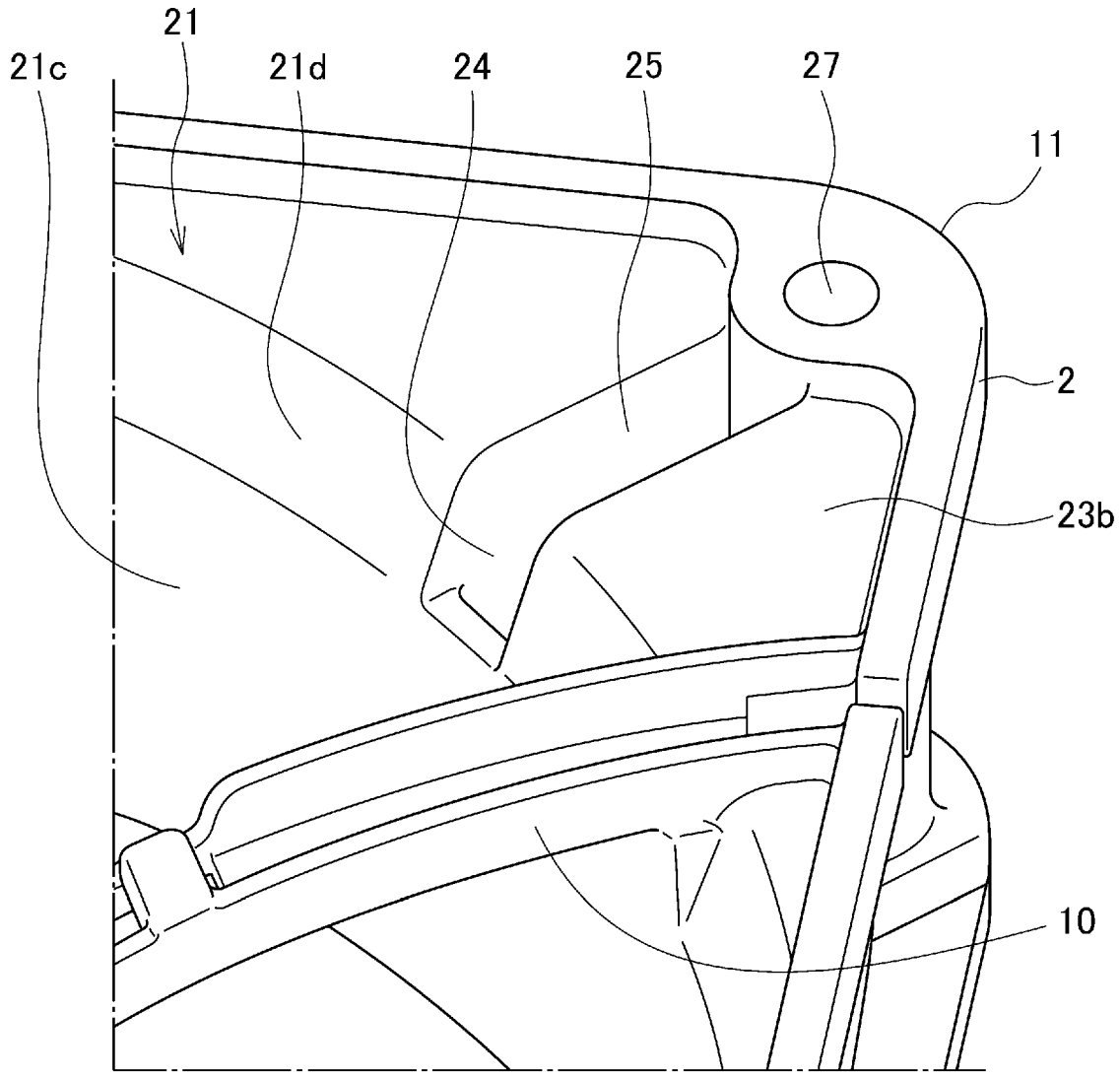


FIG. 5

