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(71) Applicant: **LG Electronics Inc.**
150-721 Seoul (KR)

(72) Inventors:
- **Cho, Namjoon**
  153-802 Seoul (KR)
- **Yang, Dongkeun**
  153-802 Seoul (KR)
- **Park, Youngmin**
  153-802 Seoul (KR)

(74) Representative: **Vossius & Partner**
Siebertstrasse 4
81675 München (DE)

(54) **Turbofan**

(57) Provided is a turbofan (200). The turbofan (200) comprises a main plate (115) rotating by a fan motor (120) providing power; and a plurality of blades (400) having one ends connected to the main plate (115), the plurality of blades (400) being disposed along a circumferential direction on the main plate (115), wherein each of the plurality of blades (400) comprises: a first curved part (421) curved in one direction with respect to an extension part (500); and a second curved part (422) curved in the other direction with respect to the extension part (500), wherein a plurality of projections (423) protruding in one direction from the one end of the blade (400) and a plurality of grooves (424) protruding in the other direction are alternately disposed on the first (421) and second (422) curved parts.

Fig.3

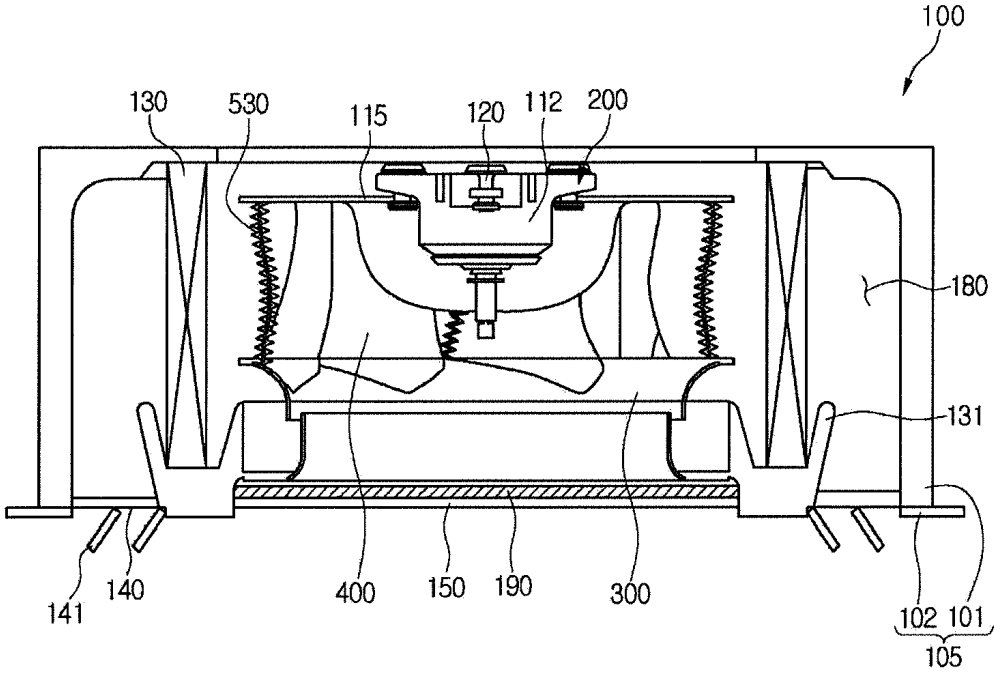

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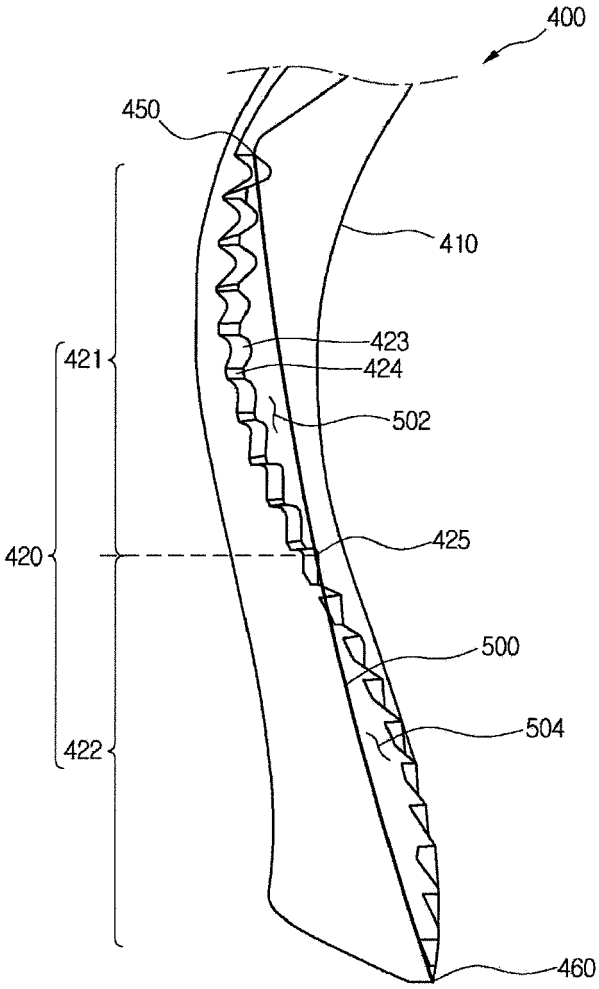
Fig.4



Description

[0001] The present disclosure relates to a turbo fan.

