



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
26.11.2014 Bulletin 2014/48

(51) Int Cl.:
F24F 1/38 (2011.01)

(21) Application number: **14168751.7**

(22) Date of filing: **16.05.2014**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

- **Jang, Keun Jeong**
Seoul (KR)
- **Kim, Young Jae**
Gyeonggi-do (KR)
- **Kim, Jong Moon**
Gyeonggi-do (KR)
- **Kim, Hyun Dal**
Gyeonggi-do (KR)
- **Seo, Hyeong Joon**
Gyeonggi-do (KR)

(30) Priority: **20.05.2013 KR 20130056357**

(71) Applicant: **Samsung Electronics Co., Ltd**
Gyeonggi-do 443-742 (KR)

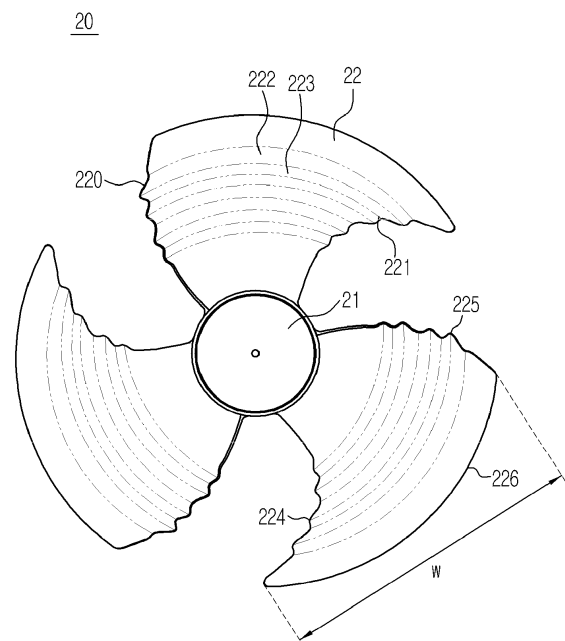
(72) Inventors:
• **Kim, Byung Ghun**
Gyeonggi-do (KR)

(74) Representative: **Hewett, Jonathan Michael**
Richard et al
Venner Shipley LLP
200 Aldersgate
London EC1A 4HD (GB)

(54) **Propeller fan and air conditioner having the same**

(57) An air conditioner includes an outdoor unit that includes a compressor configured to compress a refrigerant, a condenser configured to condense the compressed refrigerant, and a blowing fan configured to blow outdoor air into a room, an indoor unit that discharges air heat-exchanged with the refrigerant flowing in from the outdoor unit to the room, and a connection piping that connects the outdoor unit and the indoor unit. Here, a plurality of protrusions may be formed at least one side of the blowing fan, and a convex portion and a concave portion may be formed on a surface of the blowing fan so that the surface of the blowing fan is indented.

FIG. 2



Description

[0001] The present invention relates to a propeller fan which reduces the magnitude of blowing noise and prevents occurrence of unpleasant noise, and an air conditioner including the same.

[0002] An air conditioner is a device that keeps indoor air comfortable so as to be suitable for human activities using a refrigerating cycle. The air conditioner may cool a room by repeatedly performing an operation to suck indoor hot air to be heat-exchanged with a low-temperature refrigerant and then discharge the sucked air into the room, or heat the room by repeatedly performing its reverse operation.

[0003] The air conditioner may cool or heat the room by a refrigerating cycle in which a refrigerant is circulated by a compressor, a condenser, an expansion valve, and an evaporator in either a forward or reverse direction.

[0004] The compressor provides a high-temperature high-pressure gaseous refrigerant, and the condenser provides a normal-temperature high-pressure liquid refrigerant. The expansion valve decompresses the normal-temperature high-pressure liquid refrigerant, and the evaporator evaporates the decompressed refrigerant in a low-temperature gas state.

[0005] The air conditioner may be classified into a separate type air conditioner in which an outdoor unit and an indoor unit are separately installed and an integrated air conditioner in which the outdoor unit and the indoor unit are integrally installed. In the case of the separate type air conditioner in which the outdoor unit and the indoor unit are separately installed, a compressor for compressing a refrigerant and a condenser (outdoor heat exchanger) are generally provided in the outdoor unit, and an evaporator (indoor heat exchanger) is provided in the indoor unit. The refrigerant can flow while circulating the outdoor unit and the indoor unit through a piping connecting the outdoor unit and the indoor unit.

[0006] The outdoor unit of the separate type air conditioner includes a compressor, a condenser, a blowing fan, a driving motor for rotating the blowing fan, and the like. The driving motor may condense a refrigerant to a liquid refrigerant through heat-exchange with a gaseous refrigerant flowing inside the condenser of the outdoor unit by rotating the blowing fan, and then discharge the condensed refrigerant to the outside of the outdoor unit.

[0007] As the blowing fan of the outdoor unit, a propeller fan may be used. The propeller fan is one axial-flow fan which includes a cylindrical hub to which a rotating shaft of the driving motor is coupled and a plurality of blades extending to the outside of the hub so as to form a flow of air in the axial direction. Such a propeller fan may be used in the outdoor unit of the air conditioner and the like to cause air to forcibly flow by a pressure difference before and behind the propeller fan.