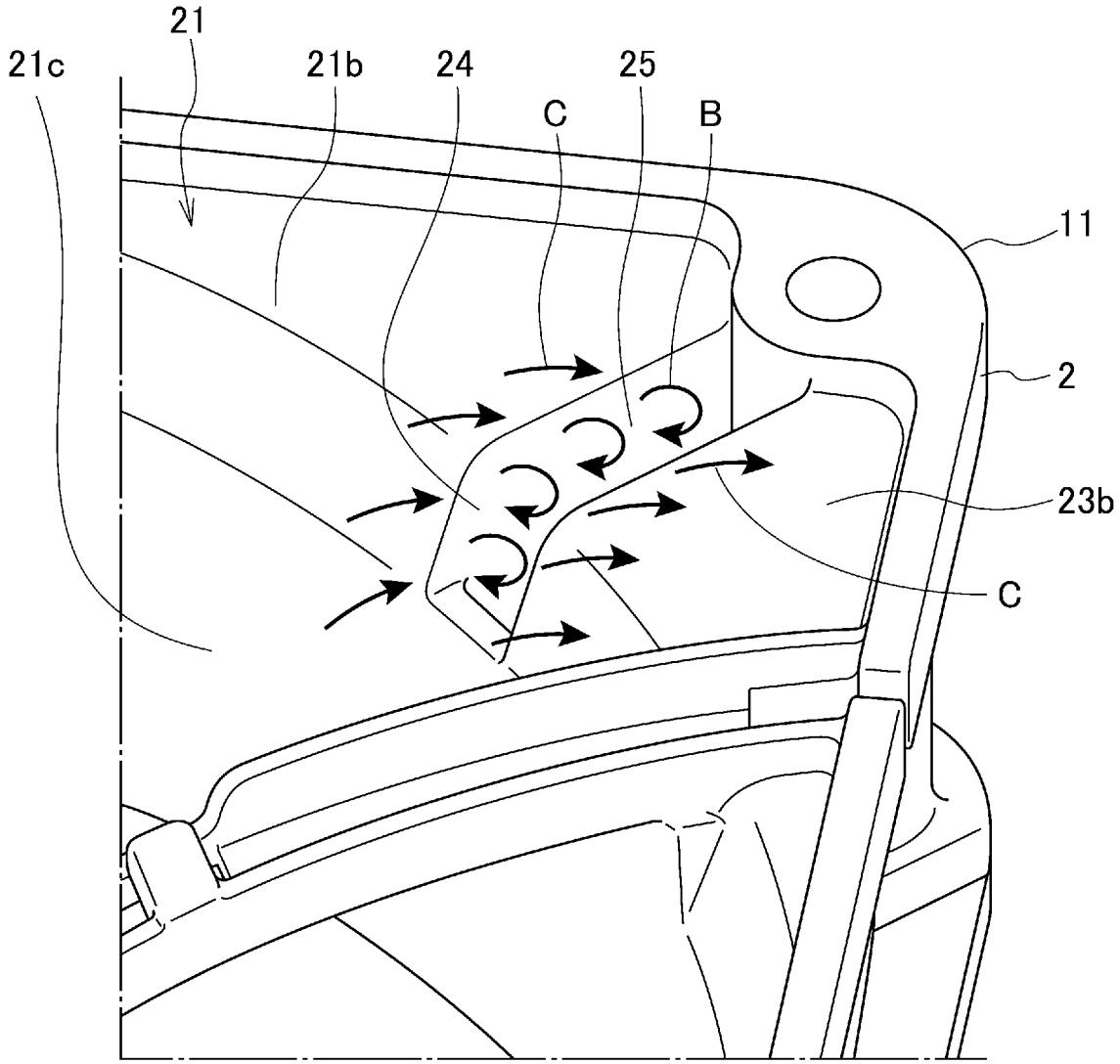


FIG. 6

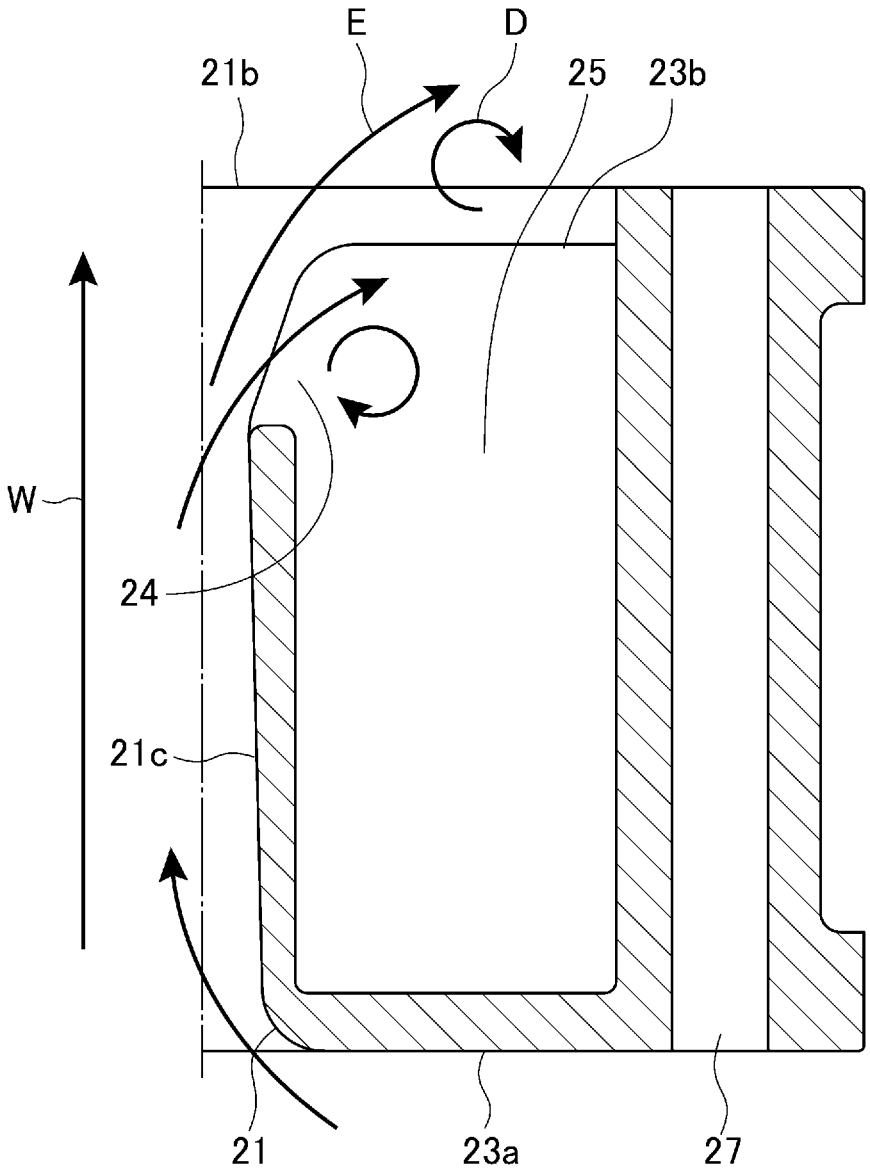
