

DESCRIPTION

TITLE OF INVENTION

Fan, Molding Die, and Fluid Feeder

5 TECHNICAL FIELD

The present invention generally relates to a fan, a molding die, and a fluid feeder, and more particularly to a fan, such as a cross-flow fan and a centrifugal fan, a molding die for use in production of the fan, and a fluid feeder provided with the fan.

BACKGROUND ART

10 As for conventional fans, Japanese Patent Laying-Open No. 2011-58414 (PTD 1), for example, discloses a cross-flow fan intended to exhibit an excellent blowing capacity. Japanese Patent Laying-Open No. 2011-58413 (PTD 2) and Japanese Patent Laying-Open No. 2011-85144 (PTD 3) each disclose a centrifugal fan intended to exhibit an excellent blowing capacity.

15 Various kinds of fans disclosed in PTDs 1 to 3 include a plurality of fan blades provided to be circumferentially spaced apart from each other. A fan blade has formed thereon a blade surface including a pressure surface and a suction surface. When cut along the plane orthogonal to the rotation axis of the fan, the fan blade has a blade cross-sectional shape in which a concave portion and a convex portion are
20 formed alternately at the blade surface.

Japanese Patent Laying-Open No. 2010-101222 (PTD 4) discloses a cross-flow fan intended to reduce power consumption without degrading performance even if blades are inclined while simultaneously restraining peak sound and abnormal noise, and to facilitate resin molding with a die.

25 The cross-flow fan disclosed in PTD 4 is formed by stacking a plurality of impellers including a plurality of vane portions in the direction of a central axis line. The central point of the cross section of a vane portion perpendicular to the rotational center line is displaced toward the forward side in the rotational direction or the backward side in the rotational direction around the rotational center line from the root

to the leading end of the vane portion, and is displaced outward in the radial direction.

Japanese Patent Laying-Open No. 10-148196 (PTD 5) and Japanese Patent Laying-Open No. 11-264394 (PTD 6) each disclose a transverse fan intended to be low noise, highly efficient, easy to change the blade shape and the fan length, reliable, and inexpensive. In the transverse fans disclosed in PTDs 5 and 6, a plurality of blades having a circular cross section are concentrically provided annularly between a pair of left and right end plates, and are inclined by a predetermined angle.

CITATION LIST

PATENT DOCUMENT

- PTD 1: Japanese Patent Laying-Open No. 2011-58414
PTD 2: Japanese Patent Laying-Open No. 2011-58413
PTD 3: Japanese Patent Laying-Open No. 2011-85144
PTD 4: Japanese Patent Laying-Open No. 2010-101222
PTD 5: Japanese Patent Laying-Open No. 10-148196
PTD 6: Japanese Patent Laying-Open No. 11-264394

SUMMARY OF INVENTION

TECHNICAL PROBLEM

As disclosed in above-mentioned PTDs 1 to 3, a known fan blade of a cross-flow fan or a centrifugal fan has a concave portion and a convex portion formed alternately on the blade surface. With such a blade cross-sectional shape of a fan blade, a vortex of air flow (secondary flow) is produced at the concave portion during rotation of the fan, and thus, the air flow (main flow) passing over the blade surface flows along the outside of the vortex produced at the concave portion. Accordingly, the fan blade shows a behavior like a thick blade as if its blade cross-sectional shape is increased in thickness by the production of the vortex, and therefore, the fan can be improved in blowing capacity.

On the other hand, when forming such a fan from resin, it is necessary to release a molded product of a fan from the die for resin molding. However, depending on the mutual behavior of a die and a molded product of a fan at the time of release, contact

pressure acts on the blade surface of the fan blade from the side surface of the die.

Accordingly, there is concern that stress may occur at a position of the convex portion formed at the blade surface, and the molded product of a fan breaks at the root of the fan blade. Particularly when a skew blade having an inclination with respect to the rotation axis of a fan is used as a fan blade, it is necessary to draw out a molded product from a die, while relatively rotating the die and the molded product of a fan at the time of release. In this case, due to a slight difference between relative rotating speeds, an excessive contact pressure may act on the blade surface of the fan blade. Therefore, there is increasing concern that the molded product of a fan may break at the root of the fan blade.

The present invention has an object to solve the above-described problem and to provide a fan formed from resin having excellent resin moldability, a molding die, and a fluid feeder.

SOLUTION TO PROBLEM

The fan according to one aspect of the present invention is a fan formed from resin. The fan includes a plurality of vane portions provided to be circumferentially spaced apart from each other, each having formed thereon a blade surface including a pressure surface arranged on a rotational direction side of the fan and a suction surface arranged on a back side of the pressure surface, and a support provided on one ends of the vane portions in the direction of a rotation axis of the fan and connecting the plurality of vane portions to each other. When cut along a plane orthogonal to the rotation axis of the fan, the vane portions each have an inner edge portion at which a center line between the pressure surface and the suction surface crosses a blade leading end on a radially inner side, and an outer edge portion at which the center line crosses a blade leading end on a radially outer side. A fluid flow flowing between the inner edge portion and the outer edge portion is produced on the blade surface with rotation of the fan.

When cut along the plane orthogonal to the rotation axis of the fan, the vane portions each have a blade cross-sectional shape in which a plurality of concave

portions are formed in at least one of the pressure surface and the suction surface. The vane portions are each formed to have a blade cross section when cut along the plane orthogonal to the rotation axis of the fan decreasing in area from the one end toward the other end of each of the vane portions in the direction of the rotation axis of the fan.

5 A first blade cross section is obtained when the vane portions are each cut on the one end of each of the vane portions along the plane orthogonal to the rotation axis of the fan, and a second blade cross section is obtained when the vane portions are each cut between the one end and the other end of each of the vane portions along the plane orthogonal to the rotation axis of the fan. The second blade cross section is enlarged
10 such that a blade circumference forming an outer circumference of the second blade cross section is entirely moved outward by an equal distance until the length between the inner edge portion and the outer edge portion becomes equal in the first blade cross section and the second blade cross section, and the center line of the second blade cross section having been enlarged is superimposed on the first blade cross section such that
15 the inner edge portion and the outer edge portion on the center line corresponds to the inner edge portion and the outer edge portion of the first blade cross section, respectively. In this case, the length between the blade surface arranged on the back side of a bottom of each of the concave portions formed in the first blade cross section and the center line of the second blade cross section is larger than the length between
20 the bottom of each of the concave portions formed in the first blade cross section and the center line of the second blade cross section.

 A fan according to another aspect of the present invention is a fan formed from resin. The fan includes a plurality of vane portions provided to be circumferentially spaced apart from each other, each having formed thereon a blade surface including a
25 pressure surface on a rotational direction side of the fan and a suction surface arranged on a back side of the pressure surface, and a support provided on one ends of the vane portions in the direction of a rotation axis of the fan and connecting the plurality of vane portions to each other. When cut along a plane orthogonal to the rotation axis of the fan, the vane portions each have an inner edge portion at which a center line

between the pressure surface and the suction surface crosses a blade leading end on a radially inner side, and an outer edge portion at which the center line crosses a blade leading end on a radially outer side. A fluid flow flowing between the inner edge portion and the outer edge portion is produced on the blade surface with rotation of the fan.

When cut along the plane orthogonal to the rotation axis of the fan, the vane portions each have a blade cross-sectional shape in which a plurality of concave portions are formed in at least one of the pressure surface and the suction surface. The vane portions are each formed to have a blade cross section when cut along the plane orthogonal to the rotation axis of the fan decreasing in area from the one end toward the other end of each of the vane portions in the direction of the rotation axis of the fan.

A first blade cross section is obtained when the vane portions are each cut on the one end of each of the vane portions along the plane orthogonal to the rotation axis of the fan, and a second blade cross section is obtained when the vane portions are each cut between the one end and the other end of each of the vane portions along the plane orthogonal to the rotation axis of the fan. The second blade cross section is enlarged such that the second blade cross section before enlargement and the second blade cross section after enlargement have a similarity relation until the length between the inner edge portion and the outer edge portion becomes equal in the first blade cross section and the second blade cross section, and the center line of the second blade cross section after enlargement is superimposed on the first blade cross section such that the inner edge portion and the outer edge portion on the center line corresponds to the inner edge portion and the outer edge portion of the first blade cross section, respectively. In this case, the length between the blade surface arranged on the back side of a bottom of each of the concave portions formed in the first blade cross section and the center line of the second blade cross section is larger than the length between the bottom of each of the concave portions formed in the first blade cross section and the center line of the second blade cross section.

According to the fan configured in this manner, the vane portions are each

formed thick on the one end side of each of the vane portions connected to the support and on the back side of the bottom of each of the concave portions. Accordingly, when releasing a molded product of a fan from a die at the time of manufacturing the fan formed from resin, the molded product of a fan can be prevented from breaking at the one end of each of the vane portions. Accordingly, the fan formed from resin can be improved in moldability.

Preferably, the vane portions each have a blade cross-sectional shape in which the concave portions formed at either one of the pressure surface and the suction surface form convex portions at the other one of the pressure surface and the suction surface. The length between the top of each of the convex portions arranged on the back side of the bottom of each of the concave portions formed in the first blade cross section and the center line of the second blade cross section is larger than the length between the bottom of each of the concave portions formed in the first blade cross section and the center line of the second blade cross section.

According to the fan configured in this manner, the vane portions are each formed thick at the convex portions arranged on the one end side of each of the vane portions connected to the support and on the back side of the bottom of each of the concave portions. When releasing the molded product of a fan from a die at the time of manufacturing the fan formed from resin, the molded product of a fan can be prevented from breaking at the one end of each of the vane portions. Accordingly, the fan formed from resin can be improved in moldability.