[0008] Therefore, it is an aspect of the present invention to provide a propeller fan which may reduce the magnitude of blowing noise by improving a structure of the

propeller fan and prevent occurrence of unpleasant noise to improve quality of the noise, and an air conditioner including the same.

[0009] Additional aspects of the present invention will be set forth in part in the description which follows, and in part, will be apparent from the description, or may be learned by practice of the invention.

[0010] In accordance with one aspect of the present invention, an air conditioner includes: an outdoor unit that includes a compressor configured to compress a refrigerant, a condenser configured to condense the compressed refrigerant, and a blowing fan configured to blow outdoor air into the outdoor unit; an indoor unit that discharges air heat-exchanged with the refrigerant flowing in from the outdoor unit to a room; and a connection piping that connects the outdoor unit and the indoor unit. Here, the blowing fan may include a plurality of blades, a plurality of protrusions may be formed on both sides of facing edges of the blade, and a convex portion and a concave portion may be formed on a surface of the blowing fan so that the surface of the blowing fan is indented.

[0011] The blowing fan may include a hub fixed to a shaft of a driving motor and the plurality of blades arranged along a circumference of the hub.

[0012] The blade may include a trailing edge and a leading edge that leads the trailing edge when rotated with respect to the hub, and the plurality of protrusions may be formed so as to protrude from both sides of the leading edge and the trailing edge.

[0013] The protrusion may be formed so as to protrude forward of the leading edge.

[0014] The protrusion may be formed so as to protrude backward of the trailing edge.

[0015] The plurality of protrusions may be formed on the leading edge, and the plurality of protrusions may be formed on the trailing edge so as to correspond to the protrusions formed on the leading edge.

[0016] The convex portion may be formed so as to connect the protrusions formed on the leading edge and the trailing edge.

[0017] The concave portion may be formed between the convex portions adjacent to each other.

[0018] The protrusion may be formed in a range of 1.3% to 6.6% of a length of the blade.

[0019] The protrusion may be formed in a range of 0.3 mm or more to 27 mm or less.

[0020] A height of the convex portion may be formed in a range of 0.5% to 6.0% of a length of the blade.

[0021] The height of the convex portion may be formed in a range of 2 mm or more to 18 mm or less.

[0022] The number of the formed protrusions may be at least three.

[0023] In accordance with another aspect of the present invention, a propeller fan includes: a hub connected to a driving motor to receive a rotational force; and a plurality of blades radially arranged on a circumference of the hub. Here, a surface of the blade may be indented, and a plurality of protrusions may be formed

on a leading edge and a trailing edge of the blade.

[0024] The plurality of protrusions may be formed to have irregular sizes.

[0025] A convex portion may be formed on the surface of the blade so as to connect the protrusions formed on the leading edge and the protrusions formed on the trailing edge so as to correspond to the protrusions of the leading edge.

[0026] The number of the convex portions may be plural, and a height of the convex portion may be irregularly formed.

[0027] A protruding length of the protrusion may be formed in a range of 1.3% to 6.6% of a length of the blade.

[0028] A height of the convex portion may be formed in a range of 0.5% to 6.0% of a length of the blade.

[0029] The blade may be formed to be inclined so as to blow air from a rear side of the blade toward a front side thereof along an axial direction of the hub.

[0030] These and/or other aspects of the invention will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompanying drawings of which:

FIG. 1 illustrates an air conditioner in accordance with one embodiment of the present invention;

FIG. 2 is a front view illustrating a propeller fan in accordance with one embodiment of the present invention;

FIG. 3 is a side view illustrating a propeller fan in accordance with one embodiment of the present invention;

FIG. 4 is a front enlarged view illustrating a portion of a propeller fan in accordance with one embodiment of the present invention;

FIG. 5 is a cross-sectional view illustrating a propeller fan in accordance with one embodiment of the present invention;

FIG. 6 are a graph showing the magnitude of noise in accordance with air flow of a propeller fan in accordance with one embodiment of the present invention; and

FIGS. 7 and 8 are graphs showing a frequency of noise due to rotation of a propeller fan in accordance with one embodiment of the present invention and a frequency of noise due to rotation of a conventional propeller fan.

[0031] Reference will now be made in detail to the embodiments of the present invention, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to like elements throughout.

[0032] Hereinafter, a propeller fan in accordance with one embodiment of the present invention and an air conditioner including the propeller fan will be described in detail with reference to the accompanying drawings.

[0033] FIG. 1 illustrates an air conditioner in accordance with one embodiment of the present invention.

[0034] Referring to FIG. 1, an air conditioner in accord-

ance with one embodiment of the present invention includes an indoor unit 1 and an outdoor unit 2. The indoor unit 1 and the outdoor unit 2 may be connected by a refrigerant piping 3. The refrigerant piping 3 may include refrigerant pipes 31, 32 which deliver gaseous refrigerant and condensed refrigerant to the outdoor unit and indoor unit, respectively. A refrigerant may circulate in a refrigerant pipe (not shown) provided in the indoor unit 1 and a refrigerant pipe (not shown) provided in the outdoor unit 2 through the refrigerant piping 3.

[0035] The indoor unit 1 may discharge air heat-exchanged with the refrigerant which has been compressed and condensed in the outdoor unit 2 into a room, and therefore a room temperature can be maintained at an appropriate temperature. The indoor unit 1 may include an expansion valve and an evaporator. The air in the room may be cooled by the refrigerant evaporated in the evaporator.