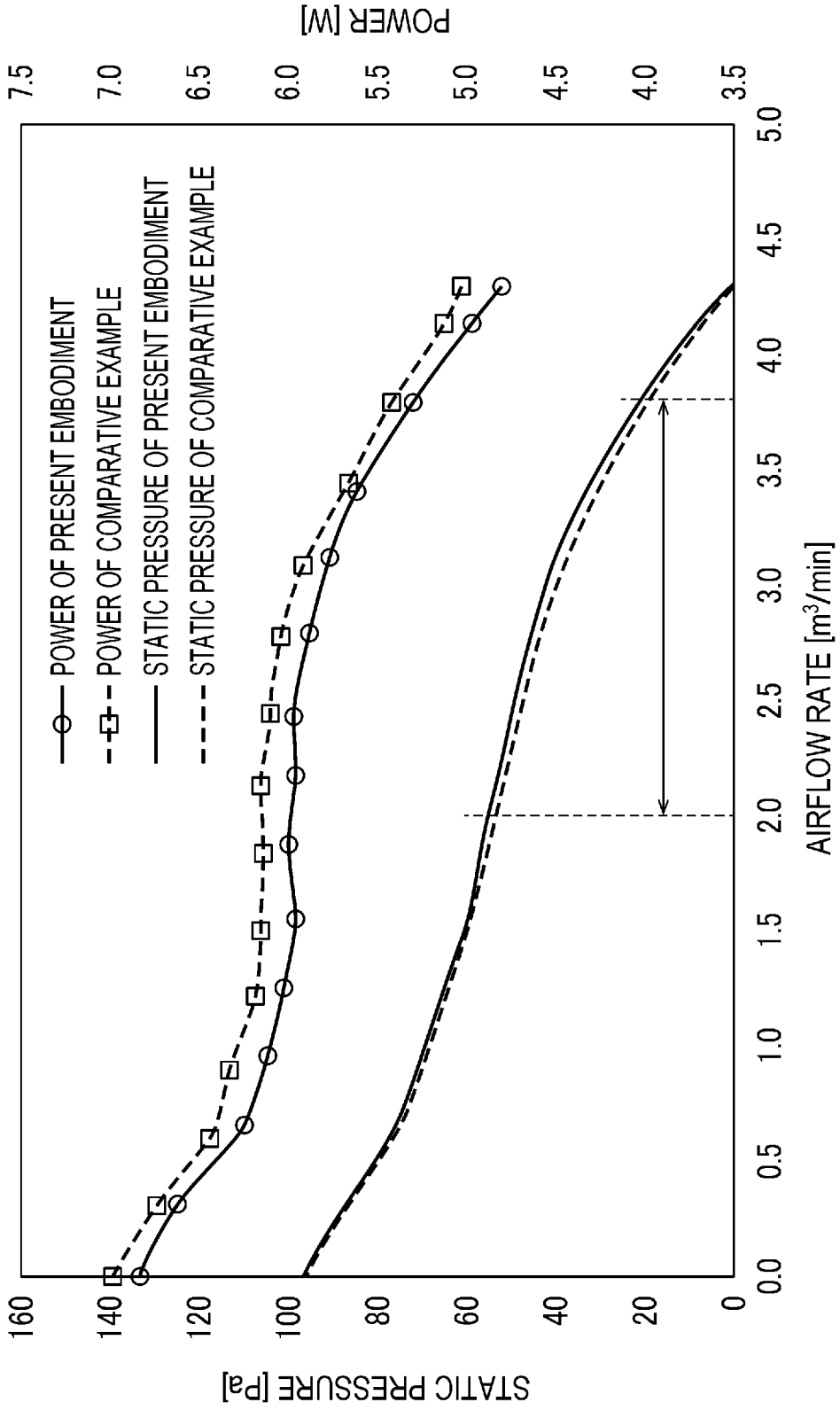