Preferably, the convex portions formed in the first blade cross section form the blade surface with a curvature larger than that of the convex portions formed in the second blade cross section in correspondence with the convex portions formed in the first blade cross section, respectively. According to the fan configured in this manner, the convex portions formed thick in the first blade cross section project more than the convex portions formed in the second blade cross section, so that a difference in curvature arises between the blade surfaces formed by the convex portions at the respective blade cross sections.

Preferably, the vane portions are each formed to have a blade cross section when cut along the plane orthogonal to the rotation axis of the fan being displaced in the rotational direction of the fan between the one end and the other end of each of the vane portions in the direction of the rotation axis of the fan.

5 According to the fan configured in this manner, the molded product of a fan can be prevented more reliably from breaking at the one end of each of the vane portions even with a great concern that contact pressure may act on the blade surface from the die when releasing the molded product of a fan from the die.

10 Preferably, an inside space is formed on the inner side of the plurality of vane portions arranged circumferentially, and an outside space is formed on the outer side thereof. Any of the fans as described above is a cross-flow fan taking in a fluid from the outside space on one side with respect to the rotation axis into the inside space and sending out the fluid having been taken in to the outside space on the other side with respect to the rotation axis, as seen from the direction of the rotation axis of the fan.

15 According to the fan configured in this manner, a cross-flow fan formed from resin and having an excellent moldability can be achieved.

20 Preferably, an inside space is formed on the inner side of the plurality of vane portions arranged circumferentially, and an outside space is formed on the outer side thereof, and the fan is a centrifugal fan sending out a fluid from the inside space to the outside space. Any of the fans as described above is a centrifugal fan sending out a fluid from the inside space to the outside space. According to the fan configured in this manner, a centrifugal fan formed from resin and having an excellent moldability can be achieved.

25 The molding die according to the present invention is used for molding any of the fans as described above. According to the molding die configured in this manner, when releasing a molded product of a fan from the molding die, the molded product can be prevented from breaking at the one end of each of the vane portions.

A fluid feeder according to the present invention includes a blower configured to include any of the fans as described above and a driving motor coupled to the fan to

rotate a plurality of vane portions. According to the fluid feeder configured in this manner, the fluid feeder can be improved in performance by the fan formed from resin and having an excellent blowing capacity.

ADVANTAGEOUS EFFECTS OF INVENTION

5 As described above, according to the present invention, a fan formed from resin and having an excellent moldability, a molding die, and a fluid feeder can be provided.

BRIEF DESCRIPTION OF DRAWINGS

Fig. 1 is a perspective view of a cross-flow fan in a first embodiment of the present invention.

10 Fig. 2 is a perspective view showing one of impellers constituting the cross-flow fan in Fig. 1.

Fig. 3 is a front view showing the impeller in Fig. 2.

Fig. 4 is a cross-sectional view showing a blade cross section between a root and a leading end of a fan blade in Fig. 3.

15 Fig. 5 is a cross-sectional view showing a blade cross section at the root of the fan blade in Fig. 3.

Fig. 6 is an enlarged view of the blade cross section in Fig. 4.

Fig. 7 is another cross-sectional view showing the blade cross section at the root of the fan blade in Fig. 3.

20 Fig. 8 is a cross-sectional view showing the fan blade taken along the line VIII-VIII in Fig. 3.

Fig. 9 is a cross-sectional view showing an air conditioner in which the cross-flow fan in Fig. 1 is used.

25 Fig. 10 is an enlarged cross-sectional view showing the proximity of an outlet port of the air conditioner in Fig. 9.

Fig. 11 is a cross-sectional view of an air flow produced in the proximity of the outlet port of the air conditioner in Fig. 9.

Fig. 12 is a cross-sectional view showing a molding die used when manufacturing the cross-flow fan in Fig. 1.

Fig. 13A is a cross-sectional view showing a step of manufacturing the impeller in Fig. 2 with the molding die in Fig. 12.

Fig. 13B is another cross-sectional view showing a step of manufacturing the impeller in Fig. 2 with the molding die in Fig. 12.

5 Fig. 14 is a cross-sectional view at the root of the fan blade showing stress produced at the root of the fan blade in the case where contact pressure acts on the pressure surface side of the fan blade from a movable die when releasing a molded product of an impeller.

10 Fig. 15 is a cross-sectional view at the root of the fan blade showing stress produced in the root of the fan blade in the case where contact pressure acts on the suction surface side of the fan blade from a movable die when releasing a molded product of an impeller.

Fig. 16 is a cross-sectional view representing a phenomenon that occurs on a blade surface of the fan blade in an upstream region shown in Fig. 10.

15 Fig. 17 is a cross-sectional view representing a phenomenon that occurs on the blade surface of the fan blade in a downstream region shown in Fig. 10.

Fig. 18 is a perspective view showing a centrifugal fan in a second embodiment of the present invention.

20 Fig. 19 is a cross-sectional view showing a blower in which the centrifugal fan in Fig. 18 is used.

Fig. 20 is a cross-sectional view showing the blower taken along the line XX-XX in Fig. 19.

Fig. 21 is a cross-sectional view showing an air purifier in which the centrifugal fan in Fig. 18 is used.

25 Fig. 22 is a cross-sectional view showing a blade cross section between a root and a leading end of a fan blade in a first modification.

Fig. 23 is a cross-sectional view showing a blade cross section at the root of the fan blade in the first modification.

Fig. 24 is an enlarged view of the blade cross section in Fig. 22.

Fig. 25 is another cross-sectional view showing a blade cross section at the root of the fan blade in the first modification.

Fig. 26 is a cross-sectional view showing a blade cross section between a root and a leading end of a fan blade in a second modification.

5 Fig. 27 is a cross-sectional view showing a blade cross section at the root of the fan blade in the second modification.

Fig. 28 is an enlarged view of the blade cross section in Fig. 26.

Fig. 29 is another cross-sectional view showing the blade cross section at the root of the fan blade in the second modification.

10 Fig. 30 is a cross-sectional view showing a blade cross section between a root and a leading end of a fan blade in a third modification.

Fig. 31 is a cross-sectional view showing a blade cross section at the root of the fan blade in the third modification.

Fig. 32 is an enlarged view of the blade cross section in Fig. 30.

15 Fig. 33 is another cross-sectional view showing the blade cross section at the root of the fan blade in the third modification.

Fig. 34 is a cross-sectional view showing a blade cross section between a root and a leading end of a fan blade in a fourth embodiment.

20 Fig. 35 is a cross-sectional view showing the blade cross section at the root of the fan blade in the fourth embodiment.

Fig. 36 is an enlarged view of the blade cross section in Fig. 34.

Fig. 37 is another cross-sectional view showing the blade cross section at the root of the fan blade in fourth embodiment.

DESCRIPTION OF EMBODIMENTS

25 Embodiments of the present invention will be described with reference to the figures. In the following, the same or corresponding members in the figures are denoted with the same reference numerals.

[First Embodiment]

(Description of Configuration of Cross-flow Fan)

Fig. 1 is a perspective view of a cross-flow fan in a first embodiment of the present invention. Fig. 2 is a perspective view showing one of impellers constituting the cross-flow fan in Fig. 1.

Referring to Figs. 1 and 2, a cross-flow fan 100 in the present embodiment has a plurality of fan blades 21. Cross-flow fan 100 has an approximately cylindrical appearance as a whole. Plurality of fan blades 21 are arranged on a circumferential surface of the approximately cylindrical shape. Cross-flow fan 100 is formed from resin. Cross-flow fan 100 rotates in the direction shown by an arrow 103 around an imaginary center axis 101 shown in the figures.

Cross-flow fan 100 is a fan using a plurality of rotating fan blades 21 to flow air in a direction orthogonal to center axis 101 serving as the rotation axis. As viewed from the axial direction of center axis 101, cross-flow fan 100 takes in air from an outside space on one side with respect to center axis 101 to an inside space of the fan and blows the taken-in air to the outside space on the other side with respect to center axis 101. Cross-flow fan 100 forms an air flow that flows in the direction crossing center axis 101 in a flat plane orthogonal to center axis 101. Cross-flow fan 100 forms an outlet flow in the form of a flat plane parallel to center axis 101.

Cross-flow fan 100 is used with the rotation speeds in the low Reynolds number region applied to a fan for home electric equipment, etc.

Cross-flow fan 100 is configured such that a plurality of impellers 12 aligned in the axial direction of center axis 101 are combined. In each impeller 12, plurality of fan blades 21 are provided to be circumferentially spaced apart from each other around center axis 101.

Cross-flow fan 100 further has a peripheral frame 13 serving as a support. Peripheral frame 13 has a ring shape annularly extending around center axis 101. Peripheral frame 13 is provided so as to connect plurality of fan blades 21 provided for each impeller 12 to each other. Peripheral frame 13 has an end surface 13a and an end surface 13b. End surface 13a is formed to face one direction along the axial direction of center axis 101. End surface 13b is arranged on the back side of end surface 13a

and is formed to face the other direction along the axial direction of center axis 101.

With attention given to impellers 12A, 12B and 12C in Fig. 1 arranged sequentially in the axial direction of center axis 101, impeller 12A includes a peripheral frame 13A and plurality of fan blades 21, impeller 12B includes a peripheral frame 13B and plurality of fan blades 21, and impeller 12C includes a peripheral frame 13C and plurality of fan blades 21.

