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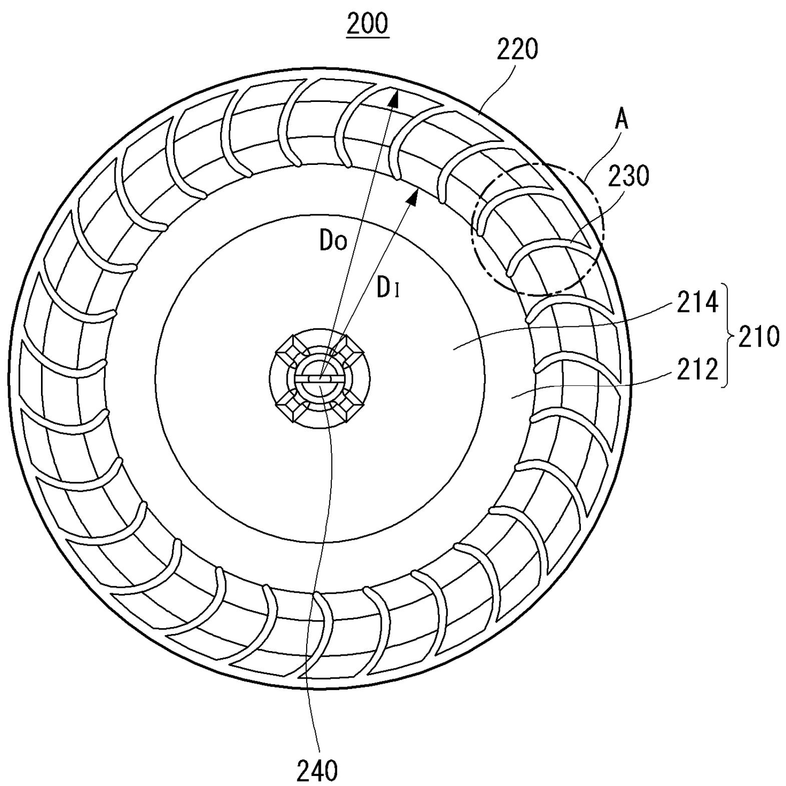
(54) **CENTRIFUGAL FAN FOR REFRIGERATOR**

(57) A centrifugal fan for a refrigerator is disclosed. According to an embodiment, the refrigerator centrifugal fan comprises a hub coupled to a rotation shaft, and a plurality of blades disposed radially about the rotation shaft on the hub, wherein the blades are formed to be entirely concave along a rotational direction.

FIG.4



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Description

[0001] The disclosure relates to centrifugal fans for refrigerators. More particularly, the disclosure relates to a centrifugal fan for a refrigerator that provides air cooled by an evaporator to a refrigerating compartment or a freezing compartment.

[0002] In general, a refrigerator may cool food or prevent spoilage by providing cold air using a refrigeration cycle device including a compressor, a condenser, an expansion mechanism, and an evaporator. A refrigerator is a device that stores food for a long time in a fresh state using cold air.

[0003] In the refrigerator, a centrifugal fan for a refrigerator is installed on the flow path, which blows air into the refrigerating compartment and freezing compartment after forcing the air to flow from the refrigerating compartment and the freezing compartment through an evaporator.

[0004] FIG. 17 is a cross-sectional view of a refrigerator according to the prior art.

[0005] As shown in FIG. 17, the refrigerator 10 typically includes an outer case 11 with a front opening, an inner case 12 disposed in the outer case 11, a storage compartment (e.g., a refrigerating compartment or a freezing compartment) disposed in the inner case 12, and a door disposed on the front surface of the outer case 11 to open and close the storage compartment.

[0006] In this case, the refrigerator 10 includes an evaporator 14 formed on a side of the storage compartment to heat-exchange the refrigerant and air to generate cold air, a cold air flow path 16 disposed between the outer case 11 and the inner case 12, a refrigerator centrifugal fan 17 for circulating the cold air from the evaporator 14 to the storage compartment through the cold air flow path 16, and a motor 15 for providing power to the refrigerator centrifugal fan 17.

[0007] On the other hand, to increase the internal capacity of the refrigerator, it is necessary to reduce the size of the evaporator, the cold air flow path, and the refrigerator centrifugal fan for the refrigerator.

[0008] When the size of the evaporator that generates cold air decreases, the number of cooling fins of the evaporator increases to increase the heat exchange amount per unit area, and when the cold air flow path narrows, the flow path resistance increases two times or more under the same flow rate condition. Thus, the centrifugal fan for refrigerator requires more than twice the work.

[0009] The diameter of a turbo fan, as disclosed in prior document 1 (Korean Patent No. 10-0389395) and prior document 2 (Korean Patent No. 10-1577875), is generally about 110 mm to 140 mm, and the rotation speed is about 1200 rpm. Here, the turbo fan may mean a fan in which blades are convexly formed in the rotation direction of the fan.

[0010] If the diameter of the fan is reduced to 85mm, the rotational speed of the fan is inversely proportional to the third power of the diameter of the fan according to the law of similarity of the fan, so that the rotational speed of the fan increases up to 2600 rpm.

[0011] Further, as mentioned above, when the number of cooling fins is increased and the flow path is narrowed, so that the flow path resistance is increased by more than two times, the rotational speed of the fan is excessively increased according to the law of similarity of the fan.

[0012] More noise may be caused due to aerodynamic or vibration resultant from the excessive increase in the rpm of the fan.

[0013] Further, such excessive increase in rpm may also shorten the lifespan of such components as the motor and oil-impregnated bushing bearing.

[PRIOR TECHNICAL DOCUMENTS]

[0014]

(Patent Document 1) Korean Patent No. 10-0389395 B (published on June 27, 2003)

(Patent Document 2) Korean Patent No. 10-1577875 B (published on December 28, 2015)

[0015] The disclosure aims to provide a centrifugal fan for a refrigerator capable of reducing the number of rotations of the fan while increasing the internal capacity of the refrigerator.

[0016] The disclosure also aims to provide a centrifugal fan for a refrigerator that reduces noise due to aerodynamic or vibration generated by an increase in the rotation speed of the fan.

[0017] The disclosure also aims to provide a centrifugal fan for a refrigerator capable of increasing the lifespan of components of the refrigerator.

[0018] The disclosure also aims to provide a high-efficiency refrigerator centrifugal fan capable of increasing the discharge pressure under the same flow rate condition.

[0019] The disclosure aims to provide a centrifugal fan for a refrigerator that may maximize discharge pressure efficiency under the same flow rate condition.

[0020] The disclosure aims to provide a centrifugal fan for a refrigerator capable of preventing interference of a product that may occur when injection molding is used.

[0021] The disclosure also aims to provide a centrifugal fan for a refrigerator capable of reducing the number of rotations of the fan under the same flow rate and pressure condition by reducing the length of the blade cord.

[0022] To achieve the foregoing objects, according to an embodiment, a centrifugal fan for a refrigerator comprises a hub coupled to a rotation shaft, and a plurality of blades disposed radially about the rotation shaft on the hub, wherein the blades are formed to be entirely concave along a rotational direction.

[0023] Thus, it is possible to increase the internal capacity of the refrigerator while maintaining a low number of rotations as compared with the conventional turbo fan.

[0024] It is also possible to reduce noise due to aerodynamic force or vibration generated by an increase in the number of rotations of the fan.
it is also possible to increase the lifespan of the components of the refrigerator by reducing the number of rotations of the fan.

[0025] The blades may meet an equation expressed as:$0.67<D_I/D_O<0.77$ (where, D_I is a distance between an inner end of the blades and a center area of the rotation shaft, and D_O is a distance between an outer end of the blades and the center area of the rotation shaft).

[0026] Preferably, the blades may meet an equation expressed as: $D_I/D_O=0.72$ (where, D_I is a distance between an inner end of the blades and a center area of the rotation shaft, and D_O is a distance between an outer end of the blades and the center area of the rotation shaft).

[0027] Therefore, it is possible to enhance the efficiency of the refrigerator centrifugal fan by increasing the discharge pressure under the same flow rate condition.

[0028] The blades may meet an equation expressed as: 0.25<L3/L2<0.3 (where, L3 is a maximum camber amount of the blades, and L2 is a chord length of the blades).

[0029] Preferably, the blades may meet an equation expressed as: L3/L2=0.275 (where, L3 is a maximum camber amount of the blades, and L2 is a chord length of the blades).

[0030] Therefore, it is possible to enhance the efficiency of the refrigerator centrifugal fan by increasing the discharge pressure under the same flow rate condition.

[0031] The blades may meet an equation expressed as: 044<L4/L2<0.58 (where L4 is a maximum camber position of the blades, and L2 is the chord length of the blades).

[0032] Preferably, the blades may meet an equation expressed as: L4/L2=0.51 (where L4 is a maximum camber position of the blades, and L2 is the chord length of the blades).

[0033] Therefore, it is possible to enhance the efficiency of the refrigerator centrifugal fan by increasing the discharge pressure under the same flow rate condition.

[0034] An inner diameter of a suction-side end of the blades may be smaller than an inner diameter of a hub-side end of the blades.

[0035] Thus, it is possible to prevent interference that may arise when injection molding is used.

[0036] A predetermined angle may be formed between a chord line of a hub-side end of the blades and a chord line of a suction-side end of the blades.

[0037] For example, the predetermined angle formed between the chord line of the hub-side end of the blades and the chord line of the suction-side end of the blades may range from 18.7 degrees to 21 degrees.

[0038] Preferably, the predetermined angle formed between the chord line of the hub-side end of the blades and the chord line of the suction-side end of the blades may be 19.8 degrees.

[0039] Therefore, it is possible to enhance the efficiency of the refrigerator centrifugal fan by increasing the discharge pressure under the same flow rate condition.

[0040] A radial outer end of the blades may be disposed in the rotational direction, as compared with an inner end of the blades.

[0041] Therefore, it is possible to reduce the number of rotations under the same flow rate and pressure conditions by reducing the length of the blade chord.

[0042] To achieve the foregoing objects, according to an embodiment, a centrifugal fan for a refrigerator comprises a hub coupled to a rotation shaft, and a plurality of blades disposed radially about the rotation shaft on the hub, wherein a predetermined angle is formed between a chord line of a hub-side end of the blades and a chord line of a suction-side end of the blades.

[0043] Therefore, it is possible to enhance the efficiency of the refrigerator centrifugal fan by increasing the discharge pressure under the same flow rate condition.

[0044] The predetermined angle formed between the chord line of the hub-side end of the blades and the chord line of the suction-side end of the blades may range from 18.7 degrees to 21 degrees.

[0045] Preferably, the predetermined angle formed between the chord line of the hub-side end of the blades and the chord line of the suction-side end of the blades may be 19.8 degrees.

[0046] Therefore, it is possible to maximize the efficiency of the refrigerator centrifugal fan under the same flow rate condition.

[0047] The blades may be formed to be entirely concave in the rotational direction.

[0048] Therefore, it is possible to enhance the efficiency of the refrigerator centrifugal fan by increasing the discharge pressure under the same flow rate condition.