[0002] Turbo fans may be used in ceiling type air conditioners that are used in homes or companies. Hereinafter, such a ceiling type air conditioner will be described as an example.

[0003] In general, ceiling type air conditioners are devices that are buried in an indoor ceiling to discharge air heat-exchanged after suctioning indoor air from the ceiling into an indoor space. In such a ceiling type air conditioner, air may be suctioned through a suction hole defined in a central portion of the ceiling type air conditioner, and then, the suctioned air may be heat-exchanged by a heat exchanger disposed within the ceiling type air conditioner. The air-conditioned air may be discharged into the indoor space through a discharge part disposed on a circumferential portion of the ceiling type air conditioner to adjust a temperature and moisture of the indoor space.

[0004] Particularly, the air suctioned through the suction hole may be guided in movement by a turbo fan disposed within the ceiling type air conditioner. That is, the turbo fan may introduce air in an axial direction with respect to the turbo fan to discharge in a radius direction of the turbo fan.

[0005] Fig. 1 is a perspective view of a turbo fan according to a related art.

[0006] Referring to Fig. 1, a turbo fan 1 according to a related art may include a main plate 10 rotating by power provided from a motor, a plurality of blades 20 radially arranged on the main plate 10 and integrated with the main plate 10, and a shroud 30 coupled to ends of the blades 20 to face one surface of the main plate 10.

[0007] Also, the turbo fan 1 may further include a hub 11 accommodating the motor therein, a boss part 12 having a shaft hole in a central portion of the hub 11 so that the motor is shaft-coupled to the shaft hole, and a vent part 13 defined in a surface of the hub 11 to cool the motor. The vent part 13 may introduce cold air into the motor therethrough to decrease a temperature of the motor.

[0008] The air suctioned into the turbo fan 1 through a suction hole 33 may be discharged to the outside of the turbo fan 1 through a discharge hole 34. The discharge hole 34 may be defined as a space between the plurality of blades 20.

[0009] When the blades 20 rotate in a counterclockwise direction in Fig. 1, air flowing along a back surface of each of the blades 20 may be discharged to the outside through the discharge hole 34. However, the air flowing along the blades 20 may be spaced and delaminated from surfaces of the blades 20. The delamination phenomenon may cause noises when the turbo fan 1 operates.

[0010] Also, in recent years, with the large-scaled air-conditioning system, an air volume required for the air-conditioning system may be increasing more and more. Also, due the increase of the air volume of the air-conditioner system, a flow nose of air passing through the turbo fan 1 is increasing. As a result, user's inconvenience may occur by the noise generated from the turbo fan 1.

[0011] Embodiments provide a turbo fan that is capable of reducing an air flow noise generated when a turbo fan operates.

[0012] In one embodiment, a turbo fan includes: a main plate rotating by a fan motor providing power; and a plurality of blades having one ends connected to the main plate, the plurality of blades being disposed along a circumferential direction on the main plate, wherein each of the plurality of blades includes: a first curved part curved in one direction with respect to an extension part; and a second curved part curved in the other direction with respect to the extension part, wherein a plurality of projections protruding in one direction from the one end of the blade and a plurality of grooves protruding in the other direction are alternately disposed on the first and second curved parts.

[0013] The first and second curved parts are disposed on rear end of the blade, and the extension part is defined as a virtual line straightly extending from an upper portion of the rear end of the blade up to a lower portion of the rear end of the blade.

[0014] The turbo fan further includes a shroud connected to the other end of the blade to guide an inflow of air into the blade, wherein the blade comprises a first contact point at which the main plate and the rear end of the blade meets each other; and a second contact point at which the shroud and the rear end of the blade meet each other, wherein the extension part is defined as a virtual line straightly extending from the first contact point up to the second contact point.

[0015] The blade further comprises a crossing part defined as a point at which the extension part and the rear end of the blade meet each other, wherein the crossing part is defined as a boundary between the first curved part and the second curved part.

[0016] The crossing part is defined as a central point of the extension part, and the first curved part has a length equal to that of the second curved part.

[0017] The turbo fan further comprises: an outer circumferential surface that is a virtual line connecting the plurality of projections to each other; and an inner circumferential surface that is a virtual line connecting the plurality of grooves to each other, wherein the outer circumferential surface and the inner circumferential surface are disposed parallel to each other.

[0018] The outer circumferential surface and the inner circumferential surface have the same curvature.

[0019] A vertical distance between the outer circumferential surface and the inner circumferential surface is constant.

[0020] The blade comprises a protrusion protruding from the inner circumferential surface toward the inner circumferential surface to constitute one surface of the blade and a hollow disposed between the protrusions, wherein the protrusion and the hollow are alternately dis-

posed with respect to each other.

[0021] The turbo fan further comprises a rotation shaft providing a rotation center of the main plate, wherein the blade comprises a blade front end disposed adjacent to the rotation shaft and a blade rear end disposed spaced from the rotation shaft, wherein the plurality of projections and the plurality of grooves are disposed on the blade rear end.