Plurality of fan blades 21 provided in impeller 12A are provided to stand on end surface 13a of peripheral frame 13A and are formed to extend like a plate along the axial direction of center axis 101 in the direction away from peripheral frame 13A. Plurality of fan blades 21 provided in impeller 12B are arranged to stand on end surface 13a of peripheral frame 13B and are formed to extend like a plate along the axial direction of center axis 101 in the direction away from peripheral frame 13B, and are connected to end surface 13b of peripheral frame 13A. Plurality of fan blades 21 provided in impeller 12C are arranged to stand on end surface 13a of peripheral frame 13C, and extend like a plate along the axial direction of center axis 101 in the direction away from peripheral frame 13C, and are connected to end surface 13b of peripheral frame 13B.

In Fig. 2, impeller 12A including peripheral frame 13A and plurality of fan blades 21 is shown representatively. In the manufacturing process of cross-flow fan 100, impeller 12 of the form shown in Fig. 2 is manufactured by resin molding. Furthermore, the form of cross-flow fan 100 shown in Fig. 1 is obtained by connecting obtained plurality of impellers 12 to each other.

Fig. 3 is a front view showing the impeller in Fig. 2. Fig. 3 partially shows the impeller seen from the axial direction of center axis 101, that is, from the rotation axis direction of cross-flow fan 100.

Referring to Figs. 2 and 3, fan blade 21 has a radially inner blade leading end 28 and a radially outer blade leading end 29. Radially inner blade leading end 28 is arranged at a radially inner end of fan blade 21. Radially outer blade leading end 29 is arranged at a radially outer end of fan blade 21. Fan blade 21 is formed to have a thin

blade cross section between radially inner blade leading end 28 and radially outer blade leading end 29.

5 Fan blade 21 has a blade surface 23 including a pressure surface 24 and a suction surface 25. Pressure surface 24 is arranged on the rotational direction side of cross-flow fan 100. Suction surface 25 is arranged on the back side of pressure surface 24. During rotation of cross-flow fan 100, as an air flow is produced on blade surface 23, a pressure distribution is generated such that pressure is relatively large at pressure surface 24 and is relatively small at suction surface 25. Fan blade 21 has a shape generally curved between radially inner blade leading end 28 and radially outer blade leading end 29 so as to be concave on the pressure surface 24 side and be convex on the suction surface 25 side.

10 Fan blade 21 has a root 31 and a leading end 32. Fan blade 21 extends along the axial direction of center axis 101 between root 31 and leading end 32. Root 31 is connected to end surface 13a of peripheral frame 13. Leading end 32 is provided at a leading end to which fan blade 21 extends in the direction away from end surface 13a of peripheral frame 13. Leading end 32 is connected to end surface 13b of peripheral frame 13 of an adjacent impeller 12.

15 Fig. 3 shows a blade cross section 21P obtained by cutting fan blade 21 at root 31 along the plane orthogonal to center axis 101 (a plane orthogonal to the rotation axis of cross-flow fan 100), a blade cross section 21Q obtained by cutting fan blade 21 along the plane orthogonal to center axis 101 at leading end 32, and a blade cross section 21R obtained by cutting fan blade 21 along the plane orthogonal to center axis 101 at any position between root 31 and leading end 32.

20 Fan blade 21 is formed such that the blade cross section when cut along the plane orthogonal to center axis 101 decreases in area from root 31 toward leading end 32. That is, the area of blade cross section 21R at any position between root 31 and leading end 32 is smaller than the area of blade cross section 21P at root 31, and the area of blade cross section 21Q at leading end 32 is smaller than the area of blade cross section 21P and the area of blade cross section 21R.

Such a tapered taper shape of fan blade 21 is determined in consideration of a draft angle at the time of releasing a molded product of impeller 12 from a molding die in resin molding of impeller 12 shown in Fig. 2.

5 Fan blade 21 is formed such that the blade cross section when cut along the plane orthogonal to center axis 101 is displaced in the rotational direction of cross-flow fan 100 between root 31 and leading end 32. In the present embodiment, fan blade 21 is formed such that its blade cross section is displaced to the forward side in the rotational direction of cross-flow fan 100 indicated by arrow 103 from root 31 toward leading end 32. That is, blade cross section 21R at any position between root 31 and leading end 32 is located with a displacement to the forward side in the rotational direction of cross-flow fan 100 with respect to blade cross section 21P at root 31, and blade cross section 21Q at leading end 32 is positioned on the forward side in the rotational direction of cross-flow fan 100 with respect to blade cross sections 21P and 21R.

15 In this way, in cross-flow fan 100 of the present embodiment, a skew blade having an inclination with respect to center axis 101 which is the rotation axis of the fan is used as fan blade 21.

Fig. 3 shows a center line 106 in the thickness direction (the direction in which pressure surface 24 and suction surface 25 are connected to each other) of the blade cross section of fan blade 21.

20 Center line 106 extends through the blade cross section so as to divide the blade cross section of fan blade 21 into the pressure surface 24 side and the suction surface 25 side. Fan blade 21 has an outer edge portion 27 at a position where center line 106 crosses radially outer blade leading end 29, and has an inner edge portion 26 at a position where center line 106 crosses radially inner blade leading end 28. Inner edge portion 26 is arranged on the radially inner side of fan blade 21. Outer edge portion 27 is arranged on the radially outer side of fan blade 21. Center line 106 extends continuously between outer edge portion 27 and inner edge portion 26. Pressure surface 24 and suction surface 25 extend between inner edge portion 26 and outer edge

portion 27 while being curved.

Fig. 4 is a cross-sectional view showing the blade cross section between the root and the leading end of the fan blade in Fig. 3. Fig. 4 shows blade cross section 21R of fan blade 21 in Fig. 3.

5 Referring to Figs. 3 and 4, fan blade 21 has a blade cross-sectional shape in which a plurality of concave portions are formed in at least one of pressure surface 24 and suction surface 25 of blade surface 23. In the present embodiment, a plurality of concave portions 41 are formed at pressure surface 24, and a plurality of concave portions 42 are formed at suction surface 25. More specifically, three concave portions 41 are formed at pressure surface 24, and two concave portions 42 are formed at suction surface 25. A larger number of concave portions 41 are formed at pressure surface 24 than concave portions 42 formed at suction surface 25.

10 A plurality of convex portions 46 are further formed in pressure surface 24. Convex portions 46 are formed to project toward the forward side in the rotational direction of cross-flow fan 100. Concave portion 41 is formed by a valley part between convex portions 46 arranged adjacent to each other. Concave portion 41 and convex portion 46 are formed to be alternately aligned in the direction in which inner edge portion 26 and outer edge portion 27 are connected to each other.

15 A plurality of convex portions 47 are further formed at suction surface 25. Convex portions 47 are formed to project toward the backward side in the rotational direction of cross-flow fan 100. Concave portion 42 is formed by a valley part between convex portions 47 arranged adjacent to each other. Concave portion 42 and convex portions 47 are formed to be alternately aligned in the direction in which inner edge portion 26 and outer edge portion 27 are connected to each other.

20 Concave portion 41 and convex portion 47 are formed at pressure surface 24 and suction surface 25 at positions corresponding to each other on the front and back, respectively. Convex portions 46 and concave portion 42 are formed at pressure surface 24 and suction surface 25 at positions corresponding to each other on the front and back, respectively. That is, in the present embodiment, concave portion 41

formed at pressure surface 24 constitutes convex portion 47 at suction surface 25, and concave portion 42 formed at suction surface 25 constitutes convex portions 46 at pressure surface 24. Each concave portion and each convex portion formed at pressure surface 24 and suction surface 25 in correspondence with each other on the front and back, respectively, have an identical approximately U-shaped cross-sectional shape.

Concave portions 41 and 42 form groove (recessed) shapes extending along the axial direction of center axis 101. The groove portions formed by concave portions 41 and 42 are formed to extend continuously between one end and the other end of fan blade 21 in the axial direction of center axis 101, that is, between root 31 and leading end 32. The groove portions formed by concave portions 41 and 42 are formed to extend linearly between root 31 and leading end 32.

It is noted that although the blade cross-sectional shape of fan blade 21 has been described above with reference to Fig. 4 showing blade cross section 21R, fan blade 21 has a similar blade cross-sectional shape at any position in the axial direction of center axis 101.

In cross-flow fan 100 in the present embodiment, fan blade 21 is formed thick at convex portions 46 and 47 on the root 31 side. Its configuration will be described in detail below. Fig. 5 is a cross-sectional view showing a blade cross section at the root of the fan blade in Fig. 3. Fig. 5 shows blade cross section 21P of the fan blade in Fig. 3.

Referring to Figs. 4 and 5, center line 106 in the thickness direction of blade cross section 21R is particularly referred to as a center line 106R, and center line 106 in the thickness direction of blade cross section 21P is particularly referred to as a center line 106P. Inner edge portion 26 and outer edge portion 27 of blade cross section 21R are referred to as an inner edge portion 26R and an outer edge portion 27R, respectively, and inner edge portion 26 and outer edge portion 27 of blade cross section 21P are referred to as an inner edge portion 26P and an outer edge portion 27P, respectively. In blade cross section 21R, the length between center line 106R and pressure surface 24

is equal to the length between center line 106R and suction surface 25. In blade cross section 21P, the length between center line 106P and pressure surface 24 is equal to the length between center line 106P and suction surface 25.

5 In blade cross section 21R, the length between inner edge portion 26R and outer edge portion 27R is L1. In blade cross section 21P, the length between inner edge portion 26P and outer edge portion 27P is L2. In fan blade 21 having tapered shape, length L2 between inner edge portion 26P and outer edge portion 27P is larger than length L1 between inner edge portion 26R and outer edge portion 27R ($L1 < L2$).