[0049] The blades may meet an equation expressed as:$0.67<D_I/D_O<0.77$ (where, D_I is a distance between an inner end of the blades and a center area of the rotation shaft, and D_O is a distance between an outer end of the blades and the center area of the rotation shaft).

[0050] The blades may meet an equation expressed as: 0.25<L3/L2<0.3 (where, L3 is a maximum camber amount of the blades, and L2 is a chord length of the blades).

[0051] The blades may meet an equation expressed as: 044<L4/L2<0.58 (where L4 is a maximum camber position of the blades, and L2 is the chord length of the blades).

[0052] Therefore, it is possible to enhance the efficiency of the refrigerator centrifugal fan by increasing the discharge pressure under the same flow rate condition.

[0053] A radial outer end of the blades may be disposed in the rotational direction, as compared with an inner end of the blades.

[0054] Therefore, it is possible to reduce the number of rotations under the same flow rate and pressure conditions by reducing the length of the blade chord.

[0055] The disclosure may provide a centrifugal fan for a refrigerator capable of reducing the number of rotations of the fan while increasing the internal capacity of the refrigerator.

[0056] The disclosure may provide a centrifugal fan for a refrigerator that reduces noise due to aerodynamic or vibration generated by an increase in the rotation speed of the fan.

[0057] The disclosure may provide a centrifugal fan for a refrigerator capable of increasing the lifespan of components of the refrigerator.

[0058] The disclosure may provide a high-efficiency refrigerator centrifugal fan capable of increasing the discharge pressure under the same flow rate condition.

[0059] The disclosure may provide a centrifugal fan for a refrigerator that may maximize discharge pressure efficiency under the same flow rate condition.

[0060] The disclosure may provide a centrifugal fan for a refrigerator capable of preventing interference of a product that may occur when injection molding is used.

[0061] The disclosure may provide a centrifugal fan for a refrigerator capable of reducing the number of rotations of the fan under the same flow rate and pressure condition by reducing the length of the blade cord.

BRIEF DESCRIPTION OF THE DRAWINGS

[0062] A more complete appreciation of the disclosure and many of the attendant aspects thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

FIG. 1 is a cross-sectional view illustrating a refrigerator according to an embodiment of the disclosure;
FIG. 2 is a cross-sectional view illustrating a blower according to an embodiment of the disclosure;
FIG. 3 is a perspective view illustrating a refrigerator centrifugal fan according to an embodiment of the disclosure;
FIG. 4 is a plan view illustrating a refrigerator centrifugal fan according to an embodiment of the disclosure;
FIG. 5 is a cross-sectional view illustrating a refrigerator centrifugal fan according to an embodiment of the disclosure;
FIG. 6 is an enlarged view of part A of FIG. 4;
FIG. 7 is a view schematically illustrating a blade according to an embodiment of the disclosure;
FIG. 8 is a graph illustrating the discharge pressure according to the diameter ratio of a blade according to an embodiment of the disclosure;
FIG. 9 is a graph illustrating the discharge pressure according to the maximum camber amount of a blade according to an embodiment of the disclosure;
FIG. 10 is a graph illustrating the discharge pressure according to the maximum camber position of a blade according to an embodiment of the disclosure;
FIG. 11 is a perspective view illustrating a refrigerator centrifugal fan according to another embodiment of the disclosure;
FIG. 12 is a plan view illustrating a refrigerator centrifugal fan according to another embodiment of the disclosure;
FIG. 13 is an enlarged view of part B of FIG. 12;
FIG. 14 is a cross-sectional view illustrating a refrigerator centrifugal fan according to another embodiment of the disclosure;
FIG. 15 is a graph illustrating the discharge pressure according to an angle between a cord line at a hub-side end of a blade and a cord line at a suction-side end according to another embodiment of the disclosure;
FIG. 16 is a graph illustrating the discharge pressure according to the flow rate of a centrifugal fan for a refrigerator according to the prior art and according to an embodiment of the disclosure; and
FIG. 17 is a cross-sectional view of a refrigerator according to the prior art.

[0063] Hereinafter, embodiments of the disclosure are described in detail with reference to the accompanying drawings. The same reference denotations may be used to refer to the same or similar elements throughout the disclosure and the drawings, and no duplicate description is given.

[0064] It will be understood that when an element or layer is referred to as being "on," "connected to," "coupled to," or "adjacent to" another element or layer, it may be directly on, connected, coupled, or adjacent to the other element or layer, or intervening elements or layers may be present.

[0065] When determined to make the subject matter of the disclosure unclear, the detailed description of the known art or functions may be skipped. The accompanying drawings are provided merely for a better understanding of the disclosure and the technical spirit or the scope of the disclosure are not limited by the drawings.

[0066] As used herein, the term "disclosure" may be replaced with other terms, such as "document," "specification," or "description."

[0067] FIG. 1 is a cross-sectional view illustrating a refrigerator according to an embodiment of the disclosure.

[0068] Referring to FIG. 1, a refrigerator 10 according to an embodiment of the disclosure may include an outer case 11, an inner case 12, a door 13, an evaporator 14, a cold air flow path 16, a blower 100, and a motor 15. However, some of the components may be excluded, or the refrigerator 10 may include more components.

[0069] The outer case 11 may have a front opening and an inner space. The outer case 11 may form the exterior of the refrigerator 10. The outer case 11 may be formed overall in a hexahedral shape with a front opening but, without limitations thereto, the outer case 11 may be formed in other various shapes.

[0070] The inner case 12 may be disposed inside the outer case 11. The inner case 12 may be spaced apart from the outer case 11. The inner case 12 may include an inner space. A storage compartment may be formed in the inner space of the inner case 12. The storage compartment may be referred to as a refrigerator compartment or a freezer compartment. There may be provided a plurality of storage compartments. The plurality of storage compartments may be maintained in different temperature zones. One of the plurality of storage compartments may be a refrigerating compartment, and the other may be a freezing compartment.

[0071] The door 13 may be disposed on the front surface of the outer case 11. The door 13 may be selectively opened and closed by a user. A plurality of doors 13 may be provided according to the number of storage compartments.

[0072] The evaporator 14 may be disposed between the outer case 11 and the inner case 12. The evaporator 14 may be disposed on one side or rear of the storage compartment. The evaporator 14 may be disposed under the cold air flow path 16. The evaporator 14 may be disposed under the blower 100. The evaporator 14 may be disposed in a lower portion of the refrigerator 10. The evaporator 14 may generate cold air by exchanging air supplied from the storage compartment with a refrigerant. The cold air generated by the evaporator 14 may be provided to the blower 100.

[0073] A plurality of evaporators 14 may be provided. One of the plurality of evaporators may cool the refrigerating compartment, and the other may cool the freezing compartment. Alternatively, both the refrigerating compartment and freezing compartment may be cooled by one evaporator.

[0074] The refrigerator 10 according to an embodiment of the disclosure may include a refrigeration cycle device including a compressor (not shown) for compressing the refrigerant, a condenser (not shown) for condensing the refrigerant compressed by the compressor, an expansion mechanism for expanding the refrigerant condensed by the condenser, and the evaporator 14 to which the refrigerant expanded by the expansion mechanism is provided.

[0075] The cold air flow path 16 may be disposed between the outer case 11 and the inner case 12. The cold air flow path 16 may be disposed on one side or rear of the storage compartment. The cold air flow path 16 may extend in upper and lower directions or a vertical direction. The cold air flow path 16 may provide a flow path through which cold air flows. One side of the cold air flow path 16 may be connected to the blower 100 and the other side may be connected to the storage compartment. The cold air flow path 16 may be disposed over the blower 100. The cold air flow path 16 may be disposed over the evaporator 14.

[0076] The blower 100 may be disposed between the outer case 11 and the inner case 12. The blower 100 may be disposed under the cold air flow path 16. The blower 100 may be disposed in a lower portion of the cold air flow path 16. The blower 100 may be disposed in front of the motor 15. The blower 100 may be coupled with the motor 15. The blower 100 may be disposed over the evaporator 14. The blower 100 may flow cold air generated by the evaporator 14 to the storage compartment through the cold air flow path 16.

[0077] The motor 15 may be coupled to the blower 100. The motor 15 may drive the blower 100 through external power. The motor 15 may be disposed behind the blower 100. The motor 15 may be disposed over the evaporator 14. The motor 15 may be disposed under the cold air flow path 16.

[0078] Referring to FIGS. 1 and 17, the internal capacity of the refrigerator 10 according to an embodiment of the disclosure may be increased in volume V as compared to the internal capacity of the refrigerator according to the prior art. Accordingly, the sizes of the blower 100 and the evaporator 14 may be reduced, and the cold air flow path 16 may be narrowed. This is described below in greater detail.

[0079] FIG. 2 is a cross-sectional view illustrating a blower according to an embodiment of the disclosure.

[0080] Referring to FIG. 2, the blower 100 according to an embodiment of the disclosure may include a housing 120, a motor 150, and a centrifugal fan 200 for a refrigerator, but some of the components may be omitted, or the blower 100 may include more components.

[0081] The housing 120 may include a suction port 120a through which cold air generated by the evaporator 14 is sucked, and a discharge port 120b for discharging the refrigerant passing through the refrigerator centrifugal fan 200. The housing 120 may be fixed to the motor 150. The centrifugal fan 200 for a refrigerator may be rotatably disposed in the housing 120. The housing 120 may form a flow path for cold air and air.

[0082] A bell mouth 110 may extend from the housing 120. The bell mouth 110 may be formed in a rea center area of the housing 120. The inner diameter of the bell mouth 110 may increase toward the centrifugal fan 200 for a refrigerator. Further, the blower 100 may include a convex portion 110a formed to be convex towards the centrifugal fan 200 for a refrigerator between the bell mouth 110 and the housing 120.

[0083] The motor 150 may be driven by external power. The motor 150 may be coupled to the housing 120. The rotation shaft of the motor 150 may be coupled to the centrifugal fan 200 for a refrigerator. The centrifugal fan 200 for a refrigerator may be rotated in one direction according to the rotation of the rotation shaft of the motor 150. The motor 150 may be understood as identical to the motor 15 described above in connection with FIG. 1.

[0084] The centrifugal fan 200 for a refrigerator may be disposed in the housing 120. The centrifugal fan 200 for a refrigerator may be rotatably connected to the motor 150. The centrifugal fan 200 for a refrigerator may rotate in one direction according to the rotation of the rotation shaft of the motor 150. The centrifugal fan 200 for a refrigerator may be disposed in front of the motor. A detailed configuration of the centrifugal fan 200 for a refrigerator will be described later.

[0085] A shroud (not shown) may be installed to introduce the air and refrigerant to be introduced through the suction port 120a and to guide the air through the discharge port 120b.