[0036] The outdoor unit 2 may include a compressor, a condenser, and a blowing fan 20. An air flow inlet through which outdoor air can flow into or out of the outdoor unit 2 may be formed on one side of the outdoor unit 2. The refrigerant is compressed by the compressor and the compressed refrigerant flows into the condenser to be condensed. In this instance, the blowing fan 20 is driven, and the outdoor air flowing in through the air flow inlet may cool heat generated in the condenser.

[0037] The blowing fan 20 provided in the outdoor unit 2 may be a propeller fan which is a kind of axial flow fan. Hereinafter, it is assumed that the blowing fan 20 is provided as the propeller fan, and a structure of the propeller fan will be described in detail with reference to the drawings.

[0038] FIG. 2 is a front view illustrating a propeller fan in accordance with one embodiment of the present invention, and FIG. 3 is a side view illustrating a propeller fan in accordance with one embodiment of the present invention.

[0039] Referring to FIGS. 2 and 3, a propeller fan 20 in accordance with one embodiment of the present invention includes a hub 21 and a plurality of blades 22. The plurality of blades 22 may be radially arranged on a circumference of the hub 21.

[0040] A shaft (not shown) of a driving motor may be connected to the hub 21. The hub 21 is firmly coupled to the shaft (not shown) of the driving motor through a screw fastening structure or the like to receive a rotational force from the shaft (not shown). Thus, the propeller fan 20 can be rotated by a driving force of the driving motor.

[0041] The blades 22 may be radially arranged at a constant interval on the circumference of the hub 21. The plurality of blades 22 may be provided to have the same shape. The blades 20 are provided to have a gentle inclination so that air behind (A) the propeller fan 20 can flow to the front (B) of the propeller fan 20 along an axial direction.

[0042] The blade 22 includes a leading edge 221 and a trailing edge 220. Any one of facing edges of the blade

22 may be the leading edge 221, and the other thereof may be the trailing edge 220. When the blade 22 is rotated with respect to the hub 21 in a clockwise direction, an edge of the blade 22 which leads the trailing edge 220 may be the leading edge 221 and an edge of the blade 22 which trails may be the trailing edge 220.

[0043] Hereinafter, it is assumed that the leading edge 221 is positioned on a front side of the blade 22 and the trailing edge 220 is positioned on a rear side thereof.

[0044] The air introduced to the blade 22 through the leading edge 221 flows along a front surface of the blade 22 and is discharged backward of the trailing edge 220. The blade 22 may be provided to have a gentle inclination so as to be directed backward of the propeller fan 20 as it goes from the leading edge 221 to the trailing edge 220. Thus, when the propeller fan 20 is rotated, the air may flow from the rear of the propeller fan 20 to the front along the axial direction.

[0045] FIG. 4 is a front enlarged view illustrating a portion of a propeller fan in accordance with one embodiment of the present invention, and FIG. 5 is a cross-sectional view illustrating a propeller fan in accordance with one embodiment of the present invention.

[0046] Referring to FIGS. 4 and 5, a plurality of protrusions 224 and 225 may be formed in the blades 22 of the propeller fan 20 in accordance with one embodiment of the present invention. A surface of the propeller fan 20 may be indented along the circumferential direction of a circle that forms a concentric circle with the hub 21. The indented portion formed on the surface of the propeller fan 20 may be provided so as to correspond to a position where the plurality of protrusions 224 and 225 are formed.

[0047] The plurality of protrusions 224 and 225 may be formed in the leading edge 221 or the trailing edge 220. The protrusions 224 may be formed so as to protrude forward of the leading edge 221. The protrusions 225 may be formed so as to protrude backward of the trailing edge 220. The protrusions 224 formed in the leading edge 221 and the protrusions 225 formed in the trailing edge 220 may be formed so as to correspond to each other.

[0048] When a position of the leading edge 221 is assumed to be P in a state in which the protrusions 224 are not formed, the protrusions 224 may be formed so as to protrude forward of the blade 22 from P. It may be assumed that a distance between P and the most protruding portion of the protrusions 224 is L. The size of the protrusion 224 may be increased along an increase in L. This may be applicable in the same manner as in the case of the trailing edge 220.

[0049] For example, at least three protrusions 224 may be formed in the leading edge 221. In addition, at least three protrusions 225 may be formed in the trailing edge 220. The plurality of protrusions 224 formed in the leading edge 221 may have different sizes and shapes. As an example, the size of the protrusions 224 positioned far away from the hub 21 may be larger than that of the protrusions 224 positioned adjacent to the hub 21. The

plurality of protrusions may be formed in such a manner that intervals between the adjacent protrusions are different. This may be applicable in the same manner as in the case of the protrusions 225 of the trailing edge 220.

[0050] The protruding length (L) of each of the protrusions 224 and 225, and may be designed in a range of 1.3% to 6.6% of a length (W) of the blade 22. For example, when the length (W) of the blade is 300 mm, the protruding length (L) of each of the protrusions 224 and 225 may be formed in a range of $4 \text{ mm} < L < 20 \text{ mm}$.

