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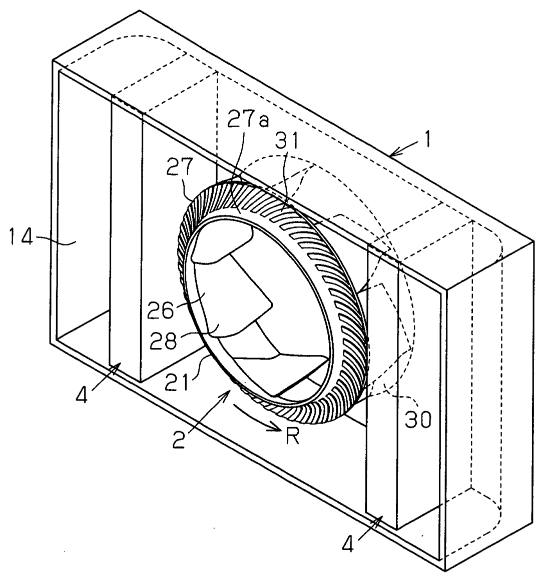
(54) ## CENTRIFUGAL FAN AND AIR CONDITIONER USING THE SAME

(57) The present invention provides a centrifugal fan by which air velocity distribution in the height direction of impellers at a fan blow-out port is made uniform and running noise is reduced, and an air conditioner whose running noise is reduced by applying the centrifugal fan thereto. The centrifugal fan is provided with a hub for fixing the rotary shaft of a motor, a main plate formed on the outer circumference of the hub, a shroud disposed to be opposed to the main plate, which forms an air passage, a plurality of impellers disposed between the main plate and the shroud, and a bellmouth disposed at the suction side of the shroud. Projections or recesses are formed on the surface of the shroud facing the bellmouth, which projections or recesses form air streams flowing from the center of the shroud toward the outer circumference thereof along the surface when running a fan. The air conditioner has a thus constructed centrifugal fan mounted therein.

Fig.3



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Description

TECHNICAL FIELD

[0001] The present invention relates to a centrifugal fan and an air conditioner using the same, in particular to a technology to reduce noise of the centrifugal fan and air conditioner using the same.

BACKGROUND ART

[0002] Generally, a centrifugal fan has been frequently employed for an air conditioner because it is highly efficient and low in noise level. Also, a ceiling built-in type air conditioner has been frequently utilized in recent years for commercial use, and a wall type air conditioner has been frequently utilized in households. In any of these air conditioners, there are many cases where such a construction is employed in which a heat exchanger is disposed at the blow-out side of a centrifugal fan to reduce the size.

[0003] Thus, in the construction in which a heat exchanger is disposed at the blow-out side of a centrifugal fan, there are many cases where the length of the impellers in the axial direction, that is, the height of the impellers is increased in compliance with the size of a heat exchanger in order to make uniform the air velocity distribution of the heat exchanger.

[0004] However, in a typical centrifugal fan, a separated flow is brought about in the vicinity of the fan blow-out port on the surface of the shroud facing the main plate. The separated flow generates noise, and at the same time, the air velocity distribution of air streams at the fan blow-out port is biased with respect to the main plate. Further, in an air conditioner in which a heat exchanger is disposed at the blow-out side of a centrifugal fan, the air velocity distribution is made uneven in the heat exchanger, resulting from the air velocity distribution of air streams at the fan blow-out port being biased with respect to the main plate. This lowers the heat exchange efficiency of the heat exchanger, and increases the airflow resistance of the heat exchanger. As a result, power required to rotate the fan is accordingly increased, and at the same time, the energy efficiency is lowered.

[0005] A description is given of the separated flow with reference to Figs. 10 and 11. Fig. 10 is a perspective view showing the appearance of impellers of a turbo fan as a prior art centrifugal fan, and Fig. 11 is a longitudinal cross-sectional view showing a part of the same turbo fan. As shown in these drawings, the turbo fan includes a hub 101 that fixes the rotary shaft of a motor, a main plate 102 integrally formed on the outer circumference of the hub 101, a shroud 104 opposed to the main plate 102, which forms an air passage 103, a plurality of impellers 105 disposed between the main plate 102 and the shroud 104, and a bellmouth 106 disposed at the suction side of the shroud 104. The hub 101, main plate 102, shroud 104 and impellers 105 compose an impeller wheel of the turbo fan. The impeller wheel rotates in the direction of arrow R shown in Fig. 10. The bellmouth 106 is attached to a member, for example, a casing, which composes an air conditioner in which the turbo fan is used. A fan suction port 107 is formed at the central part of the bellmouth 106, and the portion corresponding to the outer circumference of the shroud 104 in the air passage 103 composes a fan blow-out port 108.