[0086] FIG. 3 is a perspective view illustrating a refrigerator centrifugal fan according to an embodiment of the disclosure. FIG. 4 is a plan view illustrating a refrigerator centrifugal fan according to an embodiment of the disclosure. FIG. 5 is a cross-sectional view illustrating a refrigerator centrifugal fan according to an embodiment of the disclosure; FIG. 6 is an enlarged view of part A of FIG. 4. FIG. 7 is a view schematically illustrating a blade according to an embodiment of the disclosure; FIG. 8 is a graph illustrating the discharge pressure according to the diameter ratio of a blade according to an embodiment of the disclosure. FIG. 9 is a graph illustrating the discharge pressure according to the maximum camber amount of a blade according to an embodiment of the disclosure. FIG. 10 is a graph illustrating the discharge pressure according to the maximum camber position of a blade according to an embodiment of the disclosure.

[0087] Referring to FIGS. 3 to 7, the centrifugal fan 200 for a refrigerator according to an embodiment of the disclosure may include a hub 210, a blade 230, a connecting member 220, and a coupling part 240. However, the refrigerator centrifugal fan 200 may include more or less components according to an embodiment.

[0088] The hub 210 may be disposed in the housing 120. The hub 210 may be rotatably coupled to the motor 150. The hub 210 may be coupled to the rotation shaft of the motor 150. The hub 210 may rotate in one direction according to the rotation of the rotation shaft of the motor 150. The blade 230 may be disposed on the hub 210.

[0089] The hub 210 may include a first area 212. The blade 230 may be disposed in the first area 212. The blade 230 may be disposed on the front surface of the first area 212. The first area 212 may be formed flat. The first area 212 may be disposed adjacent to the motor 150 as compared to a second area 214. The first area 212 may be disposed behind the second area 214.

[0090] The hub 210 may include the second area 214. The second area 214 may extend from the first area 212. The second area 214 may have curvature. The second area 214 may be formed to be convex in the opposite direction or forward of the motor 150. The second area 214 may be formed in a semicircular shape. The second area 214 may have an infection point. Thus, it is possible to guide the air or refrigerant sucked through the suction port 120a toward the blade 230 disposed in the first area 212 while improving the suction efficiency of the cold air.

[0091] The blade 230 may be disposed on the hub 210. The blade 230 may be disposed in the first area 212 of the hub 210. The blade 230 may be disposed on the front surface of the first area 212 of the hub 210. The blade 230 may be spaced apart from the center area of the hub 210. The blade 230 overall may have curvature. The blade 230 may have no inflection point. The width of the blade 230 may be constant. Here, the width of the blade 230 may mean the minimum distance between the pressure surface 233 and the negative pressure surface 232.

[0092] The blade 230 may include a leading edge 231 disposed radially inward of the centrifugal fan 200 for a refrigerator, a trailing edge 234 disposed radially outward of the centrifugal fan 200 for a refrigerator, the pressure surface 233 connecting the leading edge 231 and the trailing edge 234 and disposed along the rotation direction of the refrigerator centrifugal fan 200, and the negative pressure surface 232 connecting the leading edge 231 and the trailing edge 234 and disposed in the opposite direction of the rotation direction of the refrigerator centrifugal fan 200. The pressure surface 233 has a higher pressure than the atmospheric pressure, thus pushing out the air. The negative pressure surface 232 is the opposite surface of the pressure surface 233 and may have a pressure lower than the atmospheric pressure. The leading edge 231 may contact the cold air introduced through the suction port 120a, and the trailing edge 234 may discharge the cold air toward the discharge port 120b.

[0093] In one embodiment of the disclosure, the minimum distance between the center of the leading edge 231 and the center of the trailing edge 234 is defined as a chord length L2, the virtual straight line connecting the center of the leading edge 231 with the center of the trailing edge 234 is defined as a chord line, and the line connecting the midpoints of the pressure surface 233 and the negative pressure surface 232 is defined as a camber line L1. When the virtual line perpendicular to the chord line is connected to the camber line L1, the height at the maximum camber is defined as the maximum camber amount L3, and the distance from the center of the leading edge 231 to the maximum camber is defined as the maximum camber position L4.

[0094] The blade 230 may be formed overall concave in the rotation direction. For example, with reference to FIG. 4, when the centrifugal fan 200 for a refrigerator rotates clockwise, the blade 230 may be concave clockwise or convex counterclockwise. The trailing edge 234, which is the radially outer end of the centrifugal fan 200 for a refrigerator, of the blade 230 may be disposed more in the rotational direction than the leading edge 231, which is the radially inner end. For example, when the centrifugal fan 200 for a refrigerator rotates clockwise as viewed in FIG. 4, the trailing edge 234 may be disposed more clockwise or to the right than the leading edge 231.

[0095] In this case, the length L2 of the cord may be shorter than that of the conventional turbofan, and the number of blades 230a, 230b, and 230c may be increased. Thus, it is possible to reduce the number of rotations of the centrifugal fan for a refrigerator under the same flow rate and discharge pressure conditions as compared to the turbo fan according to the prior art.

[0096] It is also possible to increase the internal capacity of the refrigerator 10 (V in FIG. 1) and maintain the centrifugal fan 200 for a refrigerator at a lower rotational speed than the turbo fan according to the prior art.

[0097] It is therefore possible to reduce noise due to aerodynamic force or vibration generated by an increase in the number of rotations of the centrifugal fan 200 for a refrigerator. Further, it is possible to increase the lifespan of such components of the refrigerator 10 as the motor 150 and oil-impregnated bushing bearing by reducing the number of rotations of the centrifugal fan 200 for a refrigerator.

[0098] There may be formed a plurality of blades 230 including blades 230a, 230b, and 230c. The plurality of blades 230a, 230b, and 230c may be disposed radially with respect to the rotation shaft of the motor 150. The plurality of blades 230a, 230b, and 230c may be disposed radially with respect to the central area of the hub 210. The plurality of blades 230a, 230b, and 230c may be spaced apart from each other in the circumferential direction.

[0099] A connecting member 220 may be coupled to the front surface of the blade 230. The connecting member 220 may be coupled to an outer surface or a trailing edge of the blade 230. The connecting member 220 may be connected to the plurality of blades 230. The connecting member 220 may be shaped as a circular band or ring.

[0100] A coupling part 240 may be formed on the hub 210. The coupling part 240 may be formed in a central area of the hub 210. The coupling part 240 may be formed in the central area of the second area 214 of the hub 210. The coupling part 240 may be coupled to the rotation shaft of the motor 150.

[0101] The blade 230 may satisfy Equation 1 below.

[Equation 1]

$$0.67 < D_I/D_O < 0.77$$

where D_I is the distance between an inner end or leading edge 231 of the blade 230 and a center area of the rotation shaft of the motor 150, and D_O is the distance between an outer end or trailing edge 234 of the blade and the center area of the rotation shaft of the motor 150.

[0102] Referring to FIG. 8, when a ratio of the distance D_I between the inner end or leading edge 231 of the blade 230 and the central region of the rotation axis of the motor 150 to the distance D_O between the outer end or the trailing edge 234 of the blade 230 and the center area of the rotational shaft of the motor 150 ranges from 0.67 to 0.77, the discharge pressure of the refrigerator centrifugal fan 200 falls within 5% of the maximum value and, when the ratio is not more than 0.67 and not less than 0.77, the discharge pressure of the refrigerator centrifugal fan 200 may sharply decrease. Accordingly, it is possible to increase the discharge pressure of the centrifugal fan 200 for a refrigerator under the same flow rate condition and increase the efficiency of the centrifugal fan 200 for a refrigerator.

[0103] The blade 230 may satisfy Equation 2 below.

[Equation 2]

$$0.67 < D_I/D_O < 0.72$$

where D_I is the distance between an inner end or leading edge 231 of the blade 230 and a center area of the rotation shaft of the motor 150, and D_O is the distance between an outer end or trailing edge 234 of the blade and the center area of the rotation shaft of the motor 150.

[0104] Likewise, referring to FIG. 8, when a ratio of the distance D_I between the inner end or leading edge 231 of the blade 230 and the central region of the rotation axis of the motor 150 to the distance D_O between the outer end or the trailing edge 234 of the blade 230 and the center area of the rotational shaft of the motor 150 is 0.72, the discharge pressure of the refrigerator centrifugal fan 200 may be at its maximum. Accordingly, it is possible to maximize the discharge pressure of the centrifugal fan 200 for a refrigerator under the same flow rate condition and maximize the efficiency of the centrifugal fan 200 for a refrigerator.

[0105] The blade 230 may satisfy Equation 3 below.

[Equation 3]

$$0.25 < L3/L2 < 0.3$$

where L3 is the maximum camber amount of the blade 230, and L2 is the cord length L2 of the blade 230.

[0106] Referring to FIG. 9, when a ratio of the maximum camber amount L3 of the blade 230 to the cord length L2 of the blade 230 ranges from 0.25 to 0.3, if the discharge pressure of the refrigerator centrifugal fan 200 falls within 5% of the maximum value and, when the ratio is not more than 0.25 and not less than 0.3, the discharge pressure of the refrigerator centrifugal fan 200 may sharply decrease. Accordingly, it is possible to increase the discharge pressure of the centrifugal fan 200 for a refrigerator under the same flow rate condition and increase the efficiency of the centrifugal fan 200 for a refrigerator.

[0107] The blade 230 may satisfy Equation 4 below.

[Equation 4]

$$L3/L2 = 0.275$$

where L3 is the maximum camber amount of the blade 230, and L2 is the cord length L2 of the blade 230.

[0108] Likewise, referring to FIG. 9, when the ratio of the maximum camber amount L3 of the blade 230 to the cord length L2 of the blade 230 is 0.275, the discharge pressure of the centrifugal fan 200 for a refrigerator is at its maximum. Accordingly, it is possible to maximize the discharge pressure of the centrifugal fan 200 for a refrigerator under the same flow rate condition and maximize the efficiency of the centrifugal fan 200 for a refrigerator.

[0109] The blade may satisfy Equation 5 below.

$$[\text{Equation 5}]$$

$$044<L4/L2<0.58$$

where L4 denotes the maximum camber position L4 of the blade 230, and L2 denotes the cord length L2 of the blade 230.

[0110] Referring to FIG. 10, when a ratio of the maximum camber position L4 of the blade 230 to the cord length L2 of the blade 230 ranges from 0.44 to 0.58, the discharge pressure of the refrigerator centrifugal fan 200 falls within 5% of the maximum value and, when the ratio is not more than 0.44 and not less than 0.58, the discharge pressure of the refrigerator centrifugal fan 200 may sharply decrease. Accordingly, it is possible to increase the discharge pressure of the centrifugal fan 200 for a refrigerator under the same flow rate condition and increase the efficiency of the centrifugal fan 200 for a refrigerator.

[0111] The blade 230 may satisfy Equation 6 below.

$$[\text{Equation 6}]$$

$$L4/L2=0.51$$

where L4 denotes the maximum camber position L4 of the blade 230, and L2 denotes the cord length L2 of the blade 230.