[0022] The plurality of projections and the plurality of grooves protrude from the blade front end toward the blade rear end.

[0023] The plurality of curved parts protrude in a direction perpendicular to the protruding direction of the plurality of projections.

[0024] Each of the plurality of projections and the plurality of grooves has a predetermined curvature.

[0025] Each of the plurality of projections and the plurality of grooves has a tip.

[0026] In another embodiment, a turbo fan includes: a main plate rotating by a fan motor providing power; a rotation shaft providing a rotation center of the main plate; a plurality of blades having a blade front end disposed adjacent to the rotation shaft and a blade rear end disposed spaced from the rotation shaft, the plurality of blades being disposed in a circumferential direction on the main plate; and an extension part defined as a virtual line straightly extending from an upper portion of the blade rear end to a lower portion of the blade rear end, wherein each of the blades includes: a first curved part curved in one direction with respect to the extension part; a second curved part curved in the other direction with respect to the extension part; a first flow part defined as a space between the extension part and the first curved part; and a second flow part defined as a space between the extension part and the second curved part.

[0027] The blade further comprises a crossing part defined as a point at which the extension part and the blade rear end meet each other, wherein the crossing part is defined as a boundary between the first flow part and the second flow part.

[0028] The details of one or more embodiments are set forth in the accompanying drawings and the description below. Other features will be apparent from the description and drawings, and from the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029]

Fig. 1 is a perspective view of a turbo fan according to a related art.

Fig. 2 is a perspective view illustrating an indoor unit of a ceiling type air conditioner according to an embodiment.

Fig. 3 is a cross-sectional view illustrating the indoor unit of the ceiling type air conditioner according to an embodiment.

Fig. 4 is a perspective view of a blade according to an embodiment.

Fig. 5 is a front view of a part of the blade according to an embodiment.

Fig. 6a and 6b are a view illustrating various shapes of a delamination delay part according to an embodiment.

Fig. 7 is a view illustrating a relationship between an air volume and a noise when the blade according to an embodiment is applied to the ceiling type air conditioner.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0030] Reference will now be made in detail to the embodiments of the present disclosure, examples of which are illustrated in the accompanying drawings.

[0031] In the following detailed description of the preferred embodiments, reference is made to the accompanying drawings that form a part hereof, and in which is shown by way of illustration specific preferred embodiments in which the invention may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention, and it is understood that other embodiments may be utilized and that logical structural, mechanical, electrical, and chemical changes may be made without departing from the spirit or scope of the invention. To avoid detail not necessary to enable those skilled in the art to practice the invention, the description may omit certain information known to those skilled in the art. The following detailed description is, therefore, not to be taken in a limiting sense.

[0032] A turbo fan may be used in home appliance of homes or companies or factory machines. For example, the turbo fan may be used in a ceiling type air conditioner. Hereinafter, the ceiling type air conditioner to which the turbo fan is applied will be described as an example.

[0033] Fig. 2 is a perspective view illustrating an indoor unit of a ceiling type air conditioner according to an embodiment, and Fig. 3 is a cross-sectional view illustrating the indoor unit of the ceiling type air conditioner according to an embodiment.

[0034] Referring to Figs. 2 and 3, a ceiling type air conditioner according to the current embodiment may include an outdoor unit (not shown) installed in an outdoor space, an indoor unit 100 installed in an indoor space, and a refrigerant tube (not shown) connecting the outdoor unit (not shown) to the indoor unit 100 to allow a refrigerant to flow therethrough.

[0035] The indoor unit 100 may include a case 105 defining an outer appearance thereof, a turbo fan 200 disposed within the case 105, a fan motor 120 coupled to the turbo fan 200 to provide power, and a heat exchanger 130 disposed outside the fan motor 120.

[0036] The case 105 may include a main body 101 defining side surfaces thereof and a front panel 102 coupled to the main body 101 to define a front surface thereof.

[0037] Also, the main body 101 is installed in an indoor

ceiling. The main body 101 may have an opened lower portion to communicate with a suction hole 150 defined in the front surface of the front panel 102. Although the main body 101 is installed in the indoor ceiling in consideration of space availability or a sense of beauty, the installation space of the main body 101 is not limited thereto. For example, the main body 101 may be installed in an indoor sidewall.

[0038] The front panel 102 may be detachably coupled to the lower portion of the main body 101. Also, the front panel 102 may be exposed to the indoor space so that air is suctioned into or discharged from the indoor unit 100. The front panel 102 may cover the opened portion of the main body 101. For example, the front panel 102 may have a square plate shape to cover the opening of the main body 101. Also, the front panel 102 may include a suction hole 150 through which indoor air is suctioned and discharge holes 140 through which air is discharged into the indoor space.

[0039] The suction hole 150 may be defined in a central portion of the front panel 102. Also, the discharge holes 140 may be symmetrically defined in four sides of the suction hole 150. The suction hole 150 may have a grill structure. Each of the discharge holes 140 may have a rectangular structure with a predetermined width and length. However, each of the suction hole 150 and the discharge hole 140 are not limited to a shape thereof.

[0040] Also, a filter 190 for removing various foreign substances contained in the air suctioned into the main body 101 through the suction hole 150 may be provided inside the front panel 102.