[0051] The shape, size, and the number of the protrusions 224 are not limited to the above descriptions and may vary depending on the structure and shape of the propeller fan 20.

[0052] A surface of the blade 22 may be indented along the circumferential direction of a circle that forms a concentric circle with the hub 21. When viewing the propeller fan 20 from the front (B), a portion that protrudes to the front (B) may be referred to as a convex portion 222 and a portion that protrudes to the rear (A) may be referred to as a concave portion 223. The convex portion 222 and the concave portion 223 may extend along the circumferential direction of the circle that forms the concentric circle with the hub 21.

[0053] The convex portion 222 and the concave portion 223 may extend so as to connect the leading edge 221 and the trailing edge 220. The protrusions may be formed in a corresponding position of each of the leading edge 221 and the trailing edge 220, and the convex portion 222 may be formed so as to connect the protrusions 224 formed in the leading edge 221 and the protrusions 225 formed in the trailing edge 220. The concave portion 223 may be formed between the adjacent convex portions 222.

[0054] When it is assumed that a flat surface of the blade 22 is P in a state in which the concave portion 223 and the convex portion 222 are not formed on the surface of the blade 22, a height (H) of any one of the plurality of convex portions 222 and a height of the adjacent convex portion 222 may be different from each other. As an example, the height (H) of the convex portion 222 positioned adjacent to the hub 21 or adjacent to a tip 226 that is an end of the blade 22 may be larger than the height of the convex portion 222 positioned in a middle portion between the hub 21 and the tip 226.

[0055] This concerning the height of the convex portion 222 may be applicable in the same manner as in a height (H') of the concave portion 223. When it is assumed that a flat surface of the blade 22 is P' in a state in which the concave portion 223 and the convex portion 222 are not formed on the surface of the blade 22, a height (H') of any one of the plurality of concave portions 223 and a height of the adjacent concave portion 223 may be different from each other. As an example, the height (H') of the concave portion 223 positioned adjacent to the hub 21 or adjacent to the tip 226 that is the end of the blade 22 may be larger than the height of the concave portion 223 positioned in a middle portion between the hub 21

and the tip 226.

[0056] The height (H) of the convex portion 222 may be formed in a range of 0.5% to 6.0% of the length (W) of the blade 22. In the same manner, the height (H') of the concave portion 223 may be formed in a range of 0.5% to 6.0% of the length (W) of the blade 22.

[0057] For example, when the length (W) of the blade 22 is 300 mm, the height (H) of the convex portion 222 or the height (H') of the concave portion 223 may be formed in a range of $1.5 \text{ mm} < H (H') < 18 \text{ mm}$.

[0058] The height (H) of the convex portion 222 or the height (H') of the concave portion 223 is not limited to the above descriptions, and the height, the shape, the number of the convex portions 222 or the concave portions 223 may vary depending on the structure of the applied propeller fan 20.

[0059] The protrusions 224 of the leading edge 221 and the protrusions 225 of the trailing edge 220 are formed, and therefore it is possible to prevent occurrence of a large turbulent flow while the blade 22 is rotated. More specifically, the turbulent flow due to the rotation of the blade 22 does not occur in the form of a large single turbulent flow, but occur in the form of small turbulent flows separated by the plurality of protrusions 224 and 225.

[0060] Since larger noise energy is obtained as the turbulent flow is increased, the turbulent flow is separated into small turbulent flows, so that noise energy is distributed, thereby reducing the magnitude of the noise. In addition, the air flows along the surface of the blade 22 which is indented in the form of waves, and therefore the magnitude of noise caused by blowing may be reduced and strident noise may be reduced by reducing the peak frequency of the noise.

[0061] Hereinafter, a noise reduction and an improvement effect of sensible noises in accordance with the structure of the propeller fan in accordance with one embodiment of the present invention will be described with reference to the drawings.

[0062] FIG. 6 is a graph showing the magnitude of noise to air flow of a propeller fan in accordance with one embodiment of the present invention.

[0063] Referring to FIG. 6, it can be seen that there is an effect in which noise at the time of blowing by the propeller fan 20 in accordance with one embodiment of the present invention is reduced. Solid line (T) shows the magnitude of noise in accordance with air flow in the conventional propeller fan in which the protrusions 224 and 225 and the convex and concave portions 222 and 223 are not formed on the surface of the blade. Dotted line (F) shows the magnitude of noise in accordance with air flow in the propeller fan 20 in accordance with one embodiment of the present invention. The conventional propeller fan and the propeller fan in accordance with one embodiment of the present invention may have the same diameter, and an experiment is conducted in an environment in which other external conditions are the same.

[0064] For example, the magnitude ② of noise that oc-

curs when an air flow of the propeller fan 20 in accordance with one embodiment of the present invention is $\alpha \text{ m}^3/\text{min}$ is reduced by 0.6 dB to 0.8 dB than the magnitude ① of noise that occurs when an air flow of the conventional propeller fan is $\alpha \text{ m}^3/\text{min}$. That is, it can be found that, in the case of the same air flow, the magnitude of the noise generated by the propeller fan 20 in accordance with one embodiment of the present invention is smaller than the magnitude of the noise generated by the conventional propeller fan.