FIG. 7


POWER [W]
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
POWER OF PRESENT EMBODIMENT
POWER OF COMPARATIVE EXAMPLE
STATIC PRESSURE OF PRESENT EMBODIMENT
STATIC PRESSURE OF COMPARATIVE EXAMPLE
160
140
120
100
80
60
40
20
0
STATIC PRESSURE [Pa]
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
AIRFLOW RATE [m3/min]

# AXIAL FAN

## CROSS-REFERENCE TO RELATED APPLICATION

**[0001]** This application is based on Japanese Patent Application No. 2022-132016 filed with the Japan Patent Office on Aug. 22, 2022, the entire content of which is hereby incorporated by reference.

## BACKGROUND

### 1. Technical Field

**[0002]** One aspect of the present disclosure relates to an axial fan.

### 2. Related Art

**[0003]** A frame of an axial fan is conventionally thinned from the perspective of a material reduction and from the perspective of product quality at the time of molding. For example, an axial fan disclosed in JP-A-2017-137871 is provided with a lightening portion on an inlet surface side of the frame.

**[0004]** However, providing the frame with the lightening portion may affect the flow of air in the axial fan. Hence, the position where in the frame the lightening portion is provided is important. However, JP-A-2017-137871 does not disclose the relationship between the position where the lightening portion is provided and the flow of air in the axial fan. Therefore, there is room for improvement in the relationship between the position where in the frame the lightening position is provided and the air flow efficiency of the fan.

**[0005]** Hence, an object of the present disclosure is to provide an axial fan whose air flow efficiency can be increased.

## SUMMARY

**[0006]** An axial fan includes: an impeller cup including a blade extending in a radial direction; a motor configured to rotate the impeller cup; and a housing accommodating the impeller cup and the motor. The housing includes: a casing portion covering an outer periphery of the impeller cup; a base portion supporting the motor; and a spoke portion connecting the base portion and the casing portion. The casing portion includes an inlet surface where air is drawn in, and an outlet surface where air is discharged. The casing portion is provided with a level difference portion at least partially in an inner peripheral surface of the casing portion on the outlet surface side.

## BRIEF DESCRIPTION OF DRAWINGS

**[0007]** FIG. **1** is a perspective view of an axial fan according to an embodiment of the present disclosure as viewed from an air outlet side;

**[0008]** FIG. **2** is a perspective view of the axial fan illustrated in FIG. **1** as viewed from an air inlet side;

**[0009]** FIG. **3** is a cross-sectional view of the axial fan illustrated in FIG. **1**, taken along line A-A;

**[0010]** FIG. **4** is a partial enlarged view illustrating a level difference portion and a lightening portion of a casing portion;

**[0011]** FIG. **5** is a perspective view schematically illustrating the flow of air on the outlet side of the axial fan illustrated in FIG. **1**;

**[0012]** FIG. **6** is a cross-sectional view schematically illustrating the flow of air on the outlet side of the axial fan illustrated in FIG. **1**; and

**[0013]** FIG. **7** is a graph illustrating the relationship between airflow rate and static pressure characteristics and the relationship between airflow rate and power consumption in the axial fan according to the embodiment of the present disclosure and an axial fan of a comparative example.

## DETAILED DESCRIPTION

**[0014]** 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.

**[0015]** An axial fan of one aspect of the present disclosure includes: an impeller cup including a blade extending in a radial direction; a motor configured to rotate the impeller cup; and a housing accommodating the impeller cup and the motor. The housing includes: a casing portion covering an outer periphery of the impeller cup; a base portion supporting the motor; and a spoke portion connecting the base portion and the casing portion. The casing portion includes an inlet surface where air is drawn in, and an outlet surface where air is discharged. The casing portion is provided with a level difference portion at least partially in an inner peripheral surface of the casing portion on the outlet surface side.

**[0016]** An axial fan of another aspect of the present disclosure includes: an impeller cup including a blade extending in a radial direction; a motor configured to rotate the impeller cup; and a housing accommodating the impeller cup and the motor. The housing includes: a casing portion covering an outer periphery of the impeller cup; a base portion supporting the motor; and a spoke portion connecting the base portion and the casing portion. The casing portion includes an inlet surface where air is drawn in, and an outlet surface where air is discharged. A lightening portion is open in the outlet surface of the casing portion, at a position off an extension line of the spoke portion in a longitudinal direction of the spoke portion.