[0006] In the turbo fan having such a construction, a part of air streams blown out from the fan blow-out port 108 is brought in the suction port 104a of the shroud 104 along the surface of the bellmouth 106. The part of the air streams forms circulation air streams that are drawn in the impellers of the turbo fan through clearance 109 between the bellmouth 106 and the shroud 104, and are blown out again through the blow-out port 108 of the fan. Since a change in shape of the surface 104b of the shroud 104 facing the main plate 102 from the suction port 104a to the fan blow-out port 108 is radical, a separate flow E is formed in the vicinity of the fan blow-out port 108. Therefore, there is a problem that noise occurs due to the separated flow E as described above, and the air velocity distribution at the fan blow-out port 108 is biased with respect to the main plate 102.

[0007] In order to solve such problems, a turbo fan described in Patent Document 1 has been proposed. The basic construction of the turbo fan is the same as that of the turbo fan shown in Figs. 10 and 11. However, the shape of the impellers is devised as described below. That is, in the impellers of the turbo fan described in Patent Document 1, the position of the coupling portion with the shroud at the rear edge part is offset from the coupling portion with the main plate by a predetermined amount in a direction opposite to the rotation direction. The positive pressure surface of the shroud side blade element is formed to protrude, and at the same time, the maximum warping position of the camber line of the shroud side blade element is located at the front edge part from the intermediate position of the chord length. Further, the impeller inlet angle at the shroud side is formed to be at the same angle as that in the case where the camber line of the shroud side blade element is made into a simple arc camber line. Also, the camber line of the main plate side blade element has a simple arcuate shape. Therefore, the impeller outlet angle at the shroud side becomes large, wherein the impeller outlet angle at the shroud side is closer to the impeller outlet angle at the main plate side.

[0008] The turbo fan according to Patent Document 1 is constructed as described above, so that the separated flow is suppressed by applying a force in the shroud direction to air streams that are flown from the front edge part of the impellers and flow toward the rear edge part of the impellers. In addition, the turbo fan is designed to make uniform the air velocity distribution in the height direction of impellers at the fan blow-out port by making the impeller outlet angle at the shroud side closer to the impeller outlet angle at the main plate side.

Patent Document 1: Japanese Laid-Open Patent Publication No. 5-312189

DISCLOSURE OF THE INVENTION

[0009] However, the turbo fan according to Patent Document 1 cannot sufficiently prevent separated flows generated in the vicinity of the fan blow-out port on the surface of the shroud facing the main plate. For this reason, noise resulting from the separated flows cannot be sufficiently prevented from occurring. Also, the air velocity distribution in the height direction of the impellers at the fan blow-out port is biased to the main plate. Further, in an air conditioner having a turbo fan according to Patent Document 1 mounted therein, there is still a problem in that running noise in the air conditioner employing the turbo fan according to Patent Document 1 is still great. In an air conditioner in which a turbo fan according to Patent Document 1 is used and at the same time, a heat exchanger is disposed at the fan blow-out side, the air velocity distribution becomes uneven in the heat exchanger. For this reason, the airflow resistance of the heat exchanger is increased, wherein power necessary to rotate the fan is accordingly increased, and the heat exchange efficiency of the heat exchanger is lowered. As a result, there is still another problem in that the energy efficiency of the air conditioner is lowered. Thus, even in the turbo fan according to Patent Document 1, it is necessary to further improve the air velocity distribution in the height direction of the impellers at the fan blow-out port. In addition, having a special shape, the impellers of the turbo fan according to Patent Document 1 are not applicable to a centrifugal fan of a general air conditioner. Therefore, an improvement has been desired, by which the turbo fan is applicable to the centrifugal fan of general air conditioners.

[0010] Accordingly, it is an objective of the present invention to provide a centrifugal fan having a novel construction applicable to general air conditioners, which centrifugal fan is capable of making uniform air velocity distribution in the height direction of the impellers at the blow-out port of the centrifugal fan by suppressing separated flows generated in the vicinity of the fan blow-out port on the surface of a shroud facing the main plate, and capable of reducing running noise of the centrifugal fan. Also, it is another objective of the present invention to provide an air conditioner capable of reducing running noise by using a thus constructed centrifugal fan, in an air conditioner having a centrifugal fan mounted therein.

[0011] In accordance with one aspect of the present invention, a centrifugal fan is provided, which includes a hub for fixing a rotary shaft of a motor, a main plate formed at an outer circumference of the hub, a shroud opposed to the main plate, which forms air passages, a plurality of impellers disposed between the main plate and the shroud, and a bellmouth disposed at the suction side of the shroud. A plurality of projections or recesses, which form air streams from a center of the shroud toward an outer circumference of the shroud along the surface of the shroud when running the fan, are formed on the surface of the shroud facing the bellmouth.