10 Fig. 6 is an enlarged view of the blade cross section in Fig. 4. Referring to Figs. 4 to 6, blade cross section 21R is enlarged such that length L1 between inner edge portion 26R and outer edge portion 27R of blade cross section 21R is equal to length L2 between inner edge portion 26P and outer edge portion 27P of blade cross section 21P. Here, in the present embodiment, blade cross section 21R is enlarged such that the blade circumference forming the outer circumference of blade cross section 21R is moved outward by an equal distance g over the entire circumference. The blade circumference forming the outer circumference of blade cross section 21R is a closed curve. Accordingly, a blade cross section 21R' shown in Fig. 6 is obtained.

15 Fig. 7 is another cross-sectional view showing a blade cross section at the root of the fan blade in Fig. 3. Referring to Fig. 7, center line 106R of blade cross section 21R' shown in Fig. 6 is superimposed on blade cross section 21P in Fig. 5 instead of center line 106P. At this time, center line 106R of blade cross section 21R' is superimposed such that inner edge portion 26R and outer edge portion 27R defined on center line 106R correspond to inner edge portion 26P and outer edge portion 27P of blade cross section 21P, respectively.

20 In cross-flow fan 100 of the present embodiment, the length between suction surface 25 arranged on the back side of concave portion 41 and center line 106R is larger than the length between the bottom of concave portion 41 formed at pressure surface 24 of blade cross section 21P and center line 106R ($T1 > T2$, $T7 > T8$, $T9 > T10$). The length between pressure surface 24 arranged on the back side of concave portion

42 and center line 106R is larger than the length between the bottom of concave portion 42 formed at suction surface 25 of blade cross section 21P and center line 106R ($T3>T4$, $T5>T6$).

5 It is noted that concave portions 41 and 42 each form a groove shape. The bottom of each of concave portions 41 and 42 is at a position where the groove shape has the largest depth.

10 In the present embodiment, concave portion 41 and convex portion 47 are formed at pressure surface 24 and suction surface 25 at positions corresponding to each other on the front and back, respectively, and convex portions 46 and concave portion 42 are formed at pressure surface 24 and suction surface 25 at positions corresponding to each other on the front and back, respectively.

15 In such a configuration, the length between the top of convex portion 47 arranged at the back side of concave portion 41 and center line 106R is larger than the length between the bottom of concave portion 41 formed at pressure surface 24 of blade cross section 21P and center line 106R (when drawing a straight line passing through the bottom of concave portion 41 and the top of convex portion 47 arranged on the back side of concave portion 41 and assuming an intersection of that straight line and center line 106R, the length from the top of convex portion 47 to the intersection is larger than the length from the bottom of concave portion 41 to the intersection). The length between the top of convex portion 46 arranged on the back side of concave portion 42 and center line 106R is larger than the length between the bottom of concave portion 42 formed at suction surface 25 of blade cross section 21P and center line 106R (when drawing a straight line passing through the bottom of concave portion 42 and the top of convex portion 46 arranged on the back side of concave portion 42 and assuming an intersection of that straight line and center line 106R, the length from the top of convex portion 46 to the intersection is larger than the length from the bottom of concave portion 42 to the intersection).

25 It is noted that convex portions 46 and 47 have a convex shape. The top of each of convex portions 46 and 47 is at a position where the convex shape projects

most.

Fan blade 21 has blade cross section 21R which satisfies magnitude relations of T1 to T10 described above in comparison with blade cross section 21P at root 31, at any position between root 31 and leading end 32.

5 Fig. 8 is a cross-sectional view showing the fan blade taken along the line VIII-VIII in Fig. 3. Figs. 4 and 5 show a concave portion 41s formed in the proximity of the center between inner edge portion 26 and outer edge portion 27 and a convex portion 47s arranged on the back side thereof. Fig. 8 shows a longitudinal cross section of fan blade 21 along the axial direction of center axis 101, which is the cross-
10 sectional shape of fan blade 21 at a position passing through the bottom of concave portion 41s and the top of convex portion 47s.

Referring to Fig. 8, an imaginary straight line 33 positioned at the center between root 31 and leading end 32 is shown. Furthermore, an imaginary straight line 50 connecting a central point 51 between pressure surface 24 and suction surface 25 at
15 leading end 32 and a central point 52 between pressure surface 24 and suction surface 25 on straight line 33 is shown.

In the present embodiment, at convex portion 47 on the root 31 side, fan blade 21 has a thick part 56 formed thick as compared with convex portion 47 on the leading end 32 side. Therefore, a central point 53 between pressure surface 24 and suction
20 surface 25 at root 31 is not present on straight line 50, but is present at a position shifted from straight line 50 to the suction surface 25 side at which convex portion 47 is formed.

It is noted that although the blade cross-sectional shape of fan blade 21 has been described above showing the cross section at the position passing through the bottom of
25 concave portion 41s and the top of convex portion 47s in Fig. 8, fan blade 21 also has a similar blade sectional shape at a position passing through the bottom of another concave portion and the top of another convex portion.

Referring to Figs. 4 and 5, convex portions 46 and 47 formed in blade cross section 21P form blade surface 23 having a curvature larger than those of convex

portions 46 and 47 formed in blade cross section 21R in correspondence with convex portions 46 and 47 formed in blade cross section 21P. For example, convex portion 47s formed in blade cross section 21P forms blade surface 23 having a curvature larger than that of convex portion 47s formed in blade cross section 21R.

5 In cross-flow fan 100 of the present embodiment, fan blade 21 is formed thicker at convex portions 46 and 47 on the root 31 side such that all the plurality of relations described above are satisfied. It is noted that fan blade 21 may be formed thicker at convex portions 46 and 47 on the root 31 side so as to satisfy at least one selected from the plurality of relations described above.

10 Collectively describing the configuration of cross-flow fan 100 in the first embodiment of the present invention described above, cross-flow fan 100 as a fan of the present embodiment is a fan formed from resin. Cross-flow fan 100 includes fan blades 21 as a plurality of vane portions, having formed thereon blade surface 23 and being circumferentially spaced apart from each other, blade surface 23 including
15 pressure surface 24 arranged on the rotational direction side of the fan and suction surface 25 arranged on the back side of pressure surface 24, and peripheral frame 13 as a support provided at root 31 as one end of fan blade 21 in the rotation axis direction of the fan and connecting plurality of fan blades 21 to each other. When cut along the plane orthogonal to the rotation axis of the fan, fan blade 21 has inner edge portion 26
20 at which center line 106 between pressure surface 24 and suction surface 25 crosses radially inner blade leading end 28 as a blade leading end on the radially inner side, and outer edge portion 27 at which center line 106 crosses radially outer blade leading end 29 as a blade leading end on the radially outer side. An air flow as a fluid flow flowing between inner edge portion 26 and outer edge portion 27 is produced on blade
25 surface 23 with the rotation of the fan.

When cut along the plane orthogonal to the rotation axis of the fan, fan blade 21 has a blade cross-sectional shape in which plurality of concave portions 41 and 42 are formed in at least one of pressure surface 24 and suction surface 25. Fan blade 21 is formed such that the blade cross section when cut along the plane orthogonal to the

rotation axis of the fan decreases in area from root 31 toward leading end 32 as the other end of fan blade 21 in the rotation axis direction of the fan.

When fan blade 21 is cut along the plane orthogonal to the rotation axis of the fan at root 31 of fan blade 21 in the rotation axis direction of the fan, blade cross section 21P as a first blade cross section is obtained. When fan blade 21 is cut along the plane orthogonal to the rotation axis of the fan between root 31 and leading end 32 of fan blade 21 in the rotation axis direction of the fan, blade cross section 21R as a blade cross section is obtained. Blade cross section 21R is enlarged such that the blade circumference forming the outer circumference of blade cross section 21R is moved outward by an equal distance over the entire circumference until the length between inner edge portion 26 and outer edge portion 27 becomes equal in blade cross section 21P and blade cross section 21R, and center line 106R of blade cross section 21R having been enlarged is superimposed on blade cross section 21P such that inner edge portion 26R and outer edge portion 27R on center line 106R correspond to inner edge portion 26P and outer edge portion 27P in blade cross section 21P, respectively. In this case, the length between blade surface 23 arranged on the back side of the bottoms of concave portions 41 and 42 and center line 106R of blade cross section 21R is larger than the length between the bottoms of concave portions 41 and 42 formed in blade cross section 21P and center line 106R of blade cross section 21R.

(Description of Configuration of Air Conditioner and Molding Die)

Fig. 9 is a cross-sectional view showing an air conditioner in which the cross-flow fan in Fig. 1 is used. Referring to Fig. 9, an air conditioner 210 is configured with an indoor unit 220 installed in a room and provided with an indoor heat exchanger 229 and a not-shown outdoor unit installed in the outside of the room and provided with an outdoor heat exchanger and a compressor. Indoor unit 220 and the outdoor unit are connected by piping for circulating refrigerant gas between indoor heat exchanger 229 and the outdoor heat exchanger.

Indoor unit 220 has a blower 215. Blower 215 is configured to include cross-flow fan 100, a not-shown driving motor for rotating cross-flow fan 100, and a casing

222 for producing a prescribed airflow with rotation of cross-flow fan 100.

5 Casing 222 has a cabinet 222A and a front panel 222B. Cabinet 222A is supported on a wall surface in the room. Front panel 222B is removably attached to cabinet 222A. An outlet port 225 is formed in a gap between a lower end portion of front panel 222B and a lower end portion of cabinet 222A. Outlet port 225 is formed in an approximately rectangular shape extending in the width direction of indoor unit 220 to be directed forward and downward. On the top surface of front panel 222B, a grid-like intake port 224 is formed.