[0112] Likewise, referring to FIG. 10, when the ratio of the maximum camber position L4 of the blade 230 to the cord length L2 of the blade 230 is 0.51, the discharge pressure of the centrifugal fan 200 for a refrigerator is at its maximum. Accordingly, it is possible to maximize the discharge pressure of the centrifugal fan 200 for a refrigerator under the same flow rate condition and maximize the efficiency of the centrifugal fan 200 for a refrigerator.

[0113] FIG. 11 is a perspective view illustrating a refrigerator centrifugal fan according to another embodiment of the disclosure. FIG. 12 is a plan view illustrating a refrigerator centrifugal fan according to another embodiment of the disclosure. FIG. 13 is an enlarged view of part B of FIG. 12. FIG. 14 is a cross-sectional view illustrating a refrigerator centrifugal fan according to another embodiment of the disclosure. FIG. 15 is a graph illustrating the discharge pressure according to an angle between a cord line at a hub-side end of a blade and a cord line at a suction-side end according to another embodiment of the disclosure.

[0114] Referring to FIGS. 11 to 14, the centrifugal fan 200 for a refrigerator according to another embodiment of the disclosure may include a hub 210, a blade 250, a connecting member 220, and a coupling part 240. However, the refrigerator centrifugal fan 200 may include more or less components according to an embodiment.

[0115] A configuration not described below may be appreciated as substantially identical to the detailed configuration of the centrifugal fan 200 for a refrigerator according to an embodiment of the disclosure.

[0116] The inner diameter D_T of a suction port (120a)-side end of the blades 250 may be smaller than the inner diameter D_H of a hub-side end. The blade 250 of the centrifugal fan 200 for a refrigerator may be manufactured by injection molding. In general, such a molded structure has two bodies, i.e., an upper body and a lower body, and when the two bodies are assembled together, an inner space corresponding to the shape of the centrifugal fan 200 for a refrigerator is formed. When a liquid resin (e.g., plastic resin) is pressed into the internal space and then cooled, the shape of the centrifugal fan 200 for a refrigerator is solidified. In the case of such injection molding, an under-cut occurs, causing interference between components. As the inner diameter D_T of the suction port (120a)-side end of the blades 250 is formed to be smaller than the inner diameter D_H of the hub-side end, it is possible to prevent inter-component interference due to an under-cut.

[0117] A predetermined angle may be formed between the chord line CL1 at the suction-side end of the blade 250 and the chord line CL2 at the hub-side end. For example, the angle between the chord line CL1 at the suction-side end of the blade 250 and the chord line CL2 at the hub-side end may range from 18.7 degrees to 21 degrees.

[0118] Referring to FIG. 15, when the angle between the chord line CL1 at the suction-side end of the blade 250 and the chord line CL2 at the hub-side end may range from 18.7 degrees to 21 degrees, the discharge pressure of the refrigerator centrifugal fan 200 may fall within 5% of the maximum value, and when the angle is not more than 18.7 degrees or not less than 21 degrees, the discharge pressure of the refrigerator centrifugal fan 200 may sharply decrease. Accordingly, it is possible to increase the discharge pressure of the centrifugal fan 200 for a refrigerator under the same flow rate condition and increase the efficiency of the centrifugal fan 200 for a refrigerator.

[0119] Preferably, the angle between the chord line CL1 at the suction-side end of the blade 250 and the chord line CL2 at the hub-side end may be 19.8 degrees.

[0120] Similarly, referring to FIG. 15, when the angle between the chord line CL1 at the suction-side end of the blade 250 and the chord line CL2 at the hub-side end is 19.8 degrees, the discharge pressure of the refrigerator centrifugal fan 200 may be at its maximum. Accordingly, it is possible to maximize the discharge pressure of the centrifugal fan 200 for a refrigerator under the same flow rate condition and maximize the efficiency of the centrifugal fan 200 for a refrigerator.

[0121] FIG. 16 is a graph illustrating the discharge pressure according to the flow rate of a centrifugal fan for a refrigerator according to the prior art and according to an embodiment of the disclosure.

[0122] The graph for the prior art shows the results of a test performed using a conventional turbo fan with a diameter of 110 mm and a rotation speed of 1950 rpm, and the graph, according to an embodiment, shows the results of a test performed using the refrigerator centrifugal fan 200 with a diameter of 85 mm and a rotation speed of 1790 rpm.

[0123] It may be identified that the centrifugal fan 200 for a refrigerator according to an embodiment of the disclosure, despite the reduced diameter and number of rotations as compared with the conventional turbo fan, may increase the discharge pressure relative to the same flow rate.

[0124] It is thus possible to increase the internal capacity of the refrigerator 10 (V) while reducing the number of rotations of the centrifugal fan 200 for a refrigerator. Therefore, it is possible to reduce noise due to aerodynamic or vibration and increase the lifespan of such components as the motor 150 and oil-impregnated bushing bearings.

[0125] Some of the above-described embodiments are interpreted as excluding or distinguishing from other embodiments. The components or functions in some embodiments described above may be used together or combined with the components or functions in other embodiments.

[0126] For example, component A described in connection with a particular embodiment and the drawings may be combined or merged with component B described in connection with another embodiment and the drawings. In other words, a combination of components, although not explicitly described, may be rendered possible unless stated as impossible.

[0127] Thus, the above description should be interpreted not as limiting in all aspects but as exemplary. The scope of the disclosure should be determined by reasonable interpretations of the appended claims and all equivalents of the disclosure belong to the scope of the disclosure.

[Legend of reference numbers]

[0128]

10: refrigerator 11: outer case
12: inner case 13: door
14: evaporator 15: motor
16: cold air flow path 100: blower
110: bell mouth 120: housing
200: refrigerator centrifugal fan 210: hub
220: connecting member 230, 250: blade
240: coupling part

Claims

1. A centrifugal fan (200) for a refrigerator (10), comprising:

   a hub (210) coupled to a rotation shaft; and
   a plurality of blades (230a, 230b, 230c) disposed radially about the rotation shaft on the hub (210),
   wherein the blades (230) are formed to be entirely concave along a rotational direction.

2. The centrifugal fan of claim 1, wherein the blades (230) meet an equation expressed as:

$$0.67<D_I/D_O<0.77$$

wherein D_I is a distance between an inner end (231) of the blades (230) and a center area of the rotation shaft, and D_O is a distance between an outer end (234) of the blades (230) and the center area of the rotation shaft.

3. The centrifugal fan of claim 2, wherein the blades (230) meet an equation expressed as:

$$D_I/D_O=0.72$$

wherein D_I is a distance between an inner end (231) of the blades (230) and a center area of the rotation shaft, and D_O is a distance between an outer end (234) of the blades (230) and the center area of the rotation shaft.

4. The centrifugal fan of any one of claims 1 to 3, wherein the blades (230) meet an equation expressed as:

$$0.25<L3/L2<0.3$$

wherein L3 is a maximum camber amount of the blades (230), and L2 is a chord length of the blades (230).

5. The centrifugal fan of claim 4, wherein the blades (230) meet an equation expressed as:

$$L3/L2=0.275$$

wherein L3 is a maximum camber amount of the blades (230), and L2 is a chord length of the blades (230).

6. The centrifugal fan of any one of claims 1 to 5, wherein the blades (230) meet an equation expressed as:

$$0.44<L4/L2<0.58$$

wherein L4 is a maximum camber position of the blades (230), and L2 is the chord length of the blades (230).

7. The centrifugal fan of claim 6, wherein the blades (230) meet an equation expressed as:

$$L4/L2=0.51$$

wherein L4 is a maximum camber position of the blades (230), and L2 is the chord length of the blades (230).

8. The centrifugal fan of any one of claims 1 to 7, wherein an inner diameter of a suction-side end of the blades (230) is smaller than an inner diameter of a hub-side end of the blades (230).

9. The centrifugal fan of any one of claims 1 to 8, wherein a predetermined angle is formed between a chord line (CL2) of a hub-side end of the blades (230) and a chord line (CL1) of a suction-side end of the blades (230).

10. The centrifugal fan of claim 9, wherein the predetermined angle formed between the chord line (CL2) of the hub-side end of the blades (230) and the chord line (CL1) of the suction-side end of the blades (230) ranges from 18.7 degrees to 21 degrees.

11. The centrifugal fan of claim 10, wherein the predetermined angle formed between the chord line (CL2) of the hub-side end of the blades (230) and the chord line (CL1) of the suction-side end of the blades (230) is 19.8 degrees.

12. The centrifugal fan of any one of claims 1 to 11, wherein a radial outer end (234) of the blades (230) is disposed in the rotational direction, as compared with an inner end (231) of the blades (230).

13. A centrifugal fan (200) for a refrigerator (10), comprising:

a hub (210) coupled to a rotation shaft; and
a plurality of blades (250a, 250b, 250c) disposed radially about the rotation shaft on the hub (210),
wherein a predetermined angle is formed between a chord line (CL2) of a hub-side end of the blades (250) and a chord line (CL1) of a suction-side end of the blades (250).

14. The centrifugal fan of claim 13, wherein the predetermined angle formed between the chord line (CL2) of the hub-side end of the blades (250) and the chord line (CL1) of the suction-side end of the blades (250) ranges from 18.7 degrees to 21 degrees.

15. The centrifugal fan of claim 14, wherein the predetermined angle formed between the chord line (CL2) of the hub-side end of the blades (250) and the chord line (CL1) of the suction-side end of the blades (250) is 19.8 degrees.