[0012] According to this construction, air streams flowing from the center of the shroud toward the outer circumference thereof along the surface are created by the projections or recesses formed on the surface of the shroud facing the bellmouth. In a space between the bellmouth and the surface of the shroud facing the bellmouth, the air streams are developed to circulation streams from outer circumference of the shroud to the center of the shroud via the surface of the outer circumferential wall of the bellmouth, and then from the center of the shroud to the outer circumference of the shroud. Therefore, a part of air streams blown out from the fan blow-out port is drawn in and circulated by the circulation streams. Since a part of the thus circulating air flows from the clearance between the hub and the shroud toward the fan blow-out port along the surface of the shroud facing the main plate, air streams along the surface of the shroud facing the main plate are increased. As a result, separated flows brought about in the vicinity of the fan blow-out port on the surface of the shroud facing the main plate are prevented from occurring, and running noise of the centrifugal fan is lowered. At the same time, the air velocity distribution in the height direction of the impellers at the fan blow-out port are made uniform.

[0013] It is preferable that a plurality of rib-shaped projections which form air streams from the center of the shroud toward the outer circumference of the shroud along the surface when running the fan are formed on the surface of the shroud facing the bellmouth. With such a construction, it is easy to allow the rib-shaped projections to act just like the impellers, and, in comparison with a case where a recessed portion having grooves on the surface of the shroud facing the bellmouth are formed, circulation air streams from the center of the shroud toward the outer circumference thereof are further easily generated.

[0014] It is preferable that the rib-shaped projections on the surface of the shroud facing the bellmouth have substantially the same inclination as that of the camber line of the shroud side blade element of the impellers, and at the same time, the rib-shaped projections are formed at even intervals on the entire circumference of the surface of the shroud facing the bellmouth. With such a construction, the direction of air streams, on the outer circumferential portion of the shroud, of circulation air streams formed on the surface of the shroud facing the bellmouth is the same as with the direction of air streams blown out from the fan blow-out port. Therefore, the amount of air that is drawn in from air streams blown out from the fan blow-out port by circulation air streams on the surface of the shroud facing the bellmouth is increased. As a result, the air streams from the suction port of the shroud toward the fan blow-out port along the surface of the shroud facing the main plate are increased, and separated flows is prevented from occurring in the vicinity of the fan blow-out port on the surface of the shroud facing the main plate.

[0015] It is preferable that the pitch of rib-shaped projections on the surface of the shroud facing the bellmouth is smaller than the pitch of the impellers. With such a construction, it is possible to efficiently generate circulation streams in the spacing between the surface of the shroud facing the bellmouth and the bellmouth.

[0016] It is also preferable that the height of the rib-shaped projections on the surface of the shroud facing the bellmouth is equivalent to the thickness of a plate that forms the shroud. According to the construction, when the shroud is integrally molded of resin, the amount of fluctuation in the thickness in the entirety of the shroud is reduced, and molding of the shroud is facilitated. In addition, the rib-shaped projections of the shroud have appropriate height with respect to small spacing formed between the shroud and the bellmouth. As a result, it is possible to efficiently generate the circulation streams and to efficiently reduce noise.

[0017] It is preferable that the rib-shaped projection of the shroud facing the bellmouth has a front side vertically extending from the surface of the shroud facing the bellmouth and positioned forward in the rotation direction of the impellers, a rear side vertically extending from the surface of the shroud facing the bellmouth and at the same time, positioned rearward in the rotation direction of the impellers, and a distal end face for connecting both sides together. In this case, the distal end face is connected to the front side so that they are substantially orthogonal to each other, and the rear side is curved to the front side toward the distal end.

[0018] According to the construction, since the front side that functions as the positive pressure side vertically extends to the distal end, it is possible to maintain the generation capacity of air streams advancing from the center of the surface of the shroud facing the bellmouth toward the outer circumference thereof at a high level. Also, since the rear side that functions as the negative pressure side is curved to the front side toward the distal end, air is easily brought in the negative pressure side, and it is possible to prevent eddies from occurring at the negative pressure side. Resultantly, air streams from the center on the surface of the shroud facing the bellmouth toward the outer circumference are further efficiently generated, and it is possible to prevent noise from occurring due to eddies at the negative pressure side.

[0019] Another aspect of the present invention provides an air conditioner having the above-described centrifugal fan mounted therein. With such a construction, noise of the air conditioner is reduced since the running noise of the centrifugal fan is reduced.

[0020] It is preferable that an air suction port for drawing in indoor air is formed at the front side of the fan suction port of the centrifugal fan. In this case, a heat exchanger is disposed at the blow-out side of the centrifugal fan. An air blow-out port for blowing air indoors is disposed downstream of the heat exchanger. With such a construction, a preferred construction is provided for reducing the size of the air conditioner. In addition, the air velocity distribution in the height direction of the impellers at the blow-out port of the centrifugal fan is made uniform, and the air velocity distribution of the heat exchanger is improved. As a result, the heat exchange efficiency of the heat exchanger is improved. At the same time, resistance in the air conditioner is reduced, and the energy efficiency of the air conditioner is further improved.