10 At a position opposing front panel 222B, an air filter 228 is provided for collecting and removing dust included in the air taken in from intake port 224. A not-shown air filter cleaner is provided in a space formed between front panel 222B and air filter 228. The air filter cleaner automatically removes dust accumulated in air filter 228.

15 In the inside of casing 222, an air flow channel 226 is formed, through which air is circulated from intake port 224 toward outlet port 225. Outlet portion 225 is provided with a vertical louver 232 that can change the blowing angle in the left and right directions and a plurality of horizontal louvers 231 that can change the blowing angle in the up and down directions to a forward-upward direction, a horizontal direction, a forward-downward direction, and an immediately downward direction.

20 Indoor heat exchanger 229 is arranged between cross-flow fan 100 and air filter 228 on a path of air flow channel 226. Indoor heat exchanger 229 has not-shown serpentine refrigerant pipes arranged side by side in a plurality of layers in the up and down directions and in a plurality of columns in the front and back directions. Indoor heat exchanger 229 is connected to the compressor of the outdoor unit installed in the outdoor, and the compressor is driven to operate a refrigeration cycle. Through the operation of the refrigeration cycle, indoor heat exchanger 229 is cooled to a temperature lower than the ambient temperature during cooling operation, and indoor heat exchanger 229 is heated to a temperature higher than the ambient temperature during heating operation.

Fig. 10 is an enlarged cross-sectional view showing the proximity of the outlet port of the air conditioner in Fig. 9. Referring to Figs. 9 and 10, casing 222 has a front wall portion 251 and a rear wall portion 252. Front wall portion 251 and rear wall portion 252 are arranged to face each other at a distance from each other.

5 On a path of air flow channel 226, cross-flow fan 100 is arranged to be positioned between front wall portion 251 and rear wall portion 152. A protrusion portion 253 is formed at front wall portion 251 to protrude toward the radially outer surface of cross-flow fan 100 so as to decrease the gap between cross-flow fan 100 and front wall portion 251. A protrusion portion 254 is formed at rear wall portion 252 to
10 protrude toward the radially outer surface of cross-flow fan 100 so as to decrease the gap between cross-flow fan 100 and rear wall portion 252.

Casing 222 has an upper guide portion 256 and a lower guide portion 257. Air flow channel 226 is defined by upper guide portion 256 and lower guide portion 257 on the downstream side of air flow from cross-flow fan 100.

15 Upper guide portion 256 and lower guide portion 257 are continuous from front wall portion 251 and rear wall portion 252, respectively, and extend toward outlet port 225. Upper guide portion 156 and lower guide portion 257 are formed to curve the air blown by cross-flow fan 100 such that upper guide portion 256 is located on the radially inner side and lower guide portion 257 is located on the radially outer side, and
20 to guide the air forward and downward. Upper guide portion 256 and lower guide portion 257 are formed such that the cross section of air flow channel 226 increases from cross-flow fan 100 toward outlet port 225.

In the present embodiment, front wall portion 251 and upper guide portion 256 are integrally formed with front panel 222B. Rear wall portion 252 and lower guide
25 portion 257 are integrally formed with cabinet 222A.

Fig. 11 is a cross-sectional view of an air flow produced in the proximity of the outlet port of the air conditioner in Fig. 9. Referring to Figs. 9 to 11, on the path on air flow channel 226, an upstream outside space 246 is formed to be positioned upstream of air flow from cross-flow fan 100, an inside space 247 is formed to be

positioned in the inside of cross-flow fan 100 (the radially inner side of a plurality of fan blades 21 circumferentially arranged), and a downstream outside space 248 is formed to be positioned downstream of air flow from cross-flow fan 100.

During rotation of cross-flow fan 100, at an upstream region 241 of air flow channel 226 with respect to protrusion portions 253, 254 as a boundary, an air flow 261 is formed to pass through on blade surface 23 of fan blade 21 from upstream outside space 246 toward inside space 247. At a downstream region 242 of air flow channel 226 with respect to protrusion portions 253, 254 as a boundary, air flow 261 is formed to pass through on blade surface 23 of fan blade 21 from inside space 247 toward downstream outside space 248. Here, at a position adjacent to front wall portion 251, a vortex 262 of air flow is formed.

It is noted that although an air conditioner has been described by way of example in this embodiment, the cross-flow fan in the present invention is also applicable to a fluid feeding device such as, for example, an air purifier, a humidifier, a cooling device, and a ventilating device.

Fig. 12 is a cross-sectional view of a molding die for use in production of the cross-flow fan in Fig. 1. Referring to Fig. 12, a molding die 160 has a stationary die 164 and a movable die 162. Stationary die 164 and movable die 162 define a cavity 166 which has approximately the same shape as cross-flow fan 100 and into which flowable resin is injected.

Molding die 160 may be provided with a not-shown heater for increasing the flowability of resin injected into cavity 166. The installation of such a heater is particularly effective, for example, when synthetic resin with an increased strength, such as glass-fiber-filled AS (a copolymerized compound of acrylonitrile and styrene) resin, is used.

It is noted that a centrifugal fan 10 in a second embodiment which will be described later is also manufactured by a die having a configuration similar to that of molding die 160 in Fig. 12.

(Detailed Description of Effects)

Figs. 13A and 13B are cross-sectional views showing steps of manufacturing the impeller in Fig. 2 using the molding die in Fig. 12. In the drawings, the longitudinal cross section of fan blade 21 shown in Fig. 8 and a cross section of movable die 162 corresponding to that longitudinal cross section are shown.

5 Referring to Fig. 13A, impeller 12 equipped with peripheral frame 13 and plurality of fan blades 21 extending from that end surface 13a is molded by injecting resin into cavity 166 and hardening the resin. After molding, in order to release a molded product of impeller 12 from molding die 160, movable die 162 is slidingly moved in the direction away from peripheral frame 13 (in the direction indicated by an arrow 107). Here, it is necessary to slidingly move movable die 162 while rotating movable die 162 around the rotation axis (center axis 101) of impeller 12, since a skew blade having an inclination with respect to center axis 101 is used as fan blade 21 in the present embodiment.

10 In this case, if even a slight shift occurs in synchronization between the rotation and the sliding movement of movable die 162, contact pressure will act on blade surface 23 of fan blade 21 from movable die 162. Fig. 13B shows the case where the rotating speed is slightly fast with respect to the speed of sliding movement of movable die 162 as an example. At this time, a minute gap is left between a side surface 162b of movable die 162 and pressure surface 24 of fan blade 21, while a side surface 162a of movable die 162 and suction surface 25 of fan blade 21 interfere with each other to cause contact pressure to act on suction surface 25.

20 Fig. 14 is a cross-sectional view at the root of the fan blade showing stress produced at the root of the fan blade in the case where contact pressure acts on the pressure surface side of the fan blade from the movable die when releasing a molded product of an impeller. Fig. 15 is a cross-sectional view at the root of the fan blade showing stress produced at the root of the fan blade in the case where contact pressure acts on the suction surface side of the fan blade from a movable die when releasing a molded product of an impeller.

Referring to Fig. 14, in the case where contact pressure acts on pressure surface

24 of fan blade 21 from movable die 162 when releasing a molded product of impeller 12, tensile stress occurs at convex portion 46 formed at pressure surface 24 and compressive stress occurs at concave portion 41 formed at pressure surface 24.

Referring to Fig. 15, in the case where contact pressure acts on suction surface 25 of fan blade 21 from movable die 162 when releasing a molded product of impeller 12, tensile stress occurs at convex portion 47 formed at suction surface 25 and compressive stress occurs at concave portion 42 formed at suction surface 25.

At the places where tensile stress occurs, root 31 of fan blade 21 tends to be peeled from end surface 13a of peripheral frame 13. As a result, a concern arises in that fan blade 21 may break at convex portions 46 and 47 in the proximity of root 31 when releasing a molded product of impeller 12.

In contrast, in cross-flow fan 100 in the present embodiment, thick parts 56 are provided at the places where tensile stress occurs, that is, at convex portions 46 and 47 in the proximity of root 31 of fan blade 21. With such a configuration, the strength of fan blade 21 at convex portions 46 and 47 can be ensured to prevent fan blade 21 from breaking.

Assuming the case where the thick parts are provided at concave portions 41 and 42, it is necessary to perform thickening to such an extent that the groove shapes formed by concave portions 41 and 42 are buried particularly in the proximity of the root so as to prevent fan blade 21 from breaking. In this case, problems arise in that the weight of fan blade 21 will increase to increase the motor for driving cross-flow fan 100, and in that the required quantity of a raw material of fan blade 21 increases. In contrast, in the present embodiment, since thick parts 56 are provided at convex portions 46 and 47 where tensile stress occurs, strength can be efficiently imparted to places where fan blade 21 may break.

Fig. 16 is a cross-sectional view representing a phenomenon that occurs on the blade surface of the fan blade in the upstream region shown in Fig. 10.

Referring to Fig. 16, when an air flow directed from upstream outside space 246 toward inside space 247 is formed in upstream region 241, an air flow is produced on

blade surface 23 of fan blade 21 to flow in from outer edge portion 27, pass through on blade surface 23, and flow out from inner edge portion 26. Here, a counterclockwise vortex 62 (secondary flow) of air flow is formed at concave portion 41 formed at pressure surface 24, and a clockwise vortex 64 of air flow is produced at concave portion 42 formed at suction surface 25. Accordingly, air flows 61 and 63 (main flows) passing through on blade surface 23 flow along the outside of vortices 62 and 64 produced at concave portions 41 and 42.

Fig. 17 is a cross-sectional view representing a phenomenon that occurs on the blade surface of the fan blade in the downstream region shown in Fig. 10.