[0041] The turbo fan 200 may include a hub 112 connected to a rotation shaft of the fan motor 120, a main plate 115 rotating by the fan motor 120, a plurality of blades 400 having one ends connected to the main plate 115 and arranged at a predetermined distance along a circumferential direction on the main plate 115, and a shroud 300 facing the main plate 115 to connect the other ends of the plurality of blades 400 to each other. The shroud 300 may guide an inflow of air into the suction hole 150 when the turbo fan 200 rotates.

[0042] The turbo fan 200 may be disposed on a position corresponding to the suction hole 150 to improve suction efficiency of the air suctioned into the main body 101. Particularly, in Fig. 3, the turbo fan 200 may be disposed to correspond to a vertical direction of the suction hole 150.

[0043] Also, the turbo fan 200 may blow the indoor air suctioned through the suction hole 150 toward the heat exchanger 130.

[0044] The heat exchanger 130 may surround the outside of the turbo fan 200. For example, the heat exchanger 130 may have a square structure corresponding to a shape of each of the side surfaces of the main body 101. The heat exchanger 130 may heat-exchange the air suctioned into the main body 101 through the turbo fan 200.

[0045] Particularly, when the ceiling type air conditioner operates in a cooling mode, air passing through the heat exchanger 130 may decrease in temperature. On the other hand, when the ceiling type air conditioner operates in a heating mode, air passing through the heat exchanger 130 may increase in temperature.

[0046] A drain plate 131 accommodating condensed water generated when the refrigerant passing through the heat exchanger 130 is heat-exchanged with the indoor air may be disposed under the heat exchanger 130. Also, a drain tube (not shown) for discharging the condensed water collected in the drain plate 131 to the outside may be connected to the drain plate 131.

[0047] A guide passage 180 for guiding a flow direction of air may be defined in an outer portion of the inside of the main body 101. Particularly, the guide passage 180 may guide the air heat-exchanged by the heat exchanger 130 toward the discharge hole 140.

[0048] A vane 141 for controlling the flow direction of the air may be disposed in the discharge hole 140. The vane 141 may be rotatable at a predetermined angle. Also, the vane 141 may be inclined outward from the front surface of the front panel 102. This is done for providing wind having a uniform wind speed to all indoor portions. However, the rotation direction of the vane 141 is not limited thereto. Also, the vane 141 is not limited to an arrangement, configuration, and operation method thereof.

[0049] When the turbo fan 200 operates, air introduced into the turbo fan 200 may be discharged to the outside through a space defined between the plurality of blades 400. That is, the air may flow along surfaces of the plurality of blades 400. However, the air flowing along the blades 400 may be spaced and delaminated from the surfaces of the blades 400. The delamination phenomenon may cause noises when the turbo fan 200 operates. Thus, in each of the blades 400 according to the current embodiment, a protrusion 530 may be disposed on a rear end of the blade 400.

[0050] Hereinafter, a detailed structure of the blade 400 will be described.

[0051] Fig. 4 is a perspective view of the blade according to an embodiment.

[0052] Referring to Fig. 4, the blade 400 according to the current embodiment may include a blade front end 410 disposed adjacent to the hub 112 and a blade rear end 420 spaced from the hub 112. Thus, the air introduced into the turbo fan 200 along the suction hole 150 may move from the blade front end 410 toward the blade rear end 420. Also, the air introduced into the turbo fan 200 may move along the surface of the blade 400.

[0053] A plurality of curved part may be disposed on the blade rear end 420. The plurality of curved parts may include a first curved part 421 curved in one direction with respect to an extension part 500 and a second curved part 422 curved in the other direction with respect to the extension part 500. The extension part 500 may be defined as a virtual line extending from an upper end of the blade rear end 410 up to a lower end of the blade rear end 420.

[0054] Particularly, when a point at which the main plate 115 and the blade rear end 420 meet each other is referred to as a first contact point 450, and a point at which the shroud 300 and the blade rear end 420 meet each other is referred to as a second contact point 460, the extension part 500 may be defined as a virtual line defined to straightly extend from the first contact point 450 up to the second contact point 460.

[0055] Each of the first curved part 421 and the second curved part 422 may have a curved surface with a predetermined curvature. For example, the first curved part 421 may protrude in a left direction with respect to the extension part 500. Also, the second curved part 422 may protrude in a right direction with respect to the extension part 500. However, each of the first and second curved parts 421 and 422 is not limited to the protruding direction thereof. For example, the first curved part 421 may protrude in the right direction with respect to the extension part 500, and the second curved part 422 may protrude in the left direction with respect to the extension part 500.

[0056] The blade according to the current embodiment may further include a crossing part 425 defined as a point at which the extension part 500 and the blade rear end 420 meet each other. The crossing part 425 may be defined as a boundary point between the first curved part 421 and the second curved part 422. For example, in Fig. 4, the first curved part 421 may be disposed at an upper side with respect to the crossing part 425, and the second curved part 422 may be disposed at a lower side with respect to the crossing part 425.

[0057] The first curved part 421 and the second curved part 422 may have the same length. That is, the crossing part 425 may be disposed at a central point of the extension part 500. However, each of the first and second curved parts 421 and 422 is not limited to the length thereof.