[0021] It is preferable that the centrifugal fan is a turbo fan. With such a construction, the fan efficiency is improved. At the same time, the running noise is further suppressed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022]

Fig. 1 is a perspective view showing the appearance of an air conditioner according to one embodiment of the present invention;

Fig. 2 is a plan cross-sectional view showing the air conditioner;

Fig. 3 is a perspective view showing a state where the front side of the air conditioner is opened;

Fig. 4 is a perspective view showing an impeller wheel that composes a turbo fan of the air conditioner;

Fig. 5 is an enlarged perspective view showing a part of the impeller wheel with a part thereof enlarged;

Fig. 6 is an enlarged longitudinal cross-sectional view showing a part of a turbo fan;

Fig. 7 is an enlarged cross-sectional view showing rib-shaped projections at the impeller wheel;

Fig. 8 is a cross-sectional view showing a modification of rib-shaped projections;

Fig. 9 is a perspective view showing a heat exchanger in an air conditioner;

Fig. 10 is a perspective view showing the impeller wheel in a prior art turbo fan; and

Fig. 11 is a longitudinal cross-sectional view showing a part of the turbo fan.

BEST MODE FOR CARRYING OUT THE INVENTION

[0023] Hereinafter, a description is given of a centrifugal fan and an air conditioner having the centrifugal fan according to one embodiment of the present invention with reference to the accompanying drawings.

[0024] An air conditioner according to the present embodiment is an indoor unit for a wall type air conditioner, and has a laterally long box shape as shown in the perspective view of Fig. 1. The indoor unit is formed, as shown in the plan cross-sectional view of Fig. 2, so that the thickness direction (the vertical direction in Fig. 2) becomes smaller. A turbo fan 2 operating as an indoor fan and heat exchangers 4 for cooling or heating indoor air are accommodated in a main body casing 1.

[0025] The main body casing 1 is provided with a front plate 11 at the front side of the main body casing 1 as shown in the perspective view of Fig. 1. The front plate 11 is provided with an air suction port 12 for drawing in air at the middle part thereof, and is provided with air blow-out ports 13 for blowing out air which has been subjected to heat exchange by the heat exchangers 4. As shown in the plan cross-sectional view of Fig. 2 and the perspective view of Fig. 3, a turbo fan 2 is disposed at the middle part in the interior of the main body casing 1, and the heat exchangers 4 are disposed at both sides. The turbo fan 2 is disposed so that air drawn in through the air suction port 12 is blown out sideways of the turbo fan 2. Each heat exchanger 4 is disposed at a blow-out side of the turbo fan 2. An air passage 14 is formed in the main body casing 1 so that air drawn in by the turbo fan 2 is blown out indoors through the air blow-out ports 13 after being subjected to heat-exchange by the heat exchangers 4.

[0026] The turbo fan 2 includes an impeller wheel 21, a bellmouth 22 for guiding air into the impeller wheel 21, and a motor 23 for driving the impeller wheel 21 as shown in Fig. 2. The rotary shaft of the impeller wheel 21, that is, the rotary shaft 23a of the motor 23 is disposed at the middle part in the main body casing 1 so as to extend in the thickness direction of the main body casing 1. The bellmouth 22 is disposed at the position corresponding to the air suction port 12. A low-profile motor, for example, a print motor is used as the motor 23, which is fixed at the position corresponding to the impeller wheel 21 on the backside of the main body casing 1.

[0027] The impeller wheel 21 is composed, as shown in Figs. 2 to 6, of a hub 24 for fixing the rotary shaft 23a of the motor 23, a main plate 25 integrally formed on the outer circumference of the hub 24, a shroud 27 that is opposed to the main plate 25 and forms an air passage 26, and six impellers 28 that are disposed between the main plate 25 and the shroud 27. Fig. 4 is a perspective view showing the appearance of the impeller wheel 21. Fig. 5 is a enlarged perspective view showing the appearance of a part of the impeller wheel, and Fig. 6 is a longitudinal cross-sectional view showing a part of the turbo fan 2. Arrows R shown in Figs. 3 to 5, 7 and 8 described below show the rotation direction of the impeller wheel 21. A fan suction port 29 is formed at the middle part of the bellmouth 22. The bellmouth 22 functions as a partitioning wall that sections the suction side of the heat exchanger 4, cooperating with the front plate 11, as shown in Fig. 2. The part corresponding to the outer circumference of the shroud 27 in the air passage 26, that is, the rear edge part of the impellers 28 composes a fan blow-out port 30.