[0065] Thus, through the above-described experiment, it can be confirmed that the propeller fan in accordance with one embodiment of the present invention in which the plurality of protrusions are formed in the blade and the convex portions and the concave portions are formed on the surface of the blade may generate less noise compared to the conventional propeller fan.

[0066] FIGS. 7 and 8 are graphs showing a frequency of noise due to rotation of a propeller fan in accordance with one embodiment of the present invention (FIG. 7) and a frequency of noise due to rotation of a conventional propeller fan (FIG. 8). A dotted line on the graph is a line indicating an audible range.

[0067] It can be seen that, when a frequency position is S in a case in which a rotational frequency per minute of each of the propeller fan 20 in accordance with one embodiment of the present invention and the conventional propeller fan is approximately 1kHz, the number of peak points in which the frequency of the propeller fan 20 in accordance with one embodiment of the present invention is irregularly shown is small.

[0068] That is, when the propeller fan 20 in accordance with one embodiment of the present invention is rotated at the same frequency, smaller number of irregular peak points are generated compared to when the conventional propeller fan is rotated at the same frequency. As is apparent from the fact that more strident noises occur as the number of irregular peak points is increased, less unpleasant noises offensive to the ears are made by the propeller fan 20 in accordance with one embodiment of the present invention compared to the conventional propeller fan.

[0069] As described above, in the propeller fan 20 in accordance with one embodiment of the present invention, the plurality of protrusions are formed in the leading edge 221 and trailing edge 220 of the blade 22 and the convex portions 222 and the concave portions 223 are formed on the surface of the blade 22, and therefore the propeller fan 20 may have a shape like a whale's fin or flipper. By such a shape, noise that occurs when the propeller fan 20 is rotated may be reduced, and occurrence of unpleasant noise may be prevented.

[0070] The structure of the propeller fan has been described above, but when the propeller fan is applied to an air conditioner, the propeller fan can be referred to as a blowing fan.

[0071] In accordance with one embodiment of the present invention, by applying features and advantages

of natural objects to the shape of the propeller fan, the magnitude of noise that occurs due to the rotation of the propeller fan may be reduced, and quality of a sensible noise may be improved.

[0072] Although a few embodiments of the present invention have been shown and described, it would be appreciated by those skilled in the art that changes may be made in these embodiments without departing from the invention, the scope of which is defined in the claims.

Claims

1. An air conditioner comprising:

an outdoor unit that includes a compressor configured to compress a refrigerant, a condenser configured to condense the compressed refrigerant, and a blowing fan configured to blow outdoor air into the outdoor unit;

an indoor unit that discharges air heat-exchanged with the refrigerant flowing in from the outdoor unit to a room; and

a connection piping that connects the outdoor unit and the indoor unit,

wherein the blowing fan includes a plurality of blades, a plurality of protrusions are formed on both sides of facing edges of the blade, and a convex portion and a concave portion are formed on a surface of the blowing fan so that the surface of the blowing fan is indented.

2. The air conditioner according to claim 1, wherein the blowing fan includes a hub fixed to a shaft of a driving motor and the plurality of blades arranged along a circumference of the hub.

3. The air conditioner according to claim 2, wherein the blade includes a trailing edge and a leading edge that leads the trailing edge when rotated with respect to the hub, and the plurality of protrusions are formed so as to protrude from both sides of the leading edge and the trailing edge.

4. The air conditioner according to claim 3, wherein the protrusion is formed so as to protrude forward of the leading edge.

5. The air conditioner according to claim 3, wherein the protrusion is formed so as to protrude backward of the trailing edge.

6. The air conditioner according to claim 3, wherein the plurality of protrusions are formed on the leading edge, and the plurality of protrusions are formed on the trailing edge so as to correspond to the protrusions formed on the leading edge.

7. The air conditioner according to claim 6, wherein the convex portion is formed so as to connect the protrusions formed on the leading edge and the trailing edge.

8. The air conditioner according to claim 7, wherein the concave portion is formed between the convex portions adjacent to each other.

9. The air conditioner according to claim 1, wherein the protrusion is formed in a range of 1.3% to 6.6% of a length of the blade.

10. The air conditioner according to claim 1, wherein a height of the convex portion is formed in a range of 0.5% to 6.0% of a length of the blade.