[0058] A first flow part 502 may be disposed in a space between the first curved part 421 and the extension part 500. Similarly, a second flow part 504 may be disposed in a space between the second curved part 422 and the extension part 500. Thus, the first and second flow parts 502 and 504 may guide a flow direction of air flowing from the blade front end 410 up to the blade rear end 420. Thus, the air flow delamination phenomenon occurring at a side of the blade rear end 420 may be delayed.

[0059] A plurality of projections 523 protruding in one direction from the blade rear end 420 and a plurality of grooves 424 protruding in the other direction from the blade rear end 420 may be disposed on the blade rear end 420.

[0060] The plurality of projections 423 and the plurality of grooves 424 may be perpendicular to the protruding direction of the curved part 421. That is, the plurality of projections 423 and the plurality of grooves 424 may protrude from the blade front end 410 toward the blade rear end 420.

[0061] Hereinafter, a detailed structure of the blade rear end 420 will be described.

[0062] Fig. 5 is a front view of the blade according to an embodiment.

[0063] Referring to Fig. 5, a delamination delay part 600 for delaying the delamination of the air flowing along the surface of the blade 400 from the surface of the blade 400 may be disposed on the blade rear end 420. The delamination delay part 600 may be defined as a space between a surface connecting the plurality of projections 423 disposed on the blade 400 to each other and a surface connecting the plurality of grooves 424 defined in the blade 400 to each other.

[0064] When the surface connecting the plurality of projections 423 to each other is referred to as an outer circumferential surface 510, and the surface connecting the plurality of grooves 424 to each other is referred to as an inner circumferential surface 520, each of the outer and inner circumferential surfaces may have a curved line with a predetermined curvature.

[0065] The outer and inner circumferential surfaces 510 and 520 may be disposed parallel to each other. That is, the outer circumferential surface 510 and the inner circumferential surface 520 may have the same curvature. Thus, all of the flow lamination phenomena of air passing through an upper end of the blade 400 and air passing through a lower end of the blade 400 may be delayed.

[0066] The delamination delay part 600 disposed on the upper end of the blade 400 may have a width L equal to that L' of the delamination delay part 600 disposed on the lower end of the blade 400. That is, a vertical distance between the projection 423 and the groove 424 may be constant.

[0067] Also, the delamination delay part 600 may further include a protrusion 530 protruding from the inner circumferential surface 520 toward the outer circumferential surface 510 with respect to the blade rear end 420 and a hollow 540 disposed between the protrusions 530 and defined as a hollow space. The protrusion 530 may constitute a portion of the surface of the blade 400. That is to say, the protrusion 530 may be defined as a portion of the surface of the blade 400 defined between the outer circumferential surface 510 and the inner circumferential surface 520. The protrusion 530 and the hollow 540 may be alternately disposed with respect to each other.

[0068] An eddy may be generated in the hollow 540. Thus, since the air flowing from the blade front end 410 to the blade rear end 420 is guided toward the protrusion 530 by the eddy, the air flow delamination phenomenon occurring at the blade rear end 420 may be delayed.

[0069] Fig. 6 is a view illustrating various shapes of a delamination delay part according to an embodiment.

[0070] Referring to Fig. 6A, the blade rear end 420 may have a shape with a predetermined curvature. Also, the delamination delay part 600 according to the current embodiment may include a plurality of projections 423 and a plurality of grooves 424. The plurality of projections 423 may include a first projection and a second projection

disposed adjacent to the first projection. If a distance between the first projection and the second projection is referred to as a distance A, and a length of the blade rear end 420 is referred to as a length B, a value of distance A/length B may range from about 0.05 to about 0.15. However, a ratio of the distance between the first and second projections and a length of the blade rear end 420 is not limited to the above-described value.

[0071] Also, if a height of the projection 423 with respect to the inner circumferential surface 520 is referred to as a height C, and a vertical distance from the blade front end 410 to the blade rear end 420 is referred to as a vertical distance D, a value of height C/vertical distance D may range from about 0.06 to about 0.20. However, a ratio of the height of the projection 423 and the vertical distance from the blade front end 410 to the blade rear end 420 is not limited to the above-described value.

[0072] Also, the shape of the blade rear end 420 is not limited to the curved line having the predetermined curvature.

[0073] Referring to Fig. 6b, the projection 623 may have one end having a tip shape with a tip point. Similarly, the groove 624 may also have the tip shape. Alternatively, the projection 423 the projection 423 may have a curved line shape with a predetermined curvature, and the groove 624 may have a tip shape.

[0074] Fig. 7 is a view illustrating a relationship between an air volume and a noise when the blade according to an embodiment is applied to the ceiling type air conditioner.

[0075] Referring to Fig. 7, when the ceiling type air conditioner to which the blade according to the related art is applied operates, a relationship between a wind volume and a noise may be expressed as a dotted line N of Fig. 7. Also, when the ceiling type air conditioner to which the blade according to the related art is applied operates, a relationship between a wind volume and a noise may be expressed as a solid line M of Fig. 7.

[0076] That is, if it is assumed that the wind volume of air discharged from the ceiling type air conditioner is the same, a noise generated when the ceiling type air conditioner to which the blade according to the current embodiment is applied operates may be less than that generated when the ceiling type air conditioner to which the blade according to the related art is applied operates.