**[0017]** According to the one aspect and the another aspect of the present disclosure, it is possible to provide an axial fan whose air flow efficiency can be increased.

**[0018]** An embodiment of the present disclosure is described hereinafter with reference to the drawings. Note that descriptions of members having the same reference numerals as members that have already been described are omitted in the detailed description for the convenience of description. Moreover, the dimensions of each member illustrated in the drawings may be different from actual dimensions thereof for the convenience of description.

**[0019]** FIG. **1** is a perspective view of an axial fan according to the embodiment of the present disclosure as viewed from an air outlet side. FIG. **2** is a perspective view of the axial fan illustrated in FIG. **1** as viewed from an air inlet side. As illustrated in FIGS. **1** and **2**, an axial fan **1**

according to the embodiment includes a housing **2**, an impeller cup **3** placed in the housing **2**, and a motor **7** that rotates the impeller cup **3**. The impeller cup **3** includes a plurality of (seven in this example) blades **5** that extend in the radial direction. The motor **7** is accommodated in a cup of the impeller cup **3**.

**[0020]** The housing **2** accommodates the impeller cup **3** and the motor **7**. The entire housing **2** is formed in a polygonal shape (a rectangular shape in this example). The housing **2** includes a cylindrical casing portion **21** that covers the outer periphery of the impeller cup **3**, a base portion **9** that supports the motor **7** accommodated in the impeller cup **3**, spoke portions **10** that connect the base portion **9** and the casing portion **21**, and corner portions **11** that form a rectangle. The housing **2** is mainly made of resin.

**[0021]** The casing portion **21** includes an inlet **21***a* through which air is drawn in (an opening in the casing portion on the front side in FIG. **2**), and an outlet **21***b* through which the air that has been drawn in is discharged (an opening in the casing portion on the front side in FIG. **1**). The casing portion **21** forms an airway **22** that communicates with the inlet **21***a* and the outlet **21***b*. With the rotation of the blades **5**, the air drawn in through the inlet **21***a* is sent in a direction along the airway **22** (hereinafter referred to as an air-blowing direction W), and discharged to the outside through the outlet **21***b*. Moreover, the casing portion **21** includes an inlet surface **23***a* provided to the outer peripheral portion of the inlet **21***a*, and an outlet surface **23***b* provided to the outer peripheral portion of the outlet **21***b*. FIG. **1** is a perspective view of the axial fan **1** as viewed from the outlet **21***b* side of the casing portion **21**. FIG. **2** is a perspective view of the axial fan **1** as viewed from the inlet **21***a* side of the casing portion **21**. Note that a direction of an arrow V illustrated in the drawings indicates the rotation direction of the blades **5**.

**[0022]** FIG. **3** is a cross-sectional view of the axial fan **1** illustrated in FIG. **1**, taken along line A-A. As illustrated in FIG. **3**, a central portion of a cup **30** of the impeller cup **3** is fixed to a rotary shaft **70** of the motor **7**. In the following description, a direction along the rotary shaft **70** is referred to as the "axial direction," and a direction of the radius centered around the rotary shaft **70** is referred to as the "radial direction," or "radially".

**[0023]** The rotary shaft **70** is provided in a central portion of the airway **22** in such a manner as to be along the airway **22** (the air-blowing direction W). The impeller cup **3** is fixed to the rotary shaft **70** in such a manner as to orient the opening side of the cup **30** in a direction toward the outlet **21***b* of the airway **22** and be along the airway **22**. An outer peripheral side surface **31** of the cup **30**, the outer peripheral side surface **31** being on the outer side in the radial direction, forms an inner peripheral surface of the airway **22** on the inlet **21***a* side. The outer peripheral side surface **31** of the cup **30** is formed in such a manner as to extend parallel to the air-blowing direction W. The impeller cup **30** having the blades **5** rotates, together with the rotary shaft **70**, in the airway **22**. Consequently, the air is sent in the air-blowing direction W.

**[0024]** The plurality of blades **5** is provided in such a manner as to extend in the radial direction from the outer peripheral side surface **31** of the cup **30**. The blades **5** are provided integrally with the cup **30**. Each of the plurality of blades **5** is provided in such a manner as to be inclined relative to a direction of the rotary shaft **70**.

**[0025]** The motor **7** is accommodated in the cup **30** of the impeller cup **3**, as a device that rotationally drives the blades **5**. The motor **7** includes an approximately cup-shaped rotor yoke **71**, the rotary shaft **70** press-fitted in a central portion of the rotor yoke **71**, and a stator core **81** around which a coil **82** is wound.