[0028] The construction of the impellers 28 is similar to that of the impellers described in Patent Document 1 described above. That is, at the impeller 28, the position of the coupling portion with the shroud 27 at the rear edge part thereof is offset by a predetermined amount in a direction opposite to the rotation direction from the position of the coupling portion with the main plate 25. Also, the positive pressure side of the shroud side blade element is formed to project, and the maximum warping position of the camber line of the shroud side blade element is positioned closer to the front edge than an intermediate position of the chord length. Furthermore, the impeller inlet angle at the shroud side is formed to be the same as that in the case where the camber line of the shroud side blade element is made into a simple arc camber line. At the same time, the camber line of the main plate side blade element has a simple arc shape.

[0029] As shown in Figs. 3 to 6, a plurality of rib-shaped projections 31 that form air streams from the center of the shroud 27 toward the outer circumference thereof along the surface 27a when running the fan are formed on the surface 27a of the shroud 27 facing the bellmouth 22. These rib-shaped projections 31 are formed so as to have substantially the same inclination as the camber line of the shroud side blade element of the impellers 28, and are formed at even intervals on the entire circumference of the surface 27a of the shroud 27. The pitch of the rib-shaped projections 31 is formed to be small at approximately one-tenth of the pitch of the respective impellers 28. The height of the rib-shaped projections 31 is equivalent to the thickness of a plate that forms the shroud 27, which is formed to be at 1 mm or so. As shown in Fig. 7, each rib-shaped projection 31 includes a front side 32 located forward of the rotation direction of the impellers 21, a rear side 33 located rearward thereof, and a distal end face 34 that connects the front side 32 and the rear side 33 to each other. The respective sides 32 and 33 vertically extend from the surface 27a of the shroud 27. The front side 32 and the distal end face 34 are coupled so as to be orthogonal to each other. The rear side 33 is curved to the front side 32 toward the distal end.

[0030] The heat exchangers 4 are separated and disposed substantially symmetrically with respect to the turbo fan 2 as shown in Fig. 2. As shown in the perspective view of Fig. 9, both heat exchangers 4 thus separated and disposed are connected to each other by refrigerant pipes 41 disposed in the space at the bottom of the main body casing 1, and are composed so as to operate integrally with each other. As shown in Fig. 9, in each heat exchanger 4, six rows of flat tubes 44 are disposed between the front plate 42 and the rear plate 43 so that they extend in the thickness direction of the main body casing 1 and are disposed parallel to each other. Corrugated fins 45 intervene between these flat tubes 44, and between the flat tubes 44 and the front plate 42 or the rear plate 43. The flat tubes 44 and corrugated fins 45 are connected to each other by, for example, brazing.

[0031] The air conditioner constructed as described above and the turbo fan mounted in the air conditioner operate as follows. As operation of the air conditioner is commenced, and the turbo fan 2 is also run, indoor air is drawn in through the air suction port 12. The indoor air is taken from the fan suction port 29 and is brought into the air passage 26 of the turbo fan 2, and is then blown out from the fan blow-out port 30 by the pressure thereof increased by the impellers 28. Air blown out from the fan blow-out port 30 is subjected to heat exchange by respective heat exchangers 4, and is blown out indoors through the air blow-out ports 13.

[0032] As shown in Figs. 5 and 6, the rib-shaped projections 31 formed on the surface 27a of the shroud 27 operate like impellers in the turbo fan 2, and air stream S1 flowing from the center of the shroud 27 toward the outer circumference thereof along the surface 27a is created. In the space between the surface 27a of the shroud 27 and the bellmouth 22, the air stream S1 is developed to a circulation air stream S2 from the outer circumference of the shroud 27 to the center of the shroud 27 via the surface of the outer circumferential wall of the bellmouth 22, and then from the center of the shroud 27 to the outer circumference of the shroud 27. Therefore, air stream S4 that is a part of the air stream S3 blown out from the fan blow-out port 30 is drawn in and circulated by the circulation air stream S2. The air stream S4 that is a part of the thus circulating air flows from the clearance 35 between the hub 24 and the shroud 27 toward the fan blow-out port 30 along the surface 27b of the shroud 27 facing the main plate 25. Accordingly, an air stream S5 along the surface 27b of the shroud 27 is increased. As a result, separated flows E are prevented from occurring in the vicinity of the fan blow-out port 30 on the surface 27b of the shroud 27, running noise of the turbo fan 2 is reduced, and at the same time, the air velocity distribution in the height direction of the impellers at the fan blow-out port 30 is made even.

[0033] The rib-shaped projections 31 are formed so as to have substantially the same inclination as that of the camber line of the shroud side blade element of the impellers 28. Therefore, the air stream direction of air streams S1 flowing along the surface 27a of the shroud 27 on the outer circumferential portion of the shroud 27 is the same as the direction of the air streams S3 discharged from the fan blow-out port 30. Thus, since the direction of the air streams S1 is the same as the direction the air streams S3, the amount of the air streams S4 drawn in from the air streams S3 discharged from the fan blow-out port 30 by the circulation air streams S2 on the surface 27a of the shroud 27 is increased. As a result, the air streams S5 flowing from the suction port of the shroud 27 toward the fan blow-out port 30 along the surface 27b of the shroud 27 is increased, and the separated flows E is more reliably prevented from occurring in the vicinity of the fan blow-out port 30 on the surface 27b of the shroud 27.