Referring to Fig. 17, when an air flow directed from inside space 247 toward downstream outside space 248 is formed in downstream region 242, an air flow is produced on blade surface 23 of fan blade 21 to flow in from inner edge portion 26, pass through on blade surface 23, and flow out from outer edge portion 27. Here, a clockwise vortex 67 (secondary flow) of air flow is formed at concave portion 41 formed at pressure surface 24, and a counterclockwise vortex 69 of air flow is produced at concave portion 42 formed at suction surface 25. Accordingly, air flows 66 and 68 (main flows) passing through on blade surface 23 flow along the outside of vortices 62 and 64 produced at concave portions 41 and 42.

In other words, in cross-flow fan 100, when fan blade 21 moves from upstream region 241 to downstream region 242, the direction of air flow on blade surface 23 is reversed, and the rotation direction of the vortices produced at concave portions 41 and 42 is reversed accordingly.

In cross-flow fan 100 in the present embodiment, although having a thin blade cross-sectional shape, fan blade 21 exhibits a behavior like a thick blade as if the blade cross-sectional shape is increased in thickness by the depth of concave portions 41 and 42 at which the vortices (secondary flows) are formed. As a result, the lift produced at fan blade 21 can be significantly increased.

Assuming the case where thick parts are provided at concave portions 41 and 42, the above-described effect of the thick blade obtained by production of vortices is

impaired in the proximity of root 31 of fan blade 21 since the depth of concave portions 41 and 42 will be smaller. In contrast, in the present embodiment, since thick parts 56 are provided at convex portions 46 and 47, the above-described effect of the thick blade obtained by production of vortices is fully effected.

5 In cross-flow fan 100 in the first embodiment of the present invention configured in this manner, thick parts 56 are provided at convex portions 46 and 47 in the proximity of root 31 of fan blade 21, and therefore, fan blade 21 can be prevented from breaking when releasing the molded product of impeller 12. Accordingly, cross-flow fan 100 formed from resin can be improved in moldability. Here, the effect of
10 improving blowing capacity because of concave portions 41 and 42 is fully effected because thick parts 56 are provided so as not to impair the concave shape of concave portions 41 and 42 formed at blade surface 23. Moreover, since thick parts 56 are provided at places where tensile stress occurs when releasing the molded product of impeller 12, it is possible to restrain the fan from unnecessarily increasing in weight.

15 (Second Embodiment)

The present embodiment first describes a configuration of a centrifugal fan to which a fan of the present invention is applied, and then describes a blower and an air purifier in which that centrifugal fan is used. It is noted that the centrifugal fan in the present embodiment partially includes a similar configuration as compared with cross-flow fan 100 in the first embodiment. Hereinafter, an overlapping configuration will
20 not be described repeatedly.

(Description of Configuration of Centrifugal Fan)

Fig. 18 is a perspective view showing a centrifugal fan in a second embodiment of the present invention. Referring to Fig. 18, centrifugal fan 10 in the present
25 embodiment has plurality of fan blades 21. Centrifugal fan 10 has an approximately cylindrical appearance as a whole, and plurality of fan blades 21 are arranged on the circumferential surface of the approximately cylindrical shape. Centrifugal fan 10 is integrally formed from resin. Centrifugal fan 10 rotates in the direction shown by arrow 103 around imaginary center axis 101 shown in Fig. 18.

Centrifugal fan 10 is a fan using plurality of fan blades 21 being rotated to blow air taken in from the radially inner side to the radially outer side. Centrifugal fan 10 is a fan which blows air from the center side of rotation of the fan to its radial direction by way of centrifugal force. Centrifugal fan 10 is a sirocco fan. Centrifugal fan 10 is used at rotating speeds in the low Reynolds number region applied to a fan for home electric equipment, etc.

Centrifugal fan 10 further has peripheral frames 13p and 13q as supports. Peripheral frames 13p and 13q are formed to extend annularly around center axis 101. Peripheral frames 13p and 13q are respectively arranged at positions at a distance from each other in the axial direction of center axis 101. A boss part 16 for coupling centrifugal fan 10 to a drive motor with a disk part 14 interposed therebetween is formed integrally with peripheral frame 13p.

Plurality of fan blades 21 are provided to be circumferentially spaced apart from each other around center axis 101. Plurality of fan blades 21 are supported by peripheral frames 13p and 13q at the both ends in the axial direction of center axis 101. Fan blade 21 is provided to stand on peripheral frame 13p, and is formed to extend along the axial direction of center axis 101 toward peripheral frame 13q.

In the manufacturing process of centrifugal fan 10, first, peripheral frame 13p, disk part 14, boss part 16, and plurality of fan blades 21 extending from peripheral frame 13p are manufactured integrally by resin molding. Furthermore, peripheral frame 13q is connected to the manufactured molded product, thereby obtaining the form of centrifugal fan 10 in Fig. 18.

Fan blade 21 has the same blade cross-sectional shape as fan blade 21 in the first embodiment in Fig. 3.

That is, fan blade 21 has root 31 connected to peripheral frame 13p and leading end 32 connected to peripheral frame 13q. Fan blade 21 is formed such that its blade cross section decreases in area from root 31 toward leading end 32. Fan blade 21 is formed such that its blade cross section is displaced in the rotational direction of cross-flow fan 100 between root 31 and leading end 32. Fan blade 21 has a blade cross-

sectional shape in which a plurality of concave portions are formed in at least one of pressure surface 24 and suction surface 25 of blade surface 23. Fan blade 21 is formed thick at the convex portions on the root 31 side.

(Description of Configuration of Blower and Air Purifier)

5 Fig. 19 is a cross-sectional view showing a blower in which the centrifugal fan in Fig. 18 is used. Fig. 20 is a cross-sectional view showing the blower taken along the line XX-XX in Fig. 19. Referring to Figs. 19 and 20, a blower 320 has a drive motor 328, centrifugal fan 10, and a casing 329 in an exterior casing 326.

10 The output shaft of drive motor 328 is coupled to boss part 16 molded integrally with centrifugal fan 10. Casing 329 has a guide wall 329a. Guide wall 329a is formed by a 3/4 arc arranged on the outer circumference of centrifugal fan 10. Guide wall 329a guides an air flow produced by the rotation of fan blade 21 into the rotational direction of fan blade 21, and increases the speed of the air flow.

Casing 329 has formed therein a suction part 330 and a blowing part 327.
15 Suction part 330 is formed to be positioned on the extension of center axis 101. Blowing part 327 is formed to be open at part of guide wall 329a in one of the tangential directions of guide wall 329a. Blowing part 327 presents a rectangular-tube shape projecting from part of guide wall 329a in one of the tangential directions of guide wall 329a.

20 By the driving of drive motor 328, centrifugal fan 10 is rotated in the direction indicated by arrow 103. At this time, air is taken in through suction part 330 into casing 329, and is blown out from a radially inner space 331 to a radially outer space 332 of centrifugal fan 10. The air blown out to radially outer space 332 flows circumferentially along the direction indicated by an arrow 304, and is blown to the
25 outside through blowing part 327.

Fig. 21 is a cross-sectional view showing an air purifier in which the centrifugal fan in Fig. 18 is used. Referring to Fig. 21, an air purifier 340 has a housing 344, a blower 350, a duct 345, and a (HEPA: High Efficiency Particulate Air Filter) filter 341.

Housing 344 has a back wall 344a and a ceiling wall 344b. Housing 344 has

formed therein an intake port 342 for sucking in air in the room where air purifier 340 is provided. Intake port 342 is formed in back wall 344a. Housing 344 further has formed therein a blowing port 343 through which clean air is discharged indoors. Blowing port 343 is formed in ceiling wall 344b. In general, air purifier 340 is
5 installed on the window side with back wall 344a opposed to the indoor wall.

A filter 341 is arranged to face intake port 342 within housing 344. The air introduced into housing 344 through intake port 342 passes through filter 341. Foreign substances in the air are thereby removed.

Blower 350 is provided to suck in indoor air into housing 344 and blow out air
10 cleaned with filter 341 indoors through blowing port 343. Blower 350 has centrifugal fan 10, a casing 352, and a drive motor 351. Casing 352 has a guide wall 352a. Casing 352 has formed therein a suction part 353 and a blowing part 354.

Duct 345 is provided above blower 350 and provided as a wind introducing channel through which clean air is guided from casing 352 to blowing port 343. Duct
15 345 has a shape presenting a rectangular-tube form connected to blowing part 354 at its lower end and being opened at its upper end. Duct 345 is formed to guide clean air blown out through blowing part 354 toward blowing port 343 in a laminar flow.

In air purifier 340 having such a configuration, fan blade 21 is rotated by the driving of blower 350, and air in the room is sucked into housing 344 through intake
20 port 342. At this time, an air flow is produced between intake port 342 and blowing port 343, and foreign substances, such as dust, contained in the sucked air are removed with filter 341.

Clean air obtained by passing through filter 341 is sucked into casing 352. Here, clean air sucked into casing 352 becomes a laminar flow because of guide wall
25 352a around fan blade 21. Air turned into the laminar flow is guided to blowing part 354 along guide wall 352a, and is blown into duct 345 through blowing part 354. Air is emitted through blowing port 343 to the outside space.

It is noted that although the present embodiment has described the air purifier as an example, the centrifugal fan according to the present invention can also be applied to

a device which sends out fluid, such as an air conditioner, a humidifier, a cooling device, and a ventilating device, for example.

With centrifugal fan 10 in the second embodiment of the present invention configured in this manner, the effects described in the first embodiment can be obtained similarly.

(Third Embodiment)

The present embodiment describes various modifications of the shape of fan blade 21 shown in Figs. 4 to 7.