**[0026]** The rotor yoke **71** is fitted in the cup **30** of the impeller cup **3**, and rotates together with the rotary shaft **70**. A magnet **72** is attached to an inner surface of the rotor yoke **71**. The rotary shaft **70** is rotatably supported by a bearing **73**. The bearing **73** is fixed to an inner surface of a tubular support portion **74**. The stator core **81** is fixed to an outer surface of the support portion **74**. An outer surface of the stator core **81** faces an inner surface of the magnet **72** of the rotor yoke **71** with a gap therebetween.

**[0027]** Moreover, the stator core **81** of the motor **7** is attached to the base portion **9**. The base portion **9** is formed in an approximately cup shape. The base portion **9** is provided on the outlet **21***b* side of the airway **22** in such a manner that the opening side of the base portion **9** faces the opening side of the cup **30** of the impeller cup **3**. A central portion of the base portion **9** is attached to the stator core **81** of the motor **7**, and is fixed to the outer surface of the support portion **74**. An outer peripheral side surface **91** of the base portion **9**, the outer peripheral side surface **91** being on the outer side in the radial direction, forms the inner peripheral surface of the airway **22** on the outlet **21***b* side. The base portion **9** is provided in the central portion of the airway **22** coaxially with the airway **22**.

**[0028]** The spoke portions **10** that couple the base portion **9** and the casing portion **21** are provided on the outlet **21***b* side of the housing **2**. A plurality of the spoke portions **10** is provided to the base portion **9** at substantially regular intervals in a circumferential direction of the base portion **9**. The base portion **9** and the motor **7** attached to the base portion **9** are supported by the plurality of the spoke portions **10** on the casing portion **21**.

**[0029]** The casing portion **21** includes level difference portions **24** in an inner peripheral surface **21***c* on the outlet surface **23***b* side. The level difference portions **24** are provided partially in the inner peripheral surface **21***c* in the circumferential direction. Moreover, the casing portion **21** includes lightening portions **25** in the outlet surface **23***b*. The lightening portions **25** are formed parallel to the air-blowing direction W from the outlet surface **23***b* toward the inlet surface **23***a*. The level difference portions **24** and the lightening portions **25** are further described below by use of FIG. **4**.

**[0030]** An edge of each of the corner portions **11** of the housing **2** is provided with flange portions **26** for fixing the housing **2** to, for example, an electronic apparatus. The flange portions **26** are provided, extending radially outward in the housing **2** from the inlet surface **23***a* and the outlet surface **23***b* of the casing portion **21**. A fixing hole **27** is formed in the flange portions **26** in such a manner as to penetrate the housing **2**. The axial fan **1** can be attached to, for example, an electronic apparatus by, for example, inserting a screw into the fixing hole **27**.

**[0031]** FIG. **4** is a partial enlarged view illustrating the level difference portion **24** and the lightening portion **25** of the casing portion **21**. As illustrated in FIG. **4**, the level difference portion **24** is formed in the inner peripheral surface **21***c* in such a manner as to have a shape recessed from the outlet surface **23***b* toward the inlet surface **23***a*

along the airway **22**. The level difference portion **24** of this example is formed as a rectangular recess. Note that there is, for example, a case where an end on the outlet surface **23***b* side of the inner peripheral surface **21***c* of the casing portion **21** is provided with a tapered portion **21***d* that increases in diameter toward the outlet surface **23***b* as illustrated in FIG. **4**. In this case, the level difference portion **24** is preferably a level difference having the same length (depth) as the length of the tapered portion **21***d* along the airway **22**.

**[0032]** The lightening portions **25** are formed partially in the outlet surface **23***b*. The outlet surface **23***b* is provided on the outer peripheral portion of the outlet **21***b*. For example, the area of a region provided to the corner portion **11** of the housing **2** on the outlet surface **23***b* is greater than the area of a region provided to a side of the housing **2** on the outlet surface **23***b*. The lightening portion **25** is formed in the region provided to the corner portion **11** of the housing **2** on the outlet surface **23***b* in such a manner as to extend toward the central portion (the rotary shaft **70**) of the airway **22**. The lightening portion **25** is open in the form of, for example, a rectangle in plan view perpendicular to the outlet surface **23***b*.

**[0033]** The level difference portion **24** and the lightening portion **25** are provided near the corner portion **11**. Moreover, the level difference portion **24** and the lightening portion **25** are provided in the outlet surface **23***b* of the casing portion **21**, at a position off an extension line of the spoke portion **10** in a longitudinal direction thereof. In other words, a position on the casing portion **21** where a radially outer end of the spoke portion **10** is connected is set in such a manner as to be different from the position on the casing portion **21** where the level difference portion **24** and the lightening portion **25** are formed. Each of the spoke portions **10** is connected to the outlet surface **23***b* of the casing portion **21**, at a position away in the circumferential direction from the position where the level difference portion **24** and the lightening portion **25** are formed.