[0034] The rib-shaped projections 31 are formed so that the pitch thereof is made remarkably smaller than the pitch of the impellers 28. Accordingly, it is possible to efficiently generate circulation air streams S2 in small spacing between the surface 27a of the shroud 27 and the bellmouth 22.

[0035] The height of the rib-shaped projections 31 is made equivalent to the thickness of the plate that forms the shroud 27. For this reason, when the entirety of the shroud 27 is integrally made of resin, the fluctuation amount of the thickness at the entire shroud 27 can be made low, so that molding of the shroud 27 is facilitated. In addition, the rib-shaped projection 31 has an appropriate height with respect to small spacing formed between the shroud 27 and the bellmouth 22, so that the above-described circulation air streams S2 is efficiently generated, and noise is efficiently reduced.

[0036] Since in the rib-shaped projections 31, as shown in Fig. 7, the front side 32 located at the positive pressure side vertically extends to the distal end face 34, it is possible to maintain a high generation performance of air streams S1 flowing from the center at the surface 27a of the shroud 27 toward the outer circumference thereof. Further, the distal end portion of the rear side 33 located at the negative pressure side is formed to be like a circular arc. Accordingly, air is further easily brought in the negative pressure side, so that it is possible to prevent eddies F from occurring at the negative pressure side. As a result, air streams flowing from the center on the surface 27a of the shroud 27 toward the outer circumference are further efficiently generated, so that noise due to eddies occurring at the negative pressure side is suppressed.

[0037] In the turbo fan 2 according to the present embodiment, the position of the coupling portion with the shroud 27 at the rear edge part of the impellers 28 is offset by a predetermined amount in the direction opposite to the rotation direction from the position of the coupling portion with the main plate 25 as in the turbo fan according to Patent document 1 described above. Accordingly, air streams flowing in from the front edge part of the impellers 28 and flowing to the rear edge part of the impellers 28 receive a force in the direction toward the shroud 27. The separated flows E are thus prevented based on this point. Also, the positive pressure side of the shroud side blade element is formed like a projection, and at the same time, the maximum warping position of the camber line of the shroud side blade element is located closer to the front edge than an intermediate position of the chord length. Further, the impeller inlet angle at the shroud side is formed at the same angle as in the case where the camber line of the shroud side impeller element is made into a simple arc camber line, and the camber line of the main plate side blade element has a simple arc shape. Therefore, the impeller outlet angle at the shroud side is increased, and the impeller outlet angle at the shroud side is drawn near the impeller outlet angle at the main plate side. With such a construction, the air velocity distribution in the height direction of the impellers 28 at the fan blow-out port 30 is made uniform.

[0038] An air conditioner according to the present embodiment reduces running noise as an air conditioner since the running noise of the turbo fan 2 is reduced.

[0039] The air conditioner includes an air suction port 12, which draws in indoor air, at the front side of the fan suction port 29 of the turbo fan 2. The heat exchangers 4 are disposed at the blow-out sides of the turbo fan 2, and the air blow-out ports 13 that blow out air into indoors are disposed downstream of the heat exchanger 4. Accordingly, since the dimension of each heat exchanger 4 in the thickness direction of the main body casing 1 is reduced, the outer dimension of the air conditioner in its thickness direction is reduced. The air velocity distribution in the height direction of the impellers at the fan blow-out port 30 of the turbo fan 2 is made uniform, so that the air velocity distribution of the heat exchangers 4 is improved. As a result, the heat exchange efficiency of the heat exchangers 4 is improved, and at the same time, the resistance inside the air conditioner is reduced, so that the energy efficiency of the air conditioner is improved.

[0040] In the air conditioner, the turbo fan 2 is used as an indoor fan. For this reason, the fan efficiency is further improved than in cases where other centrifugal fans are used, and the running noise is further suppressed.

[0041] The present embodiment may be modified as follows.

(1) In the illustrated embodiment, the impellers 28 have a construction similar to that of the impellers described in Patent Document 1 described above, but are not limited thereto. For example, the impellers 28 may have a two-dimensional shape in which the front edge part of the impellers 28 and the rear edge part thereof are orthogonal to the main plate 25 and the shroud 27, respectively, as has been introduced as prior art in Patent Document 1. The present invention may be applicable to this case.

(2) A description has been given of a lowering in noise of the turbo fan 2 in the present embodiment. However, a problem similar to the above exists in other centrifugal fans such as a sirocco fan, a radial fan, etc. And, the rib-shaped projections 31 may be provided on the surface 27a of the shroud 27 as in the illustrated embodiment. In this case, operations and advantages similar to those of the illustrated embodiment are obtained.