[0077] That is, in the blade 400 according to the current embodiment, a plurality of curved parts 421 and 422 may be disposed on the blade rear end 420, and a delamination delay part 600 for delaying the air flow delamination may be disposed on each of the curved parts 421 and 422. Particularly, a plurality of projections 423 and a plurality of grooves 424 may be disposed on the plurality of curved parts 421 and 422 to delay the air flow delamination phenomenon occurring at the blade rear end 420.

[0078] Although embodiments have been described with reference to a number of illustrative embodiments thereof, it should be understood that numerous other modifications and embodiments can be devised by those skilled in the art that will fall within the spirit and scope of the principles of this disclosure. More particularly, various variations and modifications are possible in the component parts and/or arrangements of the subject combination arrangement within the scope of the disclosure, the drawings and the appended claims. In addition to variations and modifications in the component parts and/or arrangements, alternative uses will also be apparent to those skilled in the art.

Claims

1. A turbo fan comprising:

a main plate rotating by a fan motor providing power; and
a plurality of blades having one ends connected to the main plate, the plurality of blades being disposed along a circumferential direction on the main plate,
wherein each of the plurality of blades comprises:

a first curved part curved in one direction with respect to an extension part; and
a second curved part curved in the other direction with respect to the extension part,
wherein a plurality of projections protruding in one direction from the one end of the blade and a plurality of grooves protruding in the other direction are alternately disposed on the first and second curved parts.

2. The turbo fan according to claim 1, wherein the first and second curved parts are disposed on rear end of the blade, and
the extension part is defined as a virtual line straightly extending from an upper portion of the rear end of the blade up to a lower portion of the rear end of the blade.

3. The turbo fan according to claim 1 or 2, further comprising a shroud connected to the other end of the blade to guide an inflow of air into the blade,
wherein the blade comprises:

a first contact point at which the main plate and the rear end of the blade meets each other; and
a second contact point at which the shroud and the rear end of the blade meet each other,
wherein the extension part is defined as a virtual line straightly extending from the first contact point up to the second contact point.

4. The turbo fan according to any one of preceding claims, wherein the blade further comprises a crossing part defined as a point at which the extension

part and the rear end of the blade meet each other, wherein the crossing part is defined as a boundary between the first curved part and the second curved part.

5. The turbo fan according to claim 4, wherein the crossing part is defined as a central point of the extension part, and
the first curved part has a length equal to that of the second curved part.

6. The turbo fan according to any one of preceding claims, further comprising:

an outer circumferential surface that is a virtual line connecting the plurality of projections to each other; and
an inner circumferential surface that is a virtual line connecting the plurality of grooves to each other,
wherein the outer circumferential surface and the inner circumferential surface are disposed parallel to each other.

7. The turbo fan according to claim 6, wherein the outer circumferential surface and the inner circumferential surface have the same curvature.

8. The turbo fan according to claim 6, wherein a vertical distance between the outer circumferential surface and the inner circumferential surface is constant.

9. The turbo fan according to claim 6, wherein the blade comprises:

a protrusion protruding from the inner circumferential surface toward the inner circumferential surface to constitute one surface of the blade; and
a hollow disposed between the protrusions,
wherein the protrusion and the hollow are alternately disposed with respect to each other.

10. The turbo fan according to any one of preceding claims, further comprising a rotation shaft providing a rotation center of the main plate,
wherein the blade comprises:

a blade front end disposed adjacent to the rotation shaft;
and
a blade rear end disposed spaced from the rotation shaft,
wherein the plurality of projections and the plurality of grooves are disposed on the blade rear end.

11. The turbo fan according to claim 10, wherein the plurality of projections and the plurality of grooves protrude from the blade front end toward the blade rear end.

12. The turbo fan according to claim 11, wherein the plurality of curved parts protrude in a direction perpendicular to the protruding direction of the plurality of projections.

13. The turbo fan according to claim 12, wherein each of the plurality of projections and the plurality of grooves has a predetermined curvature.

14. The turbo fan according to claim 12, wherein each of the plurality of projections and the plurality of grooves has a tip.