**[0034]** The level difference portion **24** is provided between the lightening portion **25** and the airway **22** being the internal opening of the casing portion **21**. The lightening portion **25** is coupled to the airway **22** of the casing portion **21** via the level difference portion **24**. In other words, a radially inner end of the lightening portion **25** that is formed toward the central portion of the airway **22** is connected to the level difference portion **24** formed in the inner peripheral surface **21***c* of the casing portion **21**, and is coupled to the airway **22** of the casing portion **21**. Note that the level difference portion **24** and the lightening portion **25** are provided in the outlet surface **23***b* of each of the corner portions **11**.

**[0035]** FIG. **5** is a perspective view schematically illustrating the flow of air on the outlet **21***b* side of the axial fan **1**. FIG. **6** is a cross-sectional view schematically illustrating the flow of air on the outlet **21***b* side of the axial fan **1**. As illustrated in FIG. **5**, the casing portion **21** is provided with the level difference portion **24** and the lightening portion **25** to allow air to flow like a vortex indicated by, for example, an arrow B at the level difference portion **24** and the lightening portion **25**. As a result, it is possible to reduce resistance to air flowing outside the level difference portion **24** and the lightening portion **25**, for example, resistance to the flow of air indicated by, for example, an arrow C. Hence, the flow of air can be made smooth on the outlet **21***b* side.

**[0036]** Moreover, as illustrated in FIG. **6**, the casing portion **21** is provided with the level difference portion **24** and the lightening portion **25** to allow air to flow unevenly as indicated by, for example, an arrow D at the level difference portion **24** and the lightening portion **25**. As a result, air flowing near the inner peripheral surface **21***c* of the casing portion **21** can be guided to the level difference portion **24** as indicated by, for example, an arrow E. Therefore, the flow of air to the outside of the housing can be made smooth on the outlet **21***b* side.

**[0037]** As described above, in the axil fan **1** according to the embodiment of the present disclosure, the level difference portions **24** are provided at least partially in the inner peripheral surface **21***c* of the casing portion **21** on the outlet surface **23***b* side. According to this configuration, the vortices of air are formed by the level difference portions **24**. Hence, it is possible to reduce resistance to the air flowing near the inner peripheral surface **21***c* of the casing portion **21**. As a result, it is possible to increase the air flow efficiency of the axial fan **1**.

**[0038]** Moreover, in the axial fan **1**, the lightening portion **25** is provided in the outlet surface **23***b* of the casing portion **21**, at the position off the extension line of each of the spoke portions **10** in the longitudinal direction thereof. According to this configuration, the spaces into which the air flowing near the inner peripheral surface **21***c* of the casing portion **21** flows are formed by the lightening portions **25**. As a result, it is possible to reduce the resistance to the air flowing near the inner peripheral surface **21***c*. As a result, it is possible to increase the air flow efficiency of the axial fan **1**. Moreover, the lightening portion **25** is provided at the position off the extension line of the each of the spoke portions **10** in the longitudinal direction thereof, which enables easy thinning of the housing **2** at the time of manufacture.

**[0039]** Moreover, in the axial fan **1**, the level difference portion **24** is provided between the respective lightening portion **25** and the airway **22** of the casing portion **21** and couples the lightening portion **25** and the airway **22**. In this manner, providing the level difference portion **24** between the respective lightening portion **25** and the airway **22** facilitates the air flowing near the inner peripheral surface **21***c* of the casing portion **21** flowing into the respective lightening portion **25**. As a result, it is possible to reduce the resistance to the air flowing near the inner peripheral surface **21***c*. Hence, it is possible to increase the air flow efficiency of the axial fan **1**. Moreover, the thickness between the lightening portion **25** and the airway **22** of the casing portion **21** can be reduced. Therefore, it makes it still easier for air to flow into the lightening portions **25**.

**[0040]** Moreover, in the axial fan **1**, the housing **2** is formed in a polygonal shape having a plurality of the corner portions **11** in plan view along the air-blowing direction W, and the level difference portion **24** and the lightening portion **25** are provided near each of the plurality of the corner portions **11**. In this manner, providing the level difference portion **24** and the lightening portion **25** near the each of the corner portions **11** enables using dead space (the outlet surface **23***b*) that is present in the corner portion **11**. Hence, it is possible to avoid an increase in the size of the axial fan **1**.

**[0041]** Next, results of a test carried out to check an increase in the air flow efficiency of the axial fan **1** according to the embodiment of the present disclosure are described. FIG. **7** is a graph illustrating the relationship between airflow

rate and static pressure characteristics and the relationship between airflow rate and power consumption in the axial fan **1** of the embodiment and an axial fan of a comparative example. Note that the axial fan of the comparative example is configured, omitting the level difference portions **24** and the lightening portions **25** from the configuration of the axial fan **1** of the embodiment.