11. The air conditioner according to claim 1, wherein the number of the formed protrusions is at least three.

FIG. 1

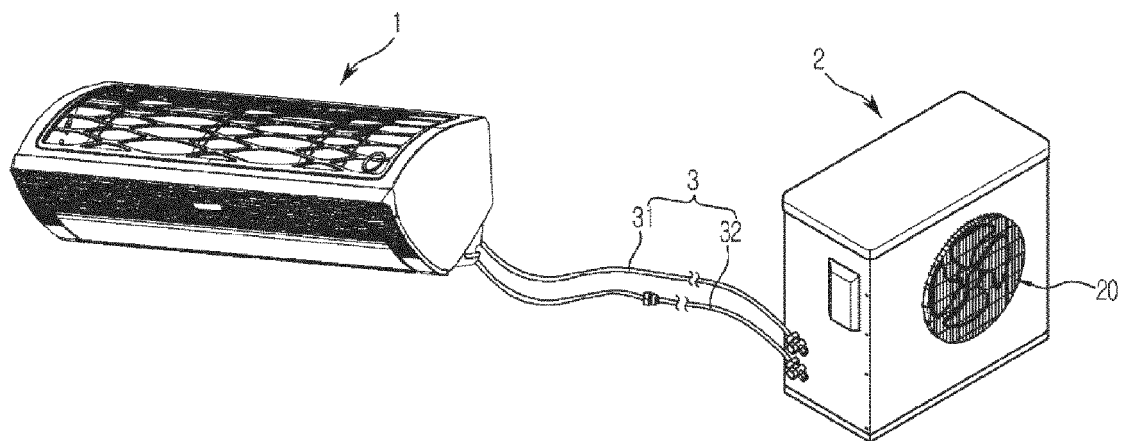


FIG. 2

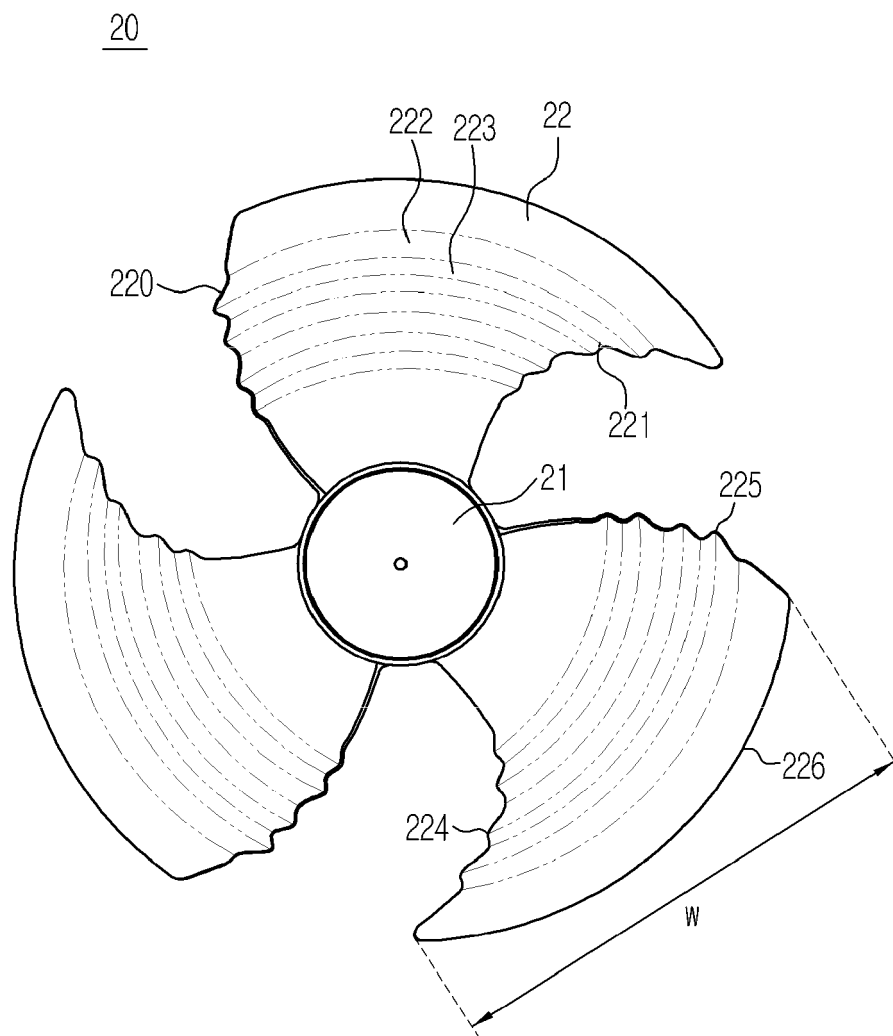


FIG. 3

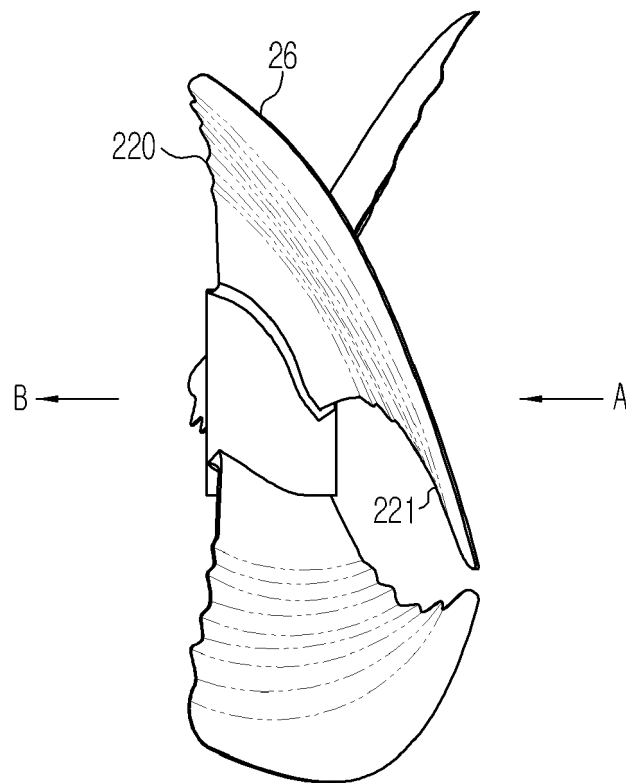


FIG. 4

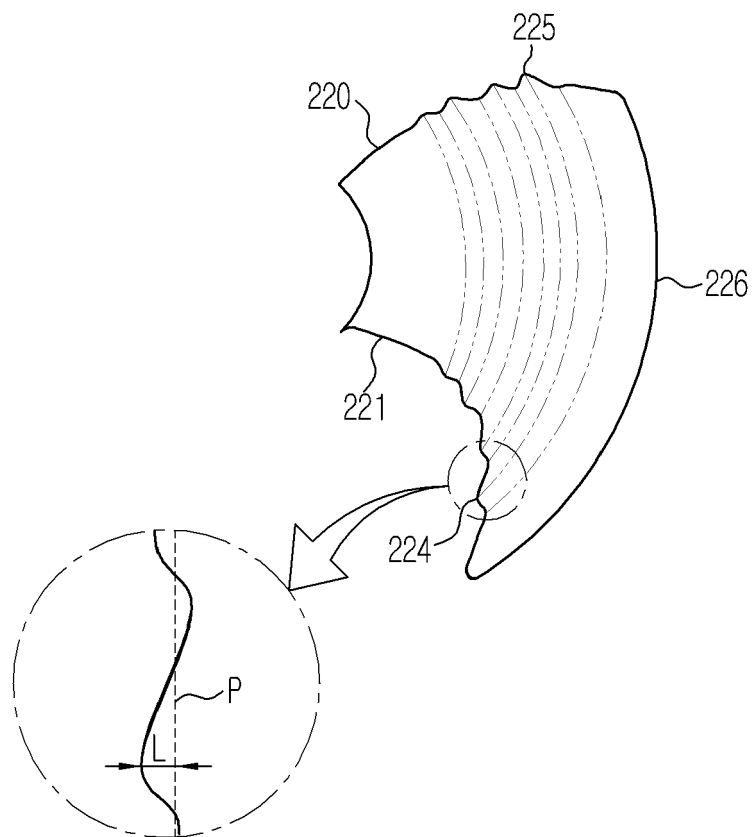


FIG. 5

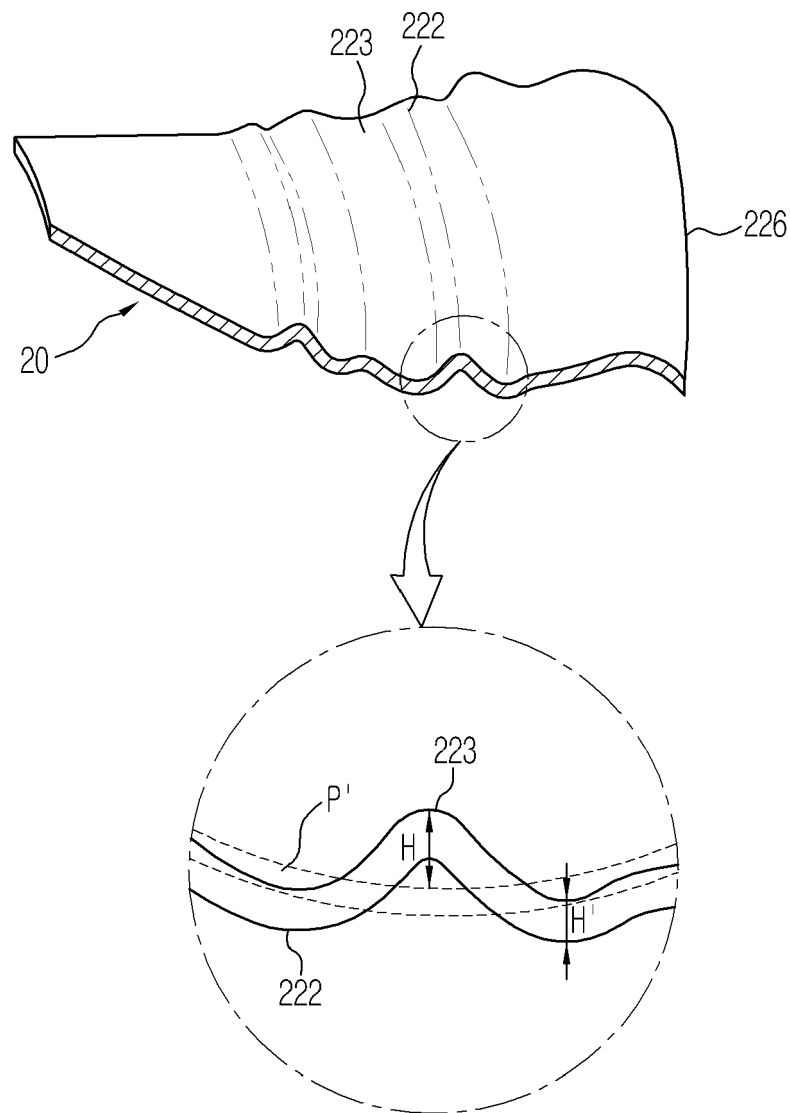


FIG. 6

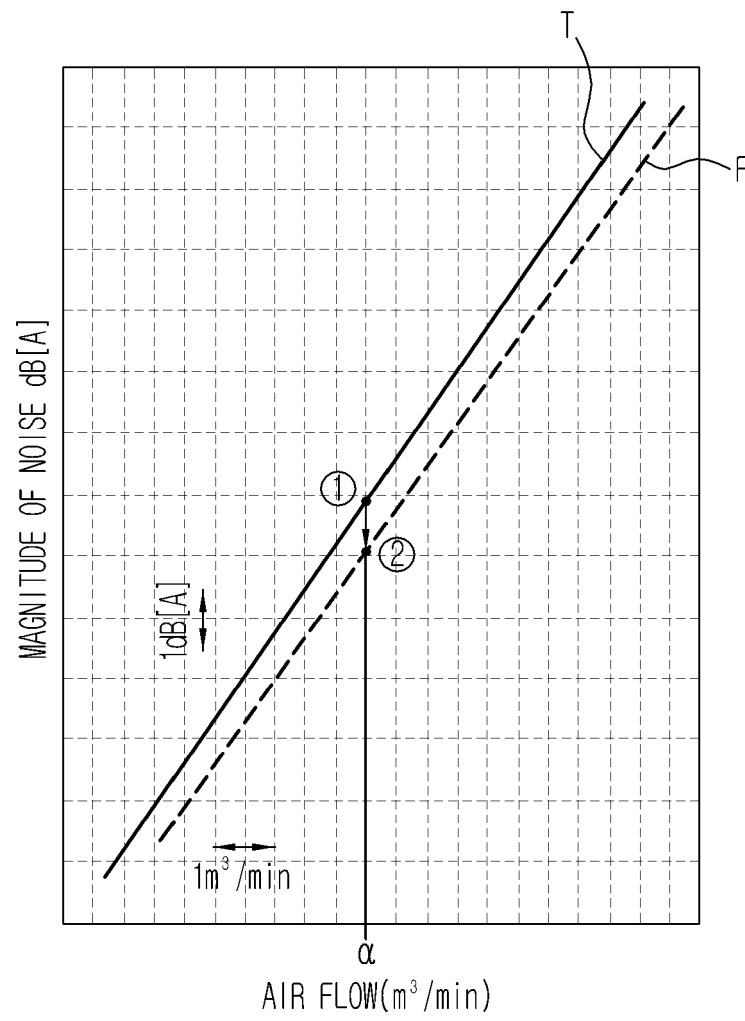


FIG. 7

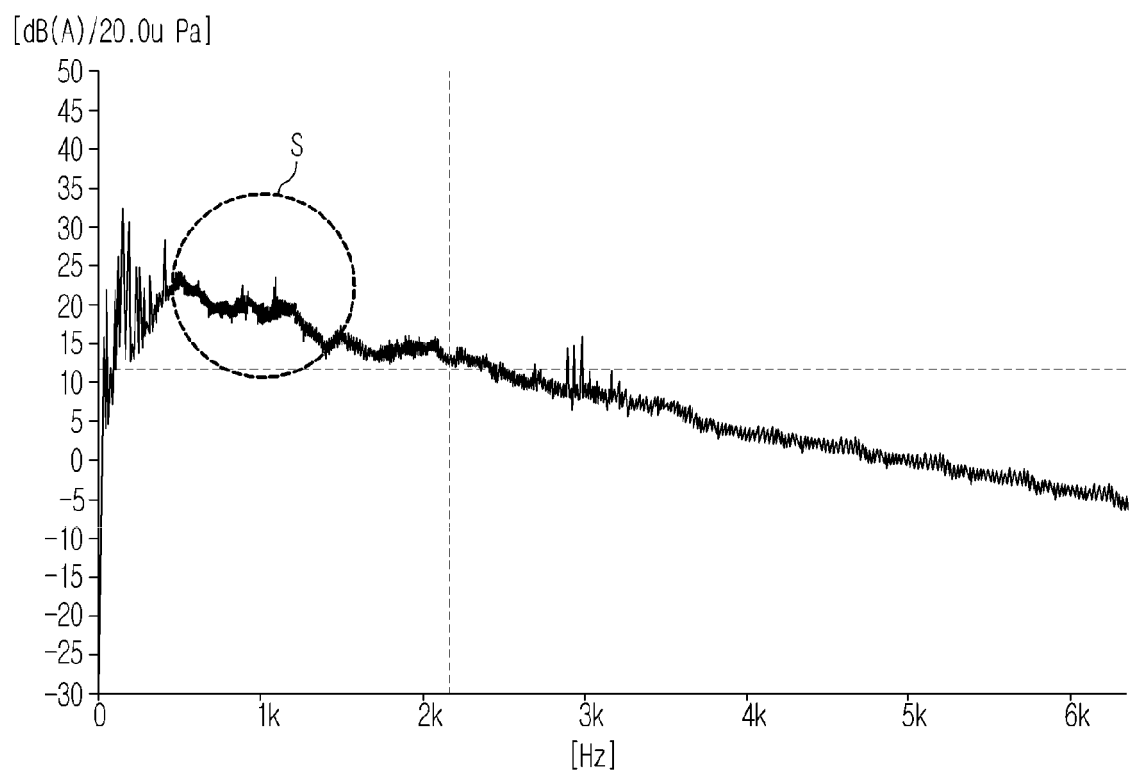


FIG. 8 - Related Art