(3) Instead of the rib-shaped projections 31 including the cases of the present embodiment and the modifications (1) and (2) described above, impeller-shaped projections that form air streams S1 or recesses such as grooves may be formed on the surface 27a of the shroud 27. However, although the recesses may be easily formed by machining, it is impossible to form deep grooves due to a restriction regarding the plate thickness of the shroud 27. Also, changes in the air streams are further increased in comparison with the case of the rib-shaped projections 31, so that it is difficult to efficiently generate air streams S1 from the center of the shroud 27 to the outer circumference thereof along the surface 27a of the shroud 27.

(4) As shown in Fig. 8, in the rib-shaped projections 31, the distal end face 34 and the front side (positive pressure side) 32 may be coupled so as to be substantially orthogonal to each other, and the distal end face 34 and the rear side (negative pressure side) 33 may be coupled so as to be substantially orthogonal to each other. However, in this case, it becomes difficult for air to be brought in the rear side (negative pressure side) 33, so that eddies F are enlarged, and the effect to reduce noise and the effect to make air velocity distribution uniform at the fan blow-out port deteriorate in comparison with the rib-shaped projection 31 in the present embodiment.

(5) The height of the rib-shaped projection 31 is approximately 1 mm in the illustrated embodiment, but it is not limited thereto. The height of the rib-shaped projection 31 may be appropriately changed in compliance with, for example, the diameter of the impellers of the turbo fan 2 or the size of spacing formed between the shroud 27 and the bellmouth 22. However, if the height of the rib-shaped projection 31 is excessively high with respect to the size of spacing formed between the shroud 27 and the bellmouth 22, eddies that occur around the rib-shaped projection 31 are enlarged and spoil the effect to reduce noise.

(6) A description has been given of a wall-type air conditioner in the illustrated embodiment. However, the air conditioner is not limited thereto. The present invention may be applicable to an air conditioner having a type other than the type of the air conditioner according to the present embodiment. The present invention is preferable to, for example, a compact ceiling built-in type air conditioner. Also, a heat exchanger having a type other than the type according to the present embodiment, for example, a cross fin coil type heat exchanger may be used as the heat exchanger 4 provided at the blow-out side of the turbo fan 2 functioning as a centrifugal fan. The air conditioner is not limited to a construction in which a heat exchanger is disposed at the blow-out side of the turbo fan 2 functioning as a centrifugal fan. That is, a centrifugal fan according to the present invention may be applicable to an air conditioner in which the heat exchanger 4 is disposed at the suction side of the turbo fan 2.

INDUSTRIAL APPLICABILITY

[0042] A centrifugal fan according to the present invention may be applicable to a general centrifugal fan such as a turbo fan, a sirocco fan, a radial fan, etc. In addition, an air conditioner having the centrifugal fan mounted therein is applicable to various types of air conditioners for household and commercial use.

Claims

1. A centrifugal fan including a hub for fixing a rotary shaft of a motor, a main plate formed on an outer circumference of the hub, a shroud disposed to be opposed to the main plate, which shroud forms an air passage, a plurality of impellers disposed between the main plate and the shroud, and a bellmouth disposed at a suction side of the shroud, the centrifugal being **characterized in that** a plurality of projections or recesses are formed on a surface of the shroud facing the bellmouth, the projections or recesses forming air streams flowing from a center of the shroud toward an outer circumference of the shroud along the surface when the fan is operated.

2. The centrifugal fan according to claim 1, **characterized in that** a plurality of rib-shaped projections are formed on the surface of the shroud facing the bellmouth, which rib-shaped projections form air streams flowing from the center of the shroud toward the outer circumference of the shroud along the surface when the fan is operated.

3. The centrifugal fan according to claim 2, **characterized in that** the rib-shaped projections on the surface of the shroud facing the bellmouth have substantially the same inclination as that of the camber line of the shroud side blade element of the impellers, and are formed at even intervals on the entire circumference of the surface of the shroud facing the bellmouth.

4. The centrifugal fan according to claim 3, **characterized in that** the pitch of the rib-shaped projections on the surface of the shroud facing the bellmouth is smaller than the pitch of the impellers.

5. The centrifugal fan according to claim 4, **characterized in that** the height of the rib-shaped projections on the surface of the shroud facing the bellmouth is equivalent to the thickness of a plate that forms the shroud.

6. The centrifugal fan according to any one of claims 2 to 5, **characterized in that** each of the rib-shaped projections on the surface of the shroud facing the bellmouth includes a front side, a rear side, and a distal end face, wherein the front side vertically extends from the surface of the shroud facing the bellmouth and is located forward in the rotation direction of an impeller wheel, wherein the rear side vertically extends from the surface of the shroud facing the bellmouth and is located rearward in the rotation direction of the impeller wheel, wherein the distal end face connects the front side and the rear side with each other, and wherein the distal end face and the front side are coupled to each other so as to be substantially orthogonal to each other, and the rear side is curved to the front side toward the distal end face.