**[0042]** As illustrated in FIG. **7**, it can be seen that in terms of a comparison based on the airflow-static pressure characteristics, the performance of the axial fan **1** of the embodiment in the operating region of the axial fan, for example, the performance of the axial fan **1** of the embodiment at airflow rates of 2.0 to 3.8 [$m^3$/min], is higher than the performance of the axial fan of the comparative example. Moreover, it can be seen that in terms of a comparison based on the airflow rate-power consumption, the power consumption of the axial fan **1** of the embodiment is lower by approximately five percent than the power consumption of the axial fan of the comparative example. Note that the rotational speed of the axial fans was set at 3050 rpm in the test.

**[0043]** Up to this point the embodiment of the present disclosure has been described. In terms of this, it is, however, needless to say that the technical scope of the present disclosure should not be construed in a limited manner by the detailed description. The embodiment is a mere example. Those skilled in the art understand that the embodiment can be modified in various manners within the technical scope of the present disclosure described in the claims. The technical scope of the present disclosure should be determined on the basis of the scope described in the claims and the scope of equivalents thereof.

**[0044]** The case where a single level difference portion **24** and a single lightening portion **25** are provided to the corner portion **11** of the housing **2** is described in the above-mentioned embodiment. However, this configuration is not essential. For example, a plurality of the level difference portions **24** and a plurality of the lightening portions **25** may be provided to the corner portion **11** of the housing **2**.

**[0045]** Moreover, in the example described in the above-mentioned embodiment, the level difference portion **24** is a rectangular recess formed in the inner peripheral surface **21***c* along the airway **22**. However, this configuration is not essential. The shape of the level difference portion **24** may be, for example, semi-circular or elliptic.

**[0046]** Furthermore, in the example described in the above-mentioned embodiment, the lightening portion **25** is formed in a rectangular shape in plan view perpendicular to the outlet surface **23***b*. However, this configuration is not essential. The shape of the lightening portion **25** may be, for example, circular or elliptic.

**[0047]** 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 fan comprising:
an impeller cup including a blade extending in a radial direction;
a motor configured to rotate the impeller cup; and
a housing accommodating the impeller cup and the motor, wherein
the housing includes:
a casing portion covering an outer periphery of the impeller cup;
a base portion supporting the motor; and
a spoke portion connecting the base portion and the casing portion,
the casing portion includes an inlet surface where air is drawn in, and an outlet surface where air is discharged, and
the casing portion is provided with a level difference portion at least partially in an inner peripheral surface of the casing portion on the outlet surface side.

**2**. The axial fan according to claim **1**, wherein the casing portion is provided with a lightening portion at least partially in the outlet surface.

**3**. The axial fan according to claim **2**, wherein the lightening portion is provided in the outlet surface of the casing portion, at a position off an extension line of the spoke portion in a longitudinal direction of the spoke portion.

**4**. The axial fan according to claim **2**, wherein
the housing has a polygonal shape including a plurality of corner portions in plan view perpendicular to an air-blowing direction of the axial fan, and
the level difference portion and the lightening portion are provided near each of a plurality of the corner portions.

**5**. An axial fan comprising:
an impeller cup including a blade extending in a radial direction;
a motor configured to rotate the impeller cup; and
a housing accommodating the impeller cup and the motor, wherein
the housing includes:
a casing portion covering an outer periphery of the impeller cup;
a base portion supporting the motor; and
a spoke portion connecting the base portion and the casing portion,
the casing portion includes an inlet surface where air is drawn in, and an outlet surface where air is discharged, and
a lightening portion is open in the outlet surface of the casing portion, at a position off an extension line of the spoke portion in a longitudinal direction of the spoke portion.

**6**. The axial fan according to claim **5**, wherein the casing portion is provided with a level difference portion at least partially in an inner peripheral surface of the casing portion on the outlet surface side.

**7**. The axial fan according to claim **6**, wherein
the housing has a polygonal shape including a plurality of corner portions in plan view perpendicular to an air-blowing direction of the axial fan, and
the level difference portion and the lightening portion are provided near each of a plurality of the corner portions.

**8**. The axial fan according to claim **2**, wherein the level difference portion is provided between the lightening portion

and an internal opening of the casing portion, and the lightening portion and the internal opening are coupled to each other.

**9**. The axial fan according to claim **3**, wherein the level difference portion is provided between the lightening portion and an internal opening of the casing portion, and the lightening portion and the internal opening are coupled to each other.

**10**. The axial fan according to claim **4**, wherein the level difference portion is provided between the lightening portion and an internal opening of the casing portion, and the lightening portion and the internal opening are coupled to each other.

**11**. The axial fan according to claim **6**, wherein the level difference portion is provided between the lightening portion and an internal opening of the casing portion, and the lightening portion and the internal opening are coupled to each other.

**12**. The axial fan according to claim **7**, wherein the level difference portion is provided between the lightening portion and an internal opening of the casing portion, and the lightening portion and the internal opening are coupled to each other.

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