Fig. 22 is a cross-sectional view showing a blade cross section between a root and a leading end of a fan blade in a first modification. The blade cross section shown in Fig. 22 corresponds to blade cross section 21R of fan blade 21 in Fig. 3. Fig. 23 is a cross-sectional view showing a blade cross section at the root of the fan blade in the first modification. The blade cross section shown in Fig. 23 corresponds to blade cross section 21P of the fan blade in Fig. 3.

Referring to Figs. 22 and 23, two concave portions 41 are formed at pressure surface 24 in the present modification. Two concave portions 41 are generally arranged on the side closer to inner edge portion 26 than outer edge portion 27. Convex portion 46 is further formed at pressure surface 24. Convex portion 46 is formed to project to the forward side in the rotational direction of cross-flow fan 100.

One concave portion 42 is formed at suction surface 25. Concave portion 42 is arranged on the side closer to inner edge portion 26 than outer edge portion 27. Plurality of convex portions 47 are further formed at suction surface 25. Convex portions 47 are formed to project to the backward side in the rotational direction of cross-flow fan 100. Concave portion 42 is formed by a valley part between convex portions 47 arranged adjacent to each other.

Concave portion 41 and convex portion 47 are formed at positions corresponding to each other at pressure surface 24 and suction surface 25 on the front and back, respectively. Convex portion 46 and concave portion 42 are formed at positions corresponding to each other at pressure surface 24 and suction surface 25 on

the front and back, respectively. Center line 106R of blade cross section 21R is bent at positions corresponding to concave portions 41, 42 and convex portions 46, 47, while center line 106P of blade cross section 21P is curved at positions corresponding to concave portions 41, 42 and convex portions 46, 47.

5 Fig. 24 is an enlarged view of the blade cross section in Fig. 22. Fig. 25 is another cross-sectional view showing a blade cross section at the root of the fan blade in the first modification.

Referring to Figs. 22 to 24, blade cross section 21R is enlarged such that length L1 between inner edge portion 26R and outer edge portion 27R of blade cross section 10 21R is equal to length L2 between inner edge portion 26P and outer edge portion 27P of blade cross section 21P. Here, blade cross section 21R is enlarged such that the blade circumference forming the outer circumference of blade cross section 21R is entirely moved outward by an equal distance. Accordingly, blade cross section 21R' shown in Fig. 24 is obtained.

15 Referring to Fig. 25, center line 106R of blade cross section 21R' shown in Fig. 24 is superimposed on blade cross section 21P in Fig. 23 instead of center line 106P. At this time, center line 106R of blade cross section 21R' is superimposed such that inner edge portion 26R and outer edge portion 27R defined on center line 106R correspond to inner edge portion 26P and outer edge portion 27P of blade cross section 20 21P, respectively.

In the present modification, the length between the top of convex portion 47 arranged on the back side of concave portion 41 and center line 106R is larger than the length between the bottom of concave portion 41 formed at pressure surface 24 of blade cross section 21P and center line 106R ($T3 > T4$, $T5 > T6$). The length between 25 the top of convex portion 46 arranged on the back side of concave portion 42 and center line 106R is larger than the length between the bottom of concave portion 42 formed at suction surface 25 of blade cross section 21P and center line 106R ($T1 > T2$).

With such a configuration, fan blade 21 is also formed thick at convex portions 46 and 47 on the root 31 side in the present modification.

Fig. 26 is a cross-sectional view showing a blade cross section between a root and a lead end of a fan blade in a second modification. The blade cross section shown in Fig. 26 corresponds to blade cross section 21R of fan blade 21 in Fig. 3. Fig. 27 is a cross-sectional view showing a blade cross section at the root of the fan blade in the second modification. The blade cross section shown in Fig. 27 corresponds to blade cross section 21P of the fan blade in Fig. 3.

Referring to Figs. 26 and 27, three concave portions 41 are formed at pressure surface 24 in the present modification. Three concave portions 41 are generally arranged on the side closer to inner edge portion 26 than outer edge portion 27. In the present modification, none of concave portion and convex portion is formed at pressure surface 24 in blade cross section 21R shown in Fig. 26.

Fig. 28 is an enlarged view of the blade cross section in Fig. 26. Fig. 29 is another cross-sectional view showing a blade cross section at the root of the fan blade in the second modification.

Referring to Fig. 28, blade cross section 21R is enlarged such that length L1 between inner edge portion 26R and outer edge portion 27R of blade cross section 21R is equal to length L2 between inner edge portion 26P and outer edge portion 27P of blade cross section 21P. Here, blade cross section 21R is enlarged such that the blade circumference forming the outer circumference of blade cross section 21R is entirely moved outward by an equal distance. Accordingly, blade cross section 21R' shown in Fig. 28 is obtained.

Referring to Fig. 29, center line 106R of blade cross section 21R' shown in Fig. 28 is superimposed on blade cross section 21P in Fig. 27 instead of center line 106P. At this time, center line 106R of blade cross section 21R' is superimposed such that inner edge portion 26R and outer edge portion 27R defined on center line 106R correspond to inner edge portion 26P and outer edge portion 27P of blade cross section 21P, respectively.

In the present modification, the length between suction surface 25 arranged on the back side of the bottom of concave portion 41 and center line 106R is larger than

the length between the bottom of concave portion 41 formed at pressure surface 24 of blade cross section 21P and center line 106R ($T1>T2$, $T3>T4$, $T5>T6$).

With such a configuration, in the present modification, fan blade 21 is formed thick on the root 31 side and on the back side of concave portion 41.

5 Fig. 30 is a cross-sectional view showing a blade cross section between a root and a leading end of a fan blade in a third modification. The blade cross section shown in Fig. 30 corresponds to blade cross section 21R of fan blade 21 in Fig. 3. Fig. 31 is a cross-sectional view showing a blade cross section at the root of the fan blade in the third modification. The blade cross section shown in Fig. 31 corresponds to blade cross section 21P of the fan blade in Fig. 3.

10 Referring to Figs. 30 and 31, three concave portions 41 are formed at pressure surface 24 in the present modification. Three concave portions 41 are generally arranged on the side closer to inner edge portion 26 than outer edge portion 27. One concave portion 42 is formed at suction surface 25. Concave portion 42 is generally
15 arranged on the side closer to outer edge portion 27 than inner edge portion 26. In the present modification, in blade cross section 21R shown in Fig. 30, no convex portion is formed at a position of suction surface 25 corresponding to the back side of concave portion 41, and no convex portion is formed at a position of pressure surface 24 corresponding to the back side of concave portion 42.

20 Fig. 32 is an enlarged view of the blade cross section in Fig. 30. Fig. 33 is another cross-sectional view showing a blade cross section at the root of the fan blade in the third modification.

 Referring to Fig. 32, blade cross section 21R is enlarged such that length L1 between inner edge portion 26R and outer edge portion 27R of blade cross section 21R is equal to length L2 between inner edge portion 26P and outer edge portion 27P of
25 blade cross section 21P. Here, blade cross section 21R is enlarged such that the blade circumference forming the outer circumference of blade cross section 21R is entirely moved outward by an equal distance. Accordingly, blade cross section 21R' shown in Fig. 32 is obtained.

Referring to Fig. 33, center line 106R of blade cross section 21R' shown in Fig. 32 is superimposed on blade cross section 21P in Fig. 31 instead of center line 106P. At this time, center line 106R of blade cross section 21R' is superimposed such that inner edge portion 26R and outer edge portion 27R defined on center line 106R correspond to inner edge portion 26P and outer edge portion 27P of blade cross section 21P, respectively.

In the present modification, the length between suction surface 25 arranged on the back side of the bottom of concave portion 41 and center line 106R is larger than the length between the bottom of concave portion 41 formed at pressure surface 24 of blade cross section 21P and center line 106R ($T1 > T2$, $T3 > T4$, $T5 > T6$). The length between pressure surface 24 arranged on the back side of the bottom of concave portion 42 and center line 106R is larger than the length between the bottom of concave portion 42 formed at suction surface 25 of blade cross section 21P and center line 106R ($T7 > T8$).

With such a configuration, in the present modification, fan blade 21 is formed thick on the root 31 side and on the back side of concave portions 41 and 42.

With the cross-flow fan in the third embodiment of the present invention configured in this manner, the effects described in the first embodiment can be obtained similarly. It is noted that fan blades 21 in the present modification may be applied to the centrifugal fan in the second embodiment.

(Fourth Embodiment)

A cross-flow fan in the present embodiment differs from cross-flow fan 100 in the first embodiment in the method of enlarging blade cross section 21R when obtaining blade cross section 21R' in Fig. 6 from blade cross section 21R in Fig. 4 in the first embodiment.

Fig. 34 is a cross-sectional view showing a blade cross section between a root and a leading end of a fan blade in a fourth embodiment. The blade cross section shown in Fig. 34 corresponds to blade cross section 21R of fan blade 21 in the first embodiment in Fig. 3. Fig. 35 is a cross-sectional view showing the blade cross

section at the root of the fan blade in the fourth embodiment. The blade cross section shown in Fig. 35 corresponds to blade cross section 21P of fan blade 21 in the first embodiment in Fig. 3.

Fig. 36 is an enlarged view of the blade cross section in Fig. 34. Referring to Figs. 34 to 36, blade cross section 21R is enlarged such that length L1 between inner edge portion 26R and outer edge portion 27R of blade cross section 21R is equal to length L2 between inner edge portion 26P and outer edge portion 27P of blade cross section 21P. Here, in the cross-flow fan in the present embodiment, blade cross section 21R is enlarged such that the blade cross section before enlargement and the blade cross section after enlargement satisfy the similarity relation. Accordingly, blade cross section 21R' shown in Fig. 36 is obtained.