7. An air conditioner **characterized by** the centrifugal fan according to any one of claims 1 to 6 mounted therein.

8. The air conditioner according to claim 7, **characterized in that** an air suction port that draws in indoor air is formed at the front side of the fan suction port of the centrifugal fan, a heat exchanger is disposed at the blow-out side of the centrifugal fan, and an air blow-out port that blows out air indoors is disposed downstream of the heat exchanger.

9. The air conditioner according to claim 7 or 8, **characterized in that** the centrifugal fan is a turbo fan.

Fig.1

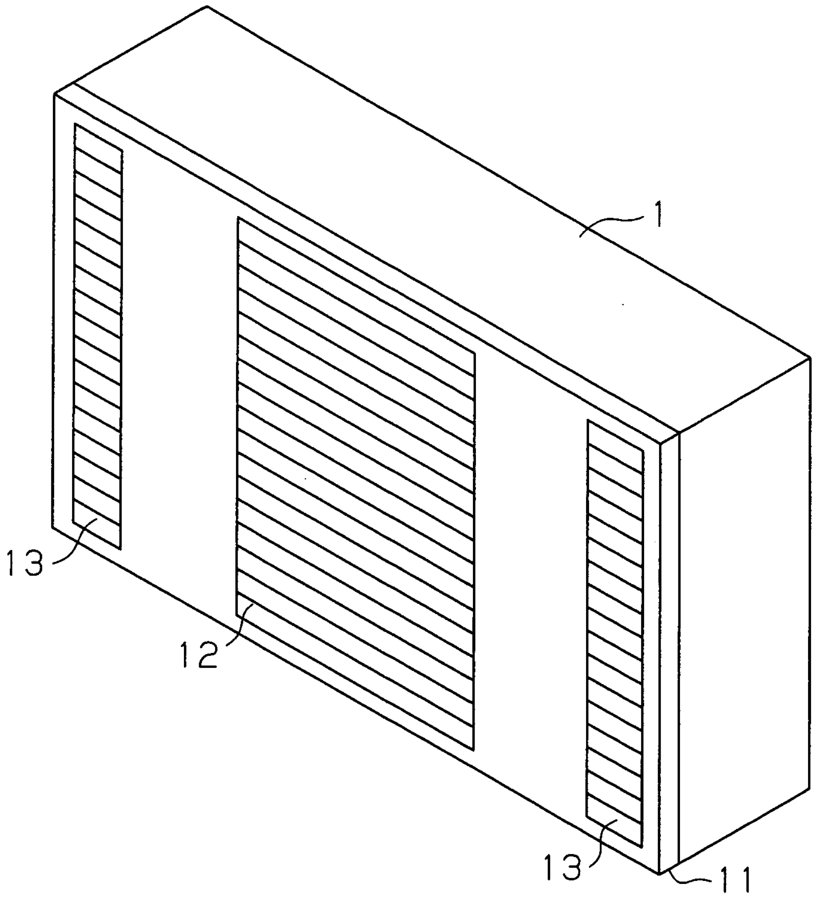

Fig.2

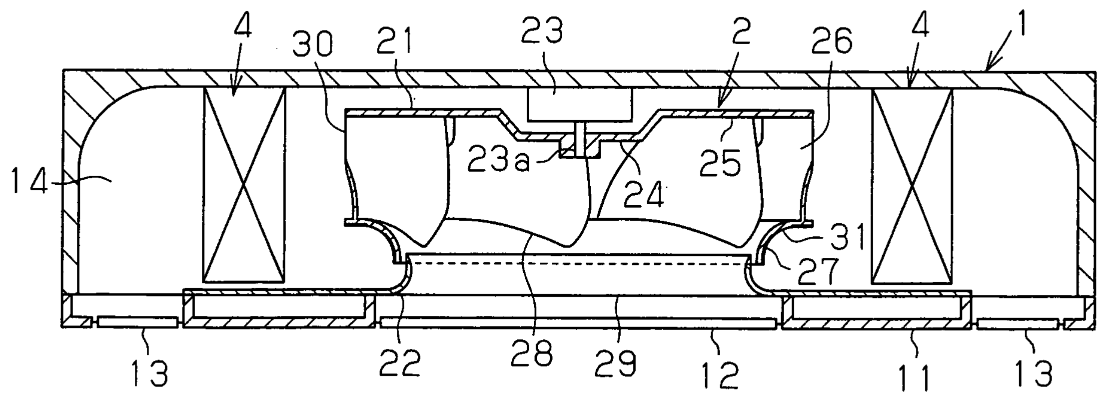

Fig.3