FIG.1

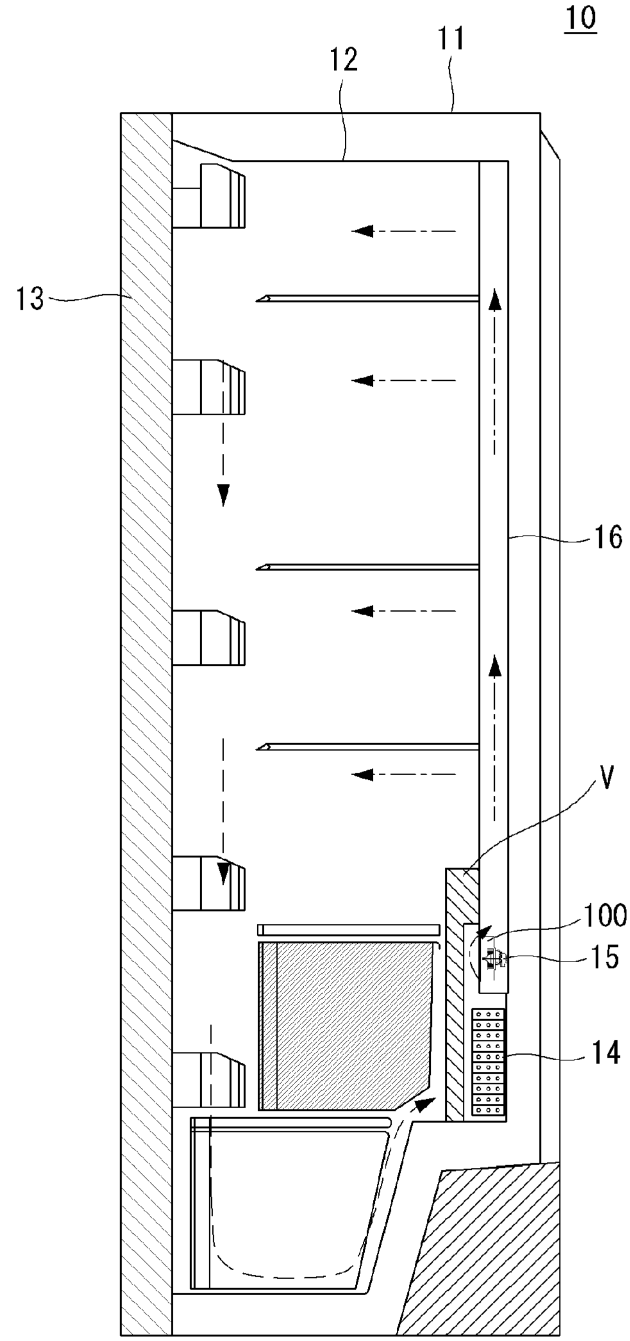


FIG.2

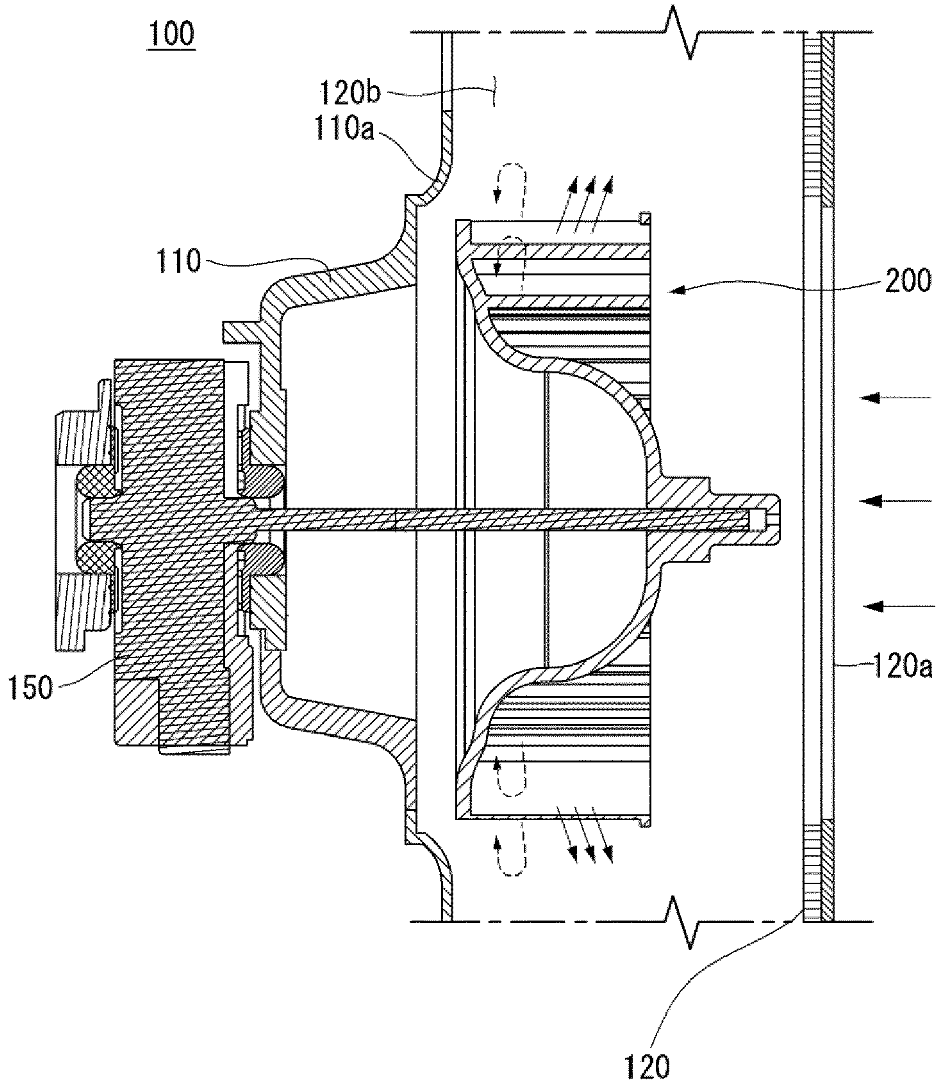


FIG.3

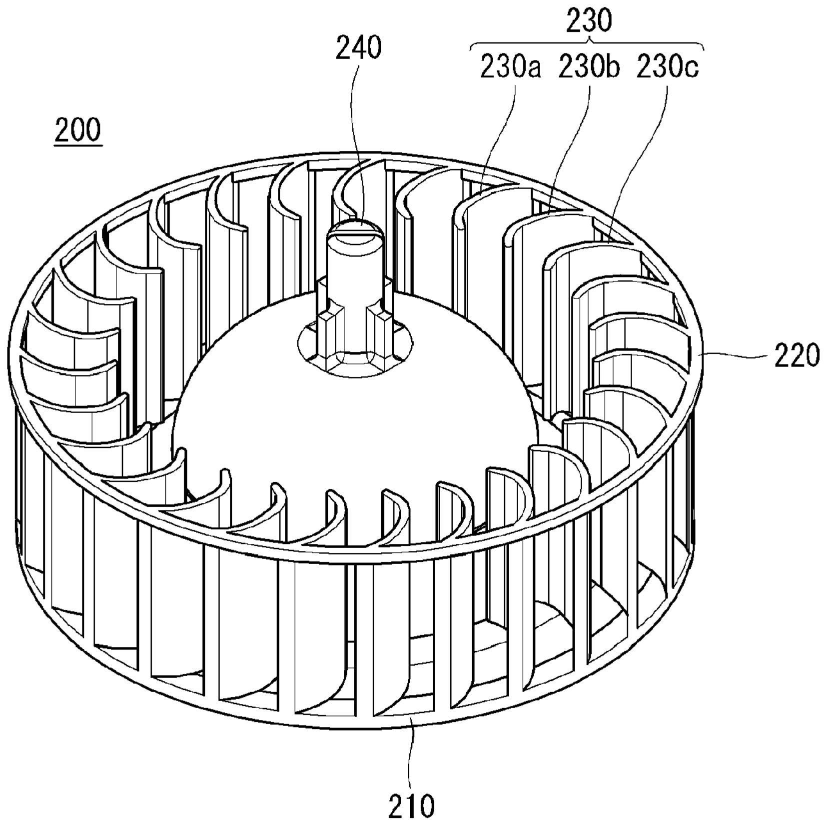


FIG.4

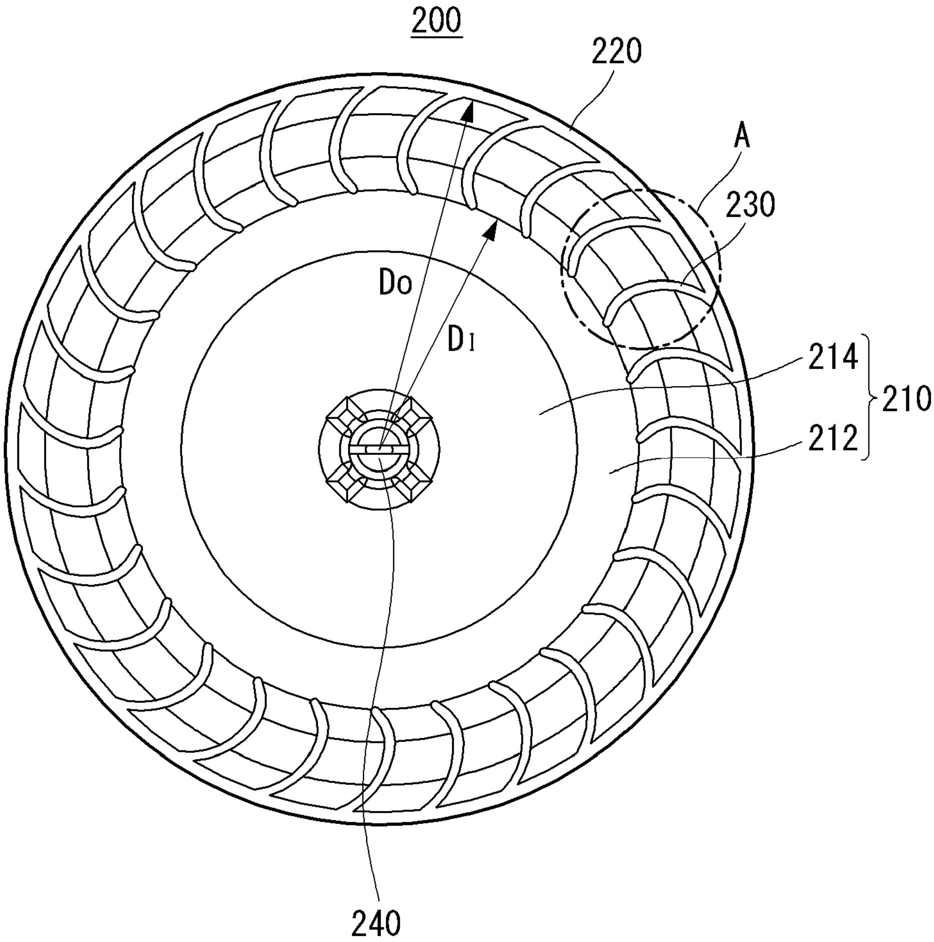


FIG.5

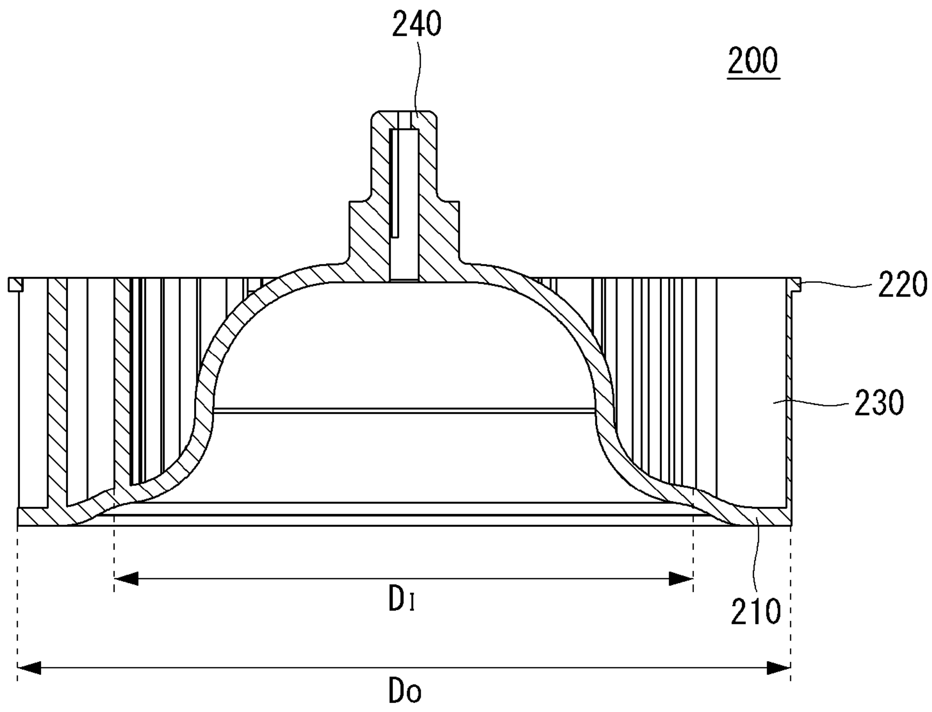


FIG.6

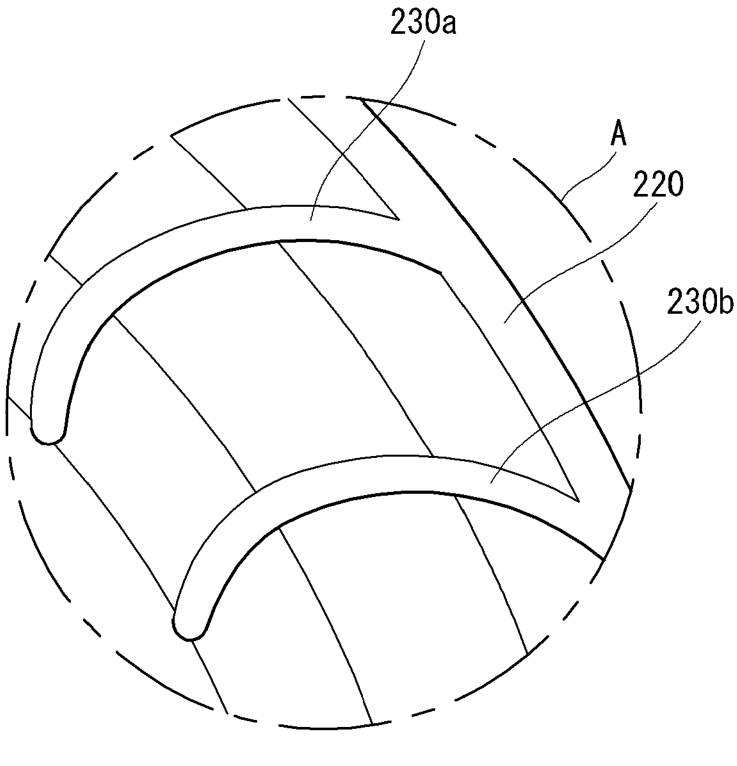


FIG.7

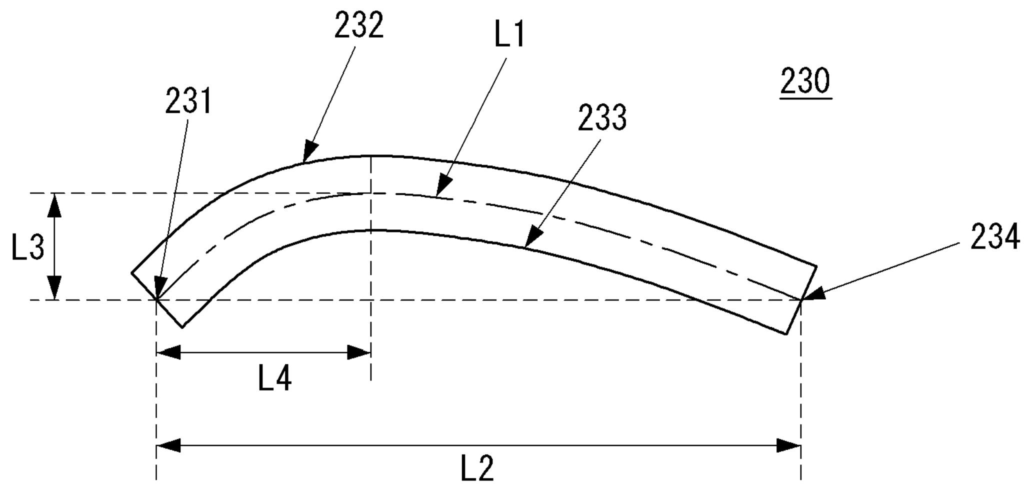

232
L1
230
231
233
234
L3
L4
L2

FIG.8

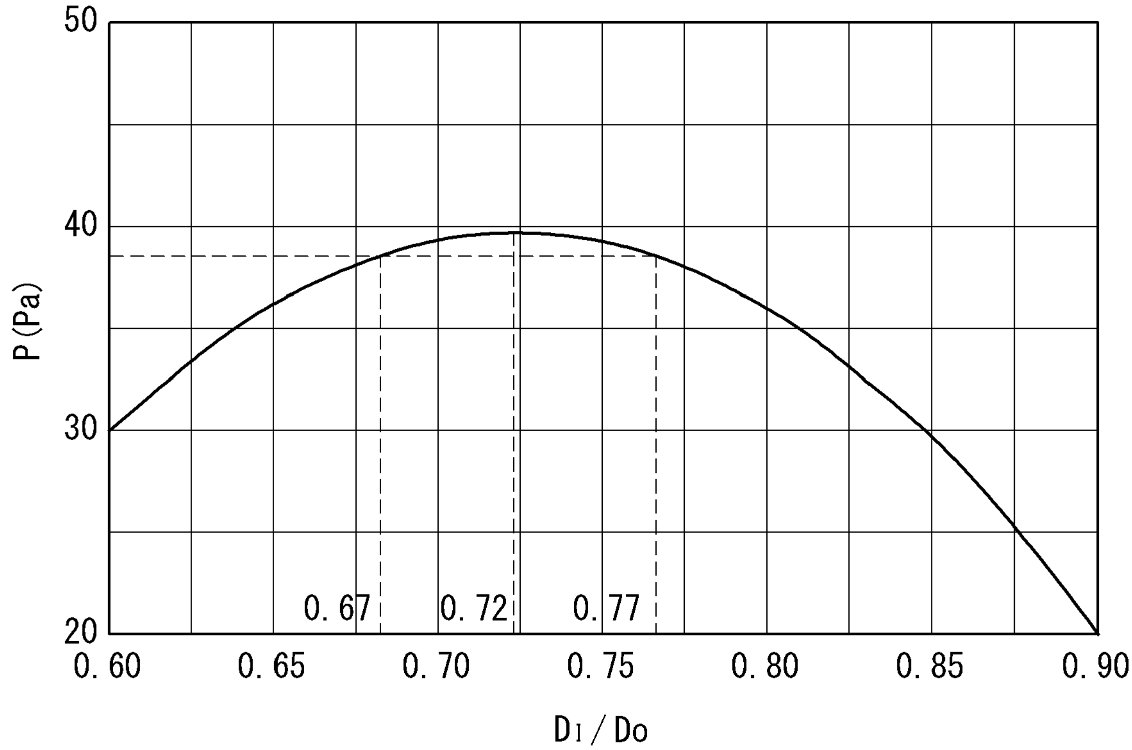

50
40
30
20
P (Pa)
0.67
0.72
0.77
0.60
0.65
0.70
0.75
0.80
0.85
0.90
DI / Do

FIG.9

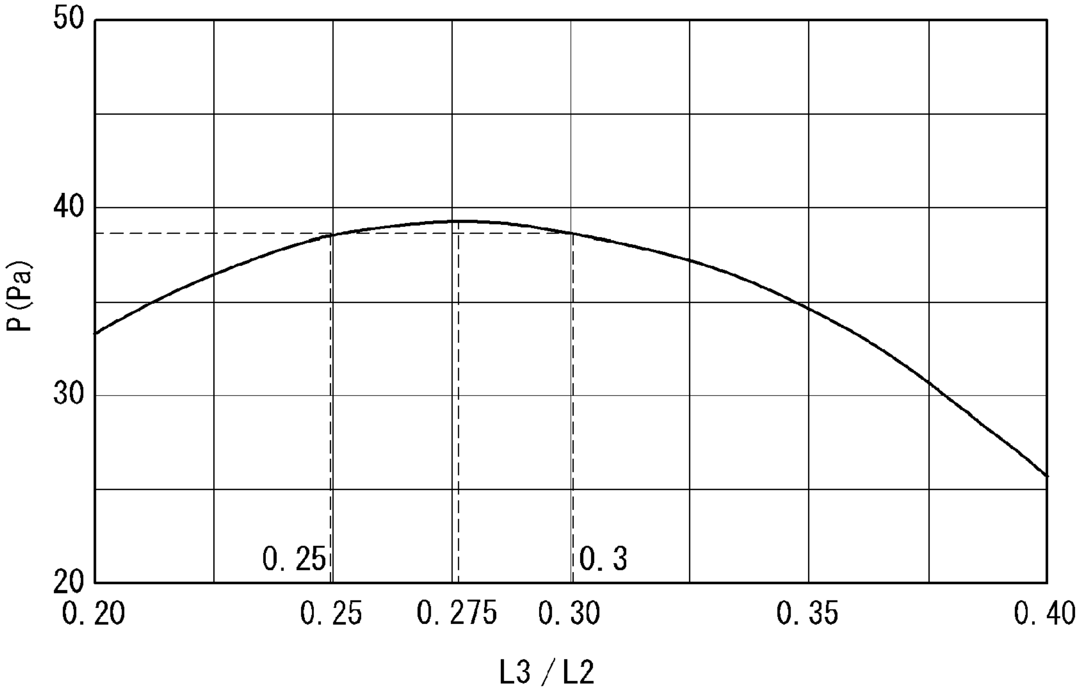

50
40
30
20
P (Pa)
0. 25
0. 3
0. 20
0. 25
0. 275
0. 30
0. 35
0. 40
L3 / L2

FIG.10

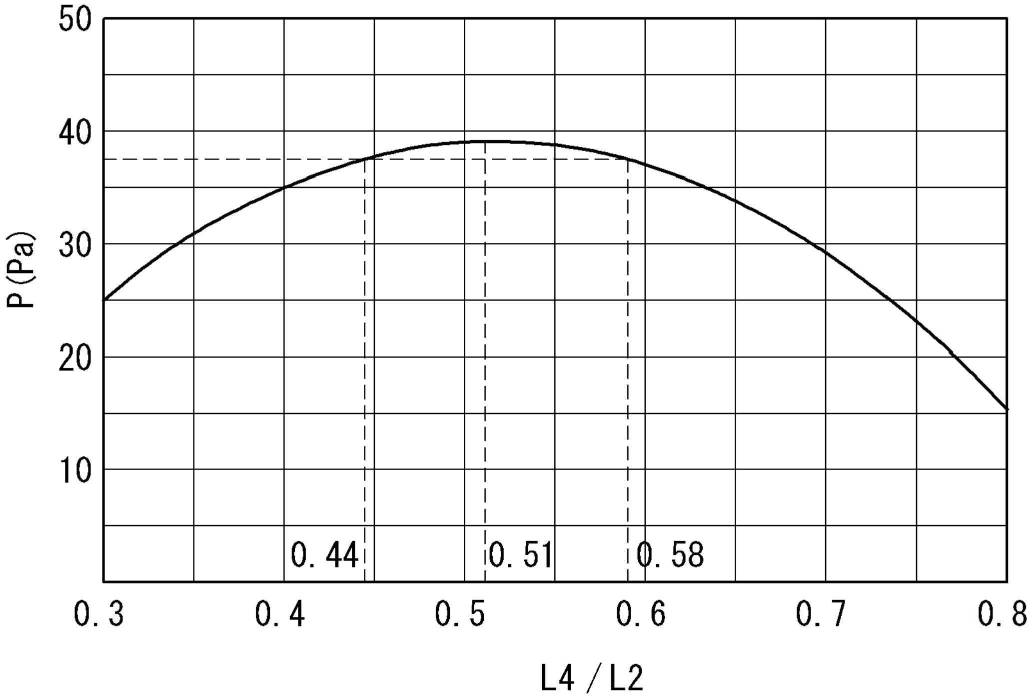

50
40
30
20
10
P (Pa)
0. 44
0. 51
0. 58
0. 3
0. 4
0. 5
0. 6
0. 7
0. 8
L4 / L2

FIG.11

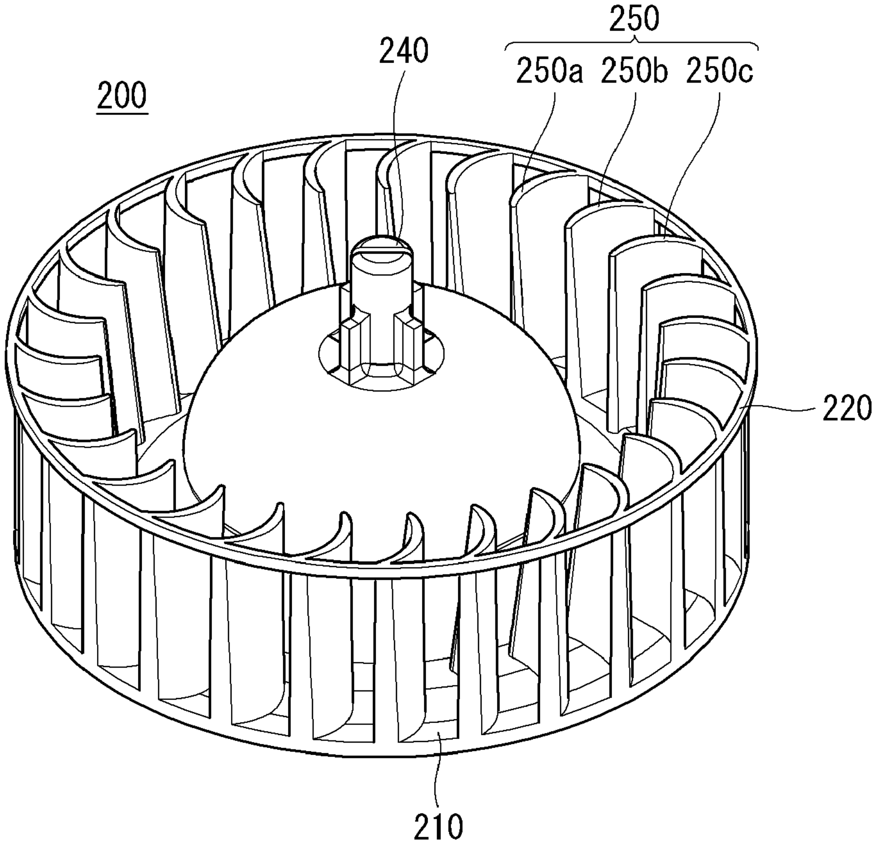


FIG.12

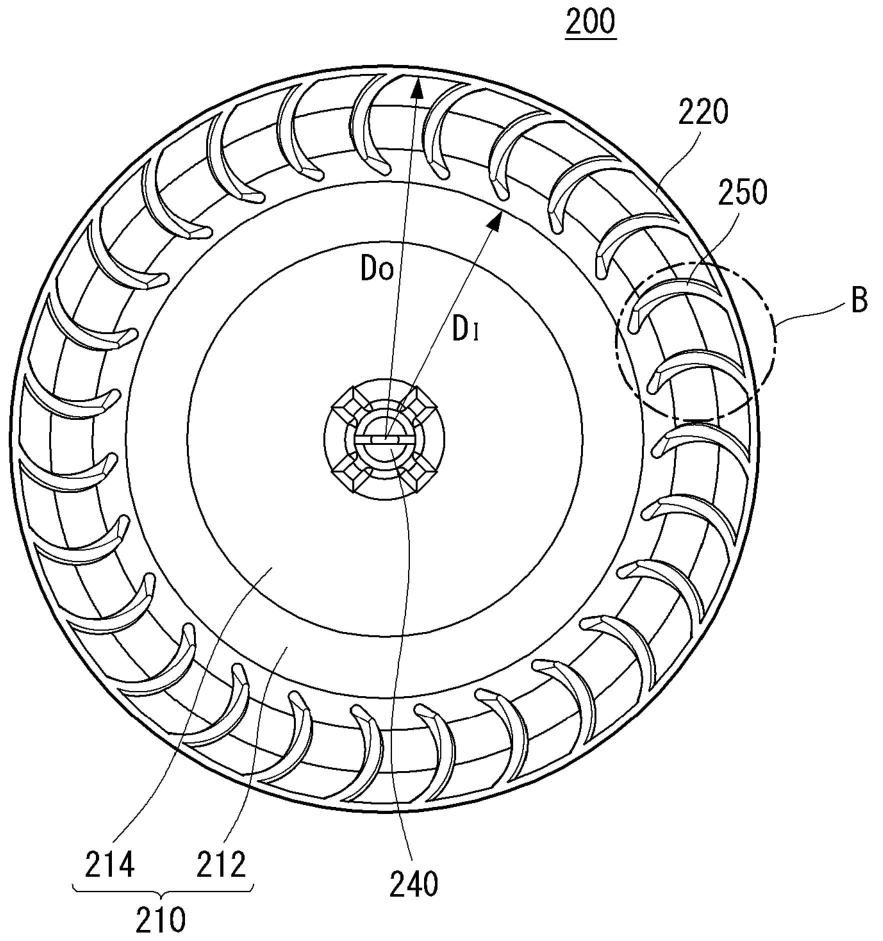


FIG.13

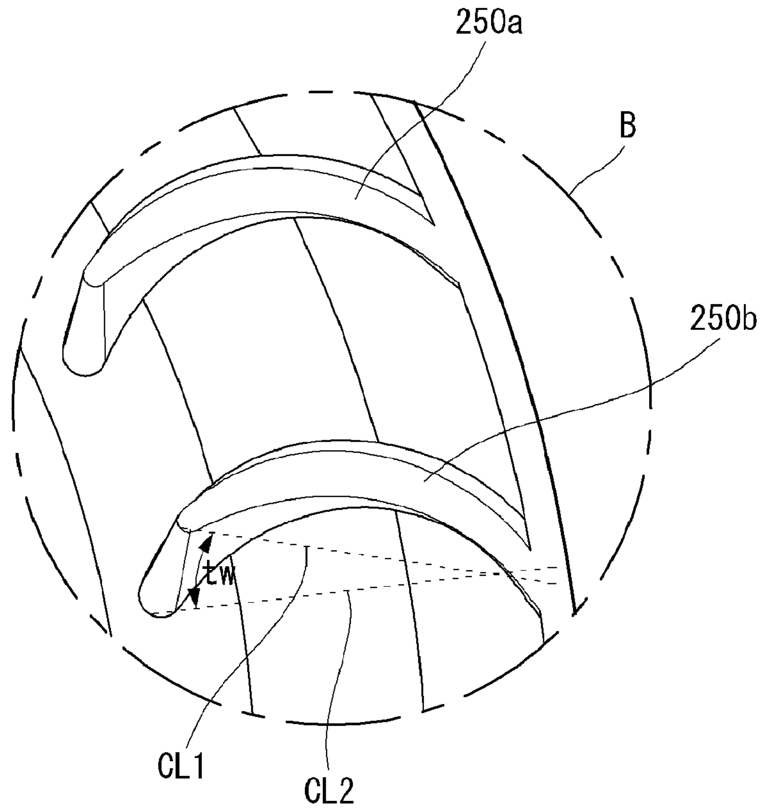


FIG.14

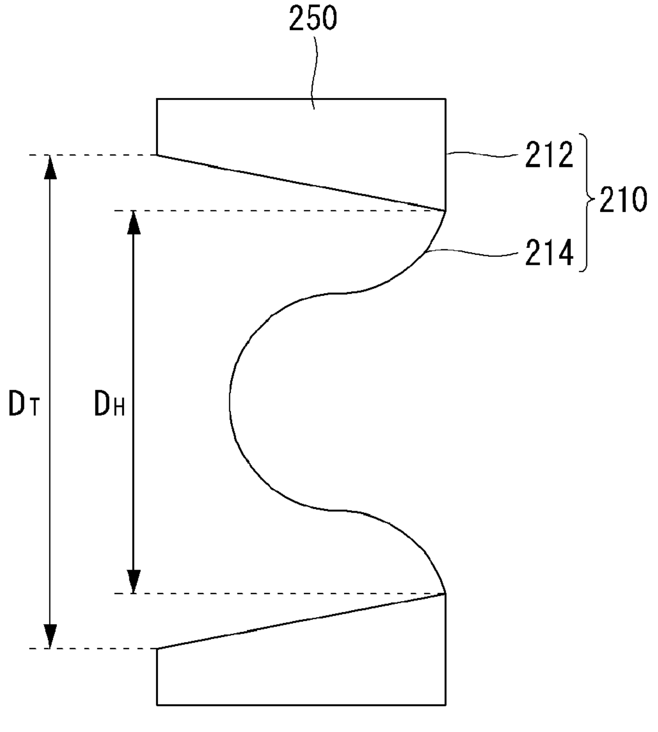