Fig. 37 is another cross-sectional view showing a blade cross section at the root of the fan blade in the fourth embodiment. Referring to Fig. 37, center line 106R of blade cross section 21R' shown in Fig. 36 is superimposed on blade cross section 21P in Fig. 35 instead of center line 106P. At this time, center line 106R of blade cross section 21R' is superimposed such that inner edge portion 26R and outer edge portion 27R defined on center line 106R correspond to inner edge portion 26P and outer edge portion 27P of blade cross section 21P, respectively.

In the present embodiment, the length between suction surface 25 arranged on the back side of concave portion 41 and center line 106R is larger than the length between the bottom of concave portion 41 formed at pressure surface 24 of blade cross section 21P and center line 106R ($T1 > T2$, $T7 > T8$, $T9 > T10$). The length between pressure surface 24 arranged on the back side of concave portion 42 and center line 106R is larger than the length between the bottom of concave portion 42 formed at suction surface 25 of blade cross section 21P and center line 106R ($T3 > T4$, $T5 > T6$).

With the cross-flow fan in the fourth embodiment of the present invention configured in this manner, the effects described in the first embodiment can be obtained similarly. It is noted that the configuration of the fan blade described in the present embodiment may be applied to the centrifugal fan in the second embodiment and the

various modifications of the fan blade in the third embodiment.

It should be understood that the embodiments disclosed herein are illustrative and non-restrictive in every respect. The scope of the present invention is defined by the claims not by the description above, and is intended to include any modification
5 within the meaning and scope equivalent to the terms of the claims.

INDUSTRIAL APPLICABILITY

The present invention is mainly applied to home electric equipment having an air blowing function, such as an air purifier and an air conditioner.

REFERENCE SIGNS LIST

- 10 10 centrifugal fan; 12, 12A, 12B, 12C impeller; 13, 13A, 13B, 13C, 13p, 13q peripheral frame; 13a, 13b end surface; 14 disk part; 16 boss part; 21 fan blade; 21P, 21Q, 21R blade cross section; 23 blade surface; 24 pressure surface; 25 suction surface; 26, 26P, 26R inner edge portion; 27, 27P, 27R outer edge portion; 28 radially inner blade leading end; 29 radially outer blade leading end; 31 root; 32 leading end; 33, 50
15 straight line; 41, 41s, 42 concave portion; 46, 47, 47s convex portion; 51, 52, 53 central point; 56 thick part; 62, 64, 67, 69 vortex; 100 cross-flow fan; 101 center axis; 106, 106P, 106R center line; 110 center axis; 160 molding die; 162 movable die; 164 stationary die; 166 cavity; 210 air conditioner; 215 blower; 220 indoor unit; 222 casing; 222A cabinet; 222B front panel; 224 intake port; 225 blowing port; 226 air flow
20 channel; 228 air filter; 229 indoor side heat exchanger; 231 horizontal louver; 232 vertical louver; 241 upstream region; 242 downstream region; 246 upstream outside space; 247 inside space; 248 downstream outside space; 251 front wall portion; 252 rear wall portion; 253, 254 protrusion portion; 256 upper guide part; 257 lower guide part; 262 forced vortex; 320 blower; 326 exterior casing; 327 blowing part; 328 drive
25 motor; 329 casing; 329a guide wall; 330 suction part; 331 radially inner space; 332 radially outer space; 340 air purifier; 341 filter; 342 intake port; 343 blowing port; 344 housing; 344a back wall; 344b ceiling wall; 345 duct; 350 blower; 351 drive motor; 352 casing; 352a guide wall; 353 suction part; 354 blowing part.

CLAIMS

1. A fan formed from resin, comprising:

5 a plurality of vane portions provided to be circumferentially spaced apart from each other, each having formed thereon a blade surface including a pressure surface arranged on a rotational direction side of the fan and a suction surface arranged on a back side of said pressure surface; and

a support provided on one ends of said vane portions in the direction of a rotation axis of the fan and connecting said plurality of vane portions to each other,

10 when cut along a plane orthogonal to the rotation axis of the fan, said vane portions each having an inner edge portion at which a center line between said pressure surface and said suction surface crosses a blade leading end on a radially inner side, and an outer edge portion at which the center line crosses a blade leading end on a radially outer side,

15 a fluid flow flowing between said inner edge portion and said outer edge portion being produced on said blade surface with rotation of the fan,

when cut along the plane orthogonal to the rotation axis of the fan, said vane portions each having a blade cross-sectional shape in which a plurality of concave portions are formed in at least one of said pressure surface and said suction surface,

20 said vane portions each being formed to have a blade cross section when cut along the plane orthogonal to the rotation axis of the fan decreasing in area from the one end toward the other end of each of said vane portions in the direction of the rotation axis of the fan,

25 a first blade cross section being obtained when said vane portions are each cut on the one end of each of said vane portions along the plane orthogonal to the rotation axis of the fan, and a second blade cross section being obtained when said vane portions are each cut between the one end and the other end of each of said vane portions along the plane orthogonal to the rotation axis of the fan,

when said second blade cross section is enlarged such that a blade

circumference forming an outer circumference of said second blade cross section is entirely moved outward by an equal distance until the length between said inner edge portion and said outer edge portion becomes equal in said first blade cross section and said second blade cross section, and when said center line of said second blade cross section having been enlarged is superimposed on said first blade cross section such that said inner edge portion and said outer edge portion on said center line corresponds to said inner edge portion and said outer edge portion of said first blade cross section, respectively,

the length between said blade surface arranged on the back side of a bottom of each of said concave portions formed in said first blade cross section and said center line of said second blade cross section being larger than the length between the bottom of each of said concave portions formed in said first blade cross section and said center line of said second blade cross section.

2. A fan formed from resin, comprising:

a plurality of vane portions provided to be circumferentially spaced apart from each other, each having formed thereon a blade surface including a pressure surface on a rotational direction side of the fan and a suction surface arranged on a back side of said pressure surface; and

a support provided on one ends of said vane portions in the direction of a rotation axis of the fan and connecting said plurality of vane portions to each other,

when cut along a plane orthogonal to the rotation axis of the fan, said vane portions each having an inner edge portion at which a center line between said pressure surface and said suction surface crosses a blade leading end on a radially inner side, and an outer edge portion at which the center line crosses a blade leading end on a radially outer side,

a fluid flow flowing between said inner edge portion and said outer edge portion being produced on said blade surface with rotation of the fan,

when cut along the plane orthogonal to the rotation axis of the fan, said vane

portions each having a blade cross-sectional shape in which a plurality of concave portions are formed in at least one of said pressure surface and said suction surface,

5 said vane portions each being formed to have a blade cross section when cut along the plane orthogonal to the rotation axis of the fan decreasing in area from the one end toward the other end of each of said vane portions in the direction of the rotation axis of the fan,

a first blade cross section being obtained when said vane portions are each cut on the one end of each of said vane portions along the plane orthogonal to the rotation axis of the fan, and a second blade cross section being obtained when said vane
10 portions are each cut between the one end and the other end of each of said vane portions along the plane orthogonal to the rotation axis of the fan,

when said second blade cross section is enlarged such that said second blade cross section before enlargement and said second blade cross section after enlargement have a similarity relation until the length between said inner edge portion and said outer edge portion becomes equal in said first blade cross section and said second blade cross
15 section, and when said center line of said second blade cross section after enlargement is superimposed on said first blade cross section such that said inner edge portion and said outer edge portion on said center line corresponds to said inner edge portion and said outer edge portion of said first blade cross section, respectively,

20 the length between said blade surface arranged on the back side of a bottom of each of said concave portions formed in said first blade cross section and said center line of said second blade cross section being larger than the length between the bottom of each of said concave portions formed in said first blade cross section and said center line of said second blade cross section.

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3. The fan according to claim 1 or 2, wherein

said vane portions each have a blade cross-sectional shape in which the concave portions formed at either one of said pressure surface and said suction surface form convex portions at the other one of said pressure surface and said suction surface, and

the length between the top of each of said convex portions arranged on the back side of the bottom of each of said concave portions formed in said first blade cross section and said center line of said second blade cross section is larger than the length between the bottom of each of said concave portions formed in said first blade cross section and said center line of said second blade cross section.

4. The fan according to claim 3, wherein said convex portions formed in said first blade cross section form said blade surface with a curvature larger than that of said convex portions formed in said second blade cross section in correspondence with the convex portions formed in said first blade cross section, respectively.

5. The fan according to any one of claims 1 to 4, wherein said vane portions are each formed to have a blade cross section when cut along the plane orthogonal to the rotation axis of the fan being displaced in the rotational direction of the fan between the one end and the other end of each of said vane portions in the direction of the rotation axis of the fan.

6. The fan according to any one of claims 1 to 5, wherein an inside space is formed on the inner side of said plurality of vane portions arranged circumferentially, and an outside space is formed on the outer side thereof, and

the fan is a cross-flow fan taking in a fluid from said outside space on one side with respect to the rotation axis into said inside space and sending out the fluid having been taken in to said outside space on the other side with respect to the rotation axis, as seen from the direction of the rotation axis of the fan.

7. The fan according to any one of claims 1 to 5, wherein an inside space is formed on the inner side of said plurality of vane portions arranged circumferentially, and an outside space is formed on the outer side thereof, and

the fan is a centrifugal fan sending out a fluid from said inside space to said

outside space.

8. A molding die used for molding the fan as defined in any one of claims 1 to 7.

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9. A fluid feeder comprising a blower including the fan as defined in any one of claims 1 to 7 and a drive motor coupled to said fan and rotating said plurality of vane portions.