Fig.1

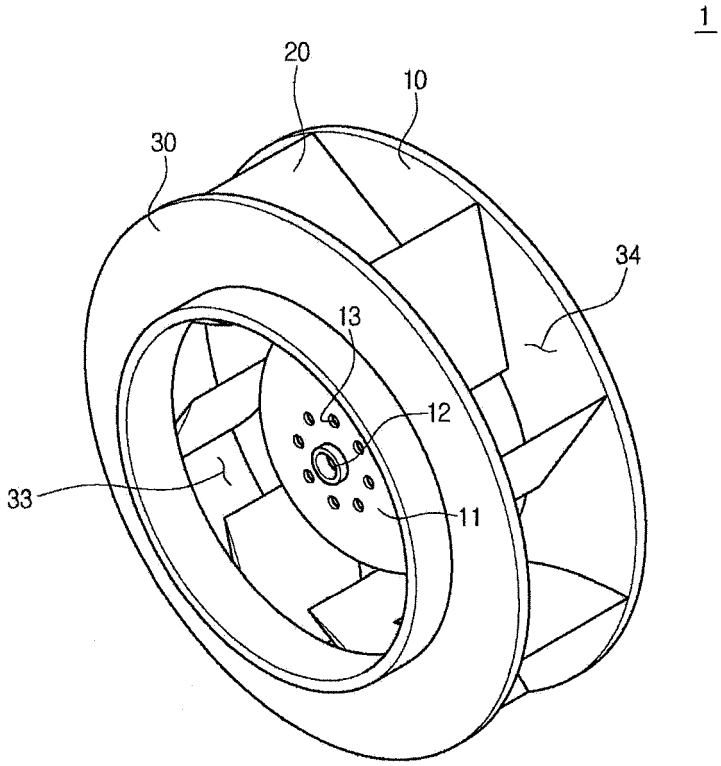


Fig.2

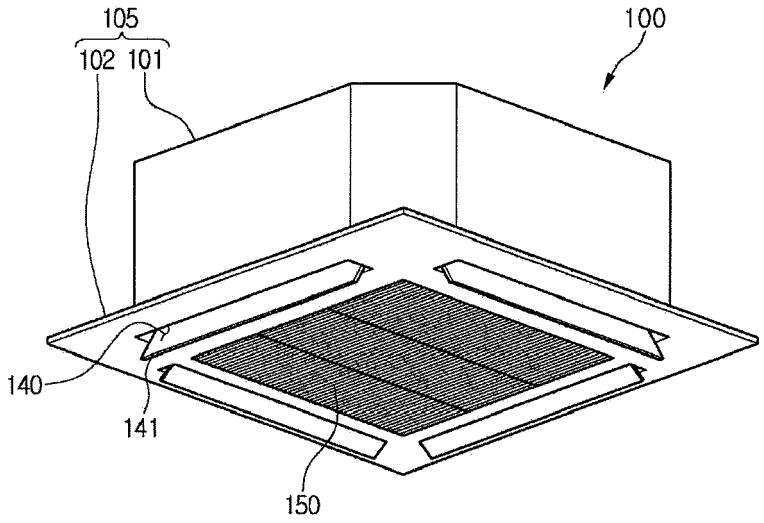
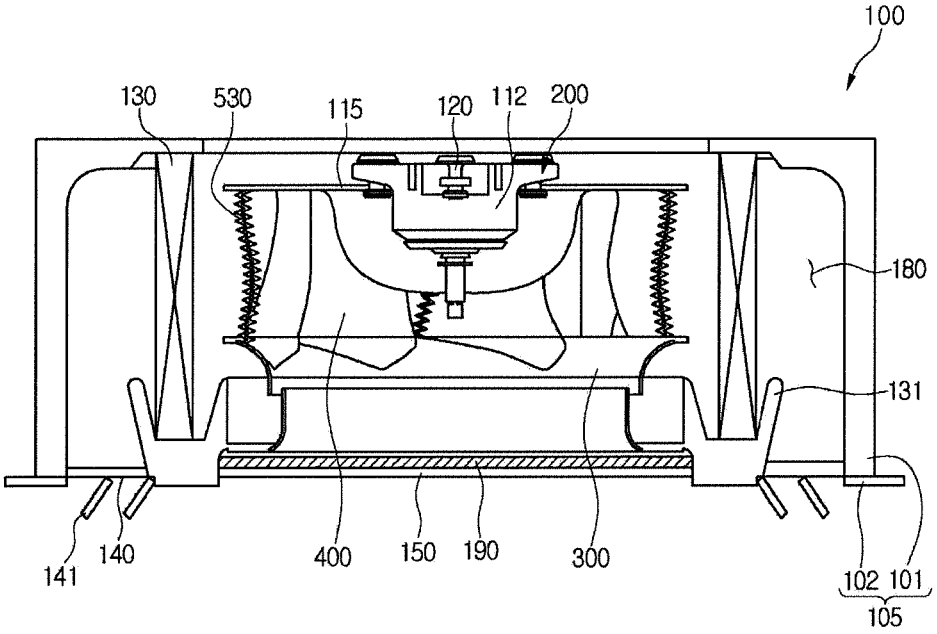


Fig.3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141
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150
190
300
102
101
105

Fig.4

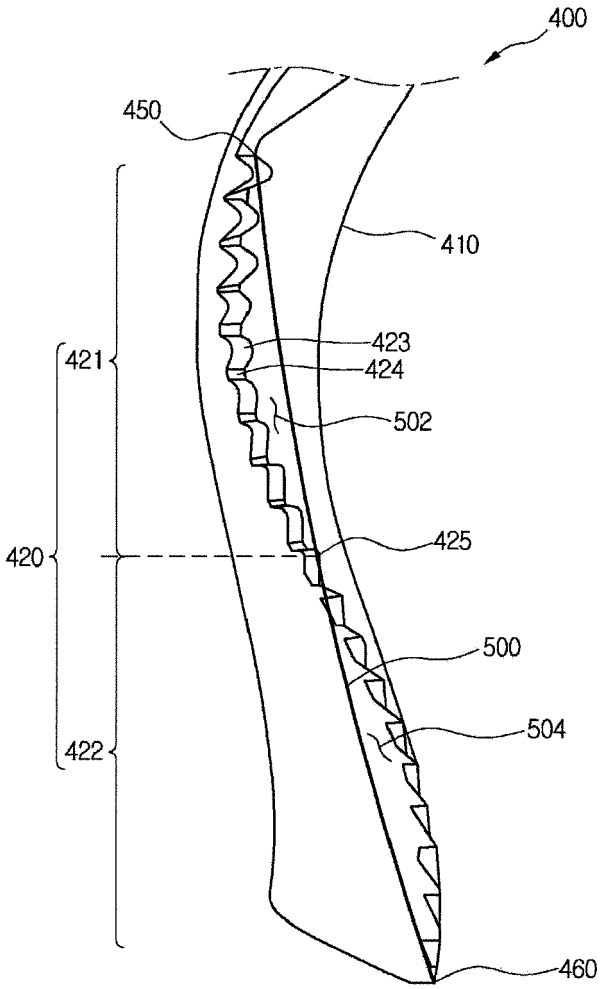

Fig.5

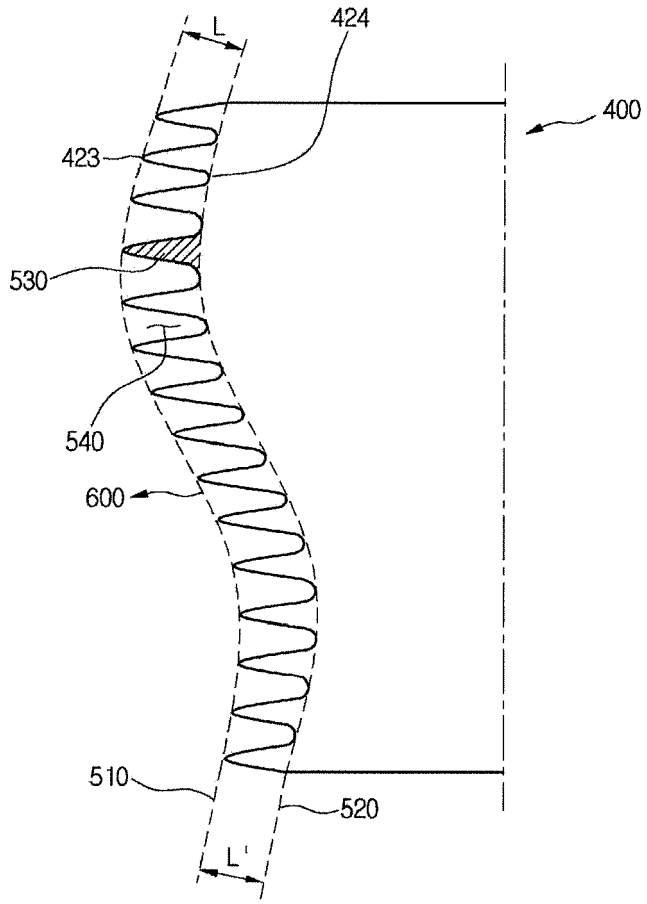

Fig.6a

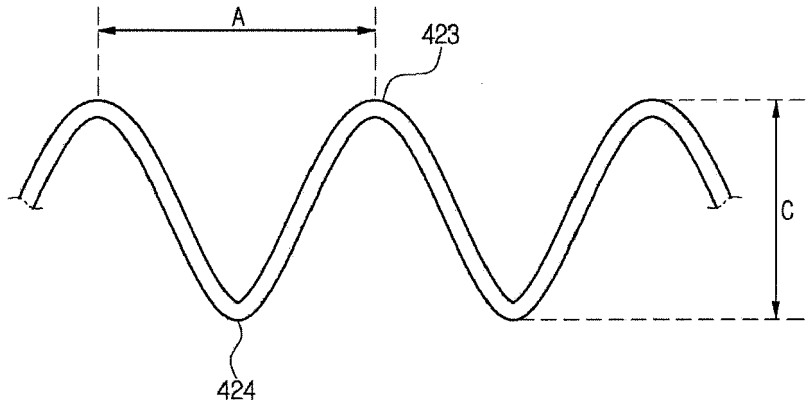

Fig.6b

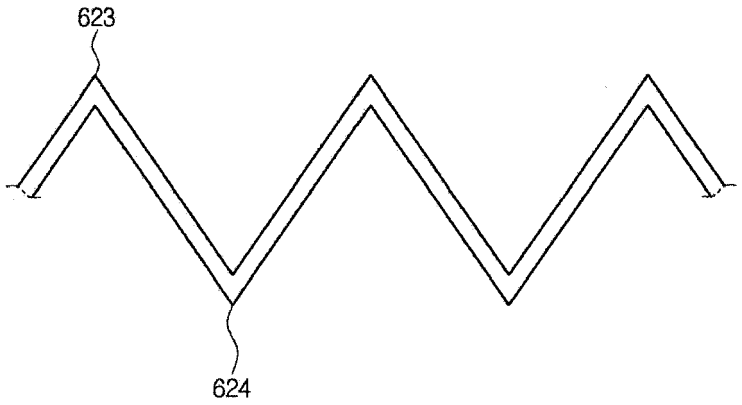

Fig.7