FIG.15

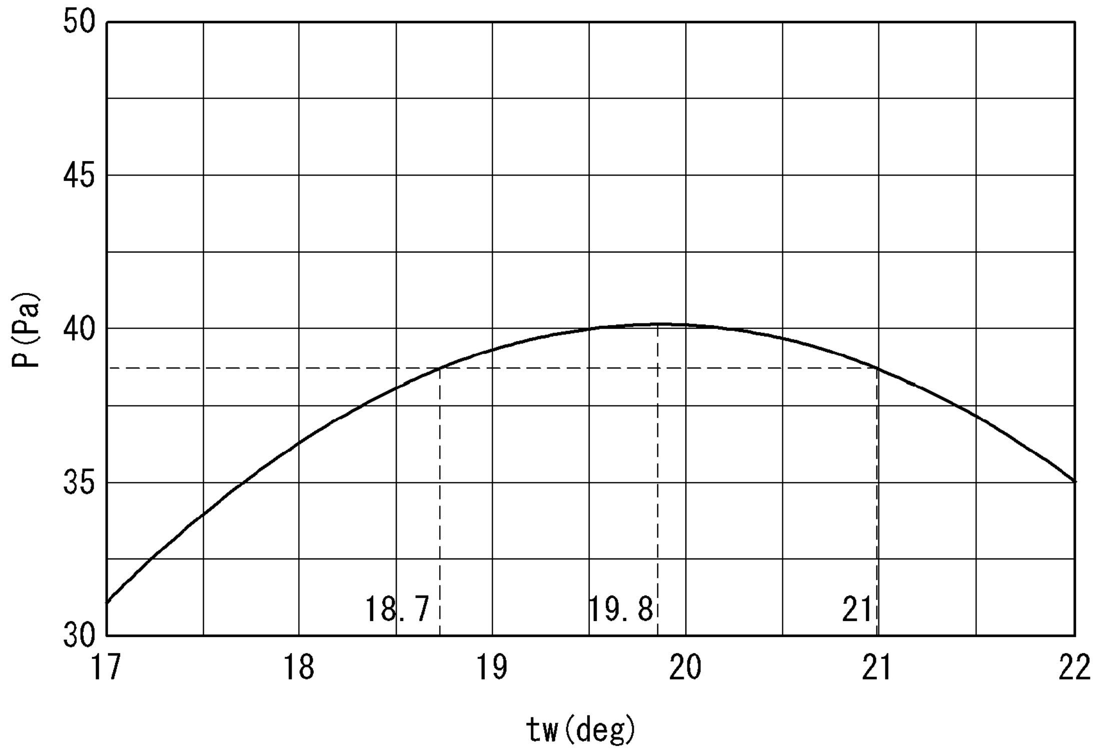

50
45
40
35
30
P(Pa)
18.7
19.8
21
17
18
19
20
21
22
tw(deg)

FIG.16

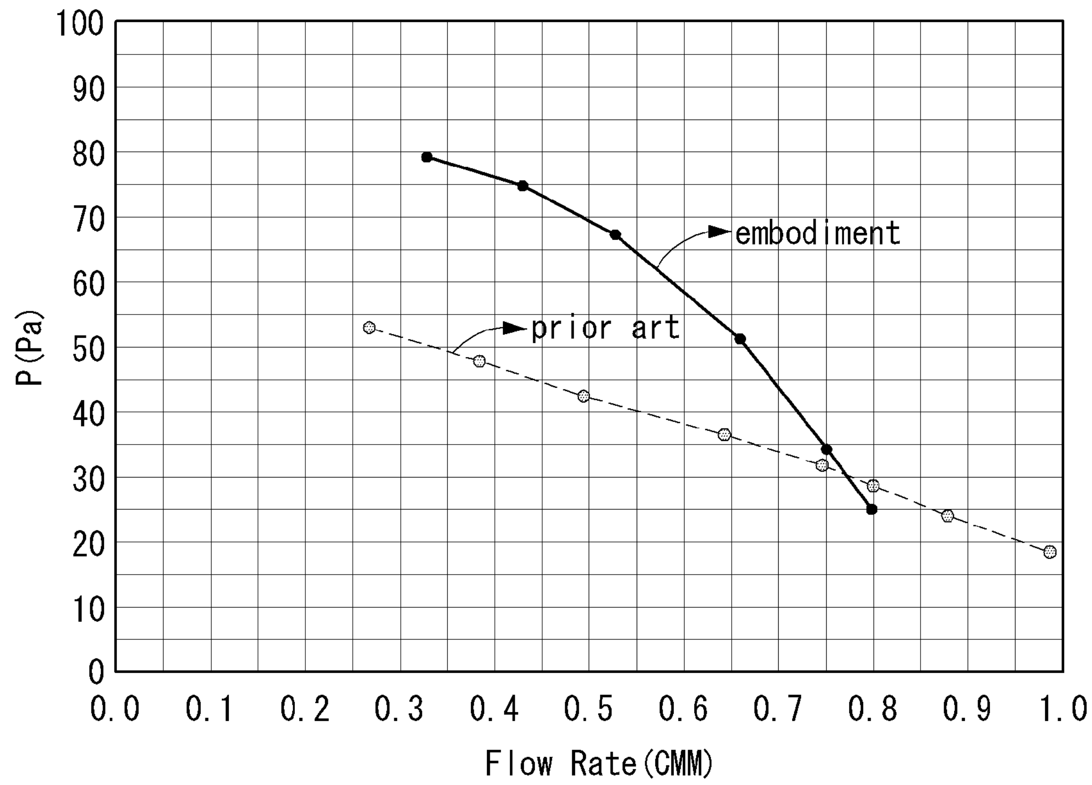
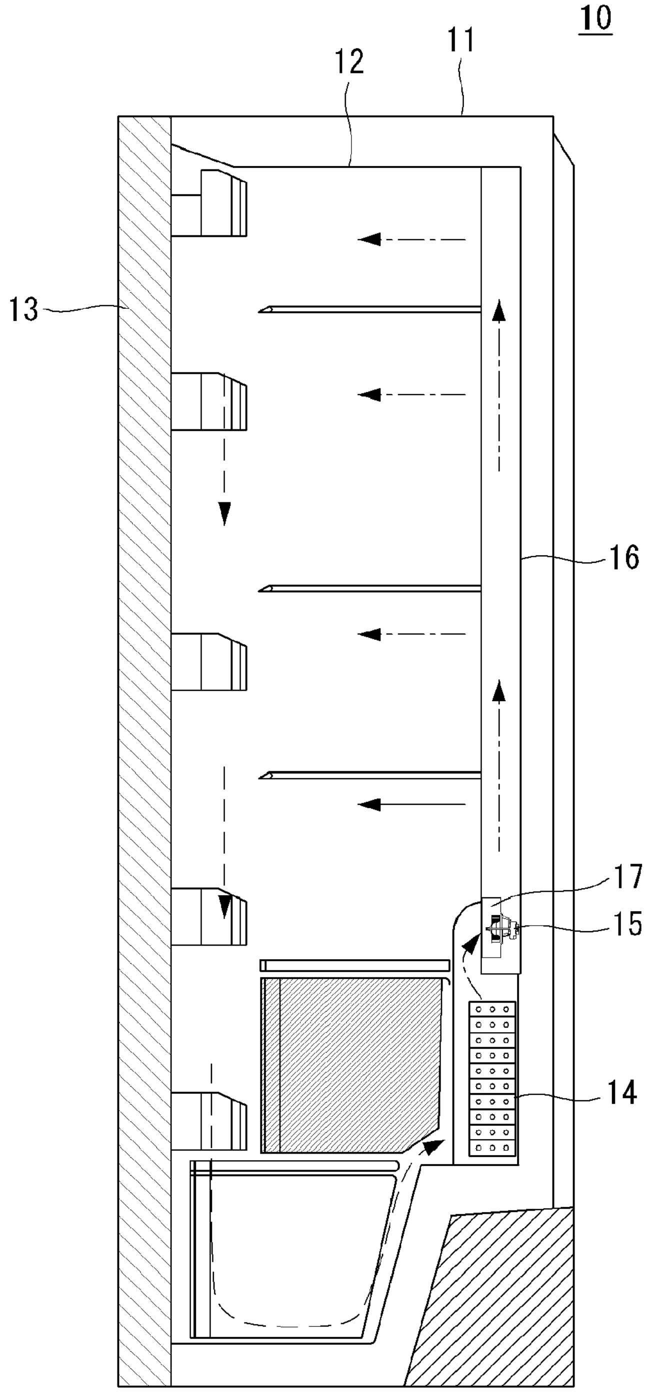

100
90
80
70
60
50
40
30
20
10
0
P(Pa)
embodiment
prior art
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Flow Rate(CMM)

FIG.17



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EUROPEAN SEARCH REPORT

Application Number
EP 21 15 5058

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2015/192143 A1 (SAKAI MASAHARU [JP] ET AL) 9 July 2015 (2015-07-09) * figures 3,6,8-10 * * paragraphs [0052] - [0096] * -----	1-15	INV. F04D29/28 F04D29/30
X	GB 2 063 365 A (PUNKER GMBH) 3 June 1981 (1981-06-03) * figure 4 * * page 2, lines 103-120 * -----	1-3	
X	US 2015/056910 A1 (IKEDA TAKASHI [JP] ET AL) 26 February 2015 (2015-02-26) * figures 6-8 * -----	1,4-7	
X	JP 2003 035293 A (DAIKIN IND LTD) 7 February 2003 (2003-02-07) * figures 13-15 * -----	1,9,12,13	
X	DE 10 2012 021845 A1 (EBM PAPST ST GEORGEN GMBH & CO [DE]) 30 April 2014 (2014-04-30) * figures 12-16 * -----	1,13	TECHNICAL FIELDS SEARCHED (IPC)
X	FR 2 984 971 A1 (SEB SA [FR]) 28 June 2013 (2013-06-28) * figures 7,8 * -----	1,13	F04D
X	US 2007/217908 A1 (OCHIAI TOSHINORI [JP] ET AL) 20 September 2007 (2007-09-20) * figure 9 * -----	1,4-7	

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	28 June 2021	Ingelbrecht, Peter

CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 21 15 5058

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28-06-2021

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2015192143 A1	09-07-2015	CN 104411980 A	11-03-2015
		DE 112013003213 T5	02-04-2015
		JP 2014029149 A	13-02-2014
		KR 20150031296 A	23-03-2015
		US 2015192143 A1	09-07-2015
		WO 2014002392 A1	03-01-2014
GB 2063365 A	03-06-1981	DE 2940773 A1	23-04-1981
		DK 425880 A	09-04-1981
		FR 2467309 A1	17-04-1981
		GB 2063365 A	03-06-1981
		SE 448018 B	12-01-1987
US 2015056910 A1	26-02-2015	CN 104302979 A	21-01-2015
		EP 2835585 A1	11-02-2015
		JP 5143317 B1	13-02-2013
		JP WO2013150569 A1	14-12-2015
		NZ 700985 A	27-05-2016
		NZ 716887 A	28-10-2016
		US 2015056910 A1	26-02-2015
		WO 2013150569 A1	10-10-2013
		WO 2013150673 A1	10-10-2013
JP 2003035293 A	07-02-2003	JP 4945859 B2	06-06-2012
		JP 2003035293 A	07-02-2003
DE 102012021845 A1	30-04-2014	DE 102012021845 A1	30-04-2014
		DE 112013005143 A5	23-07-2015
		WO 2014064284 A1	01-05-2014
FR 2984971 A1	28-06-2013	CN 203614455 U	28-05-2014
		FR 2984971 A1	28-06-2013
US 2007217908 A1	20-09-2007	DE 102007012031 A1	18-10-2007
		JP 5140986 B2	13-02-2013
		JP 2007278268 A	25-10-2007
		US 2007217908 A1	20-09-2007

EPO FORM P0459

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Patent documents cited in the description

- KR 100389395 **[0009]**
- KR 101577875 **[0009]**
- KR 100389395 B **[0014]**
- KR 101577875 B **[0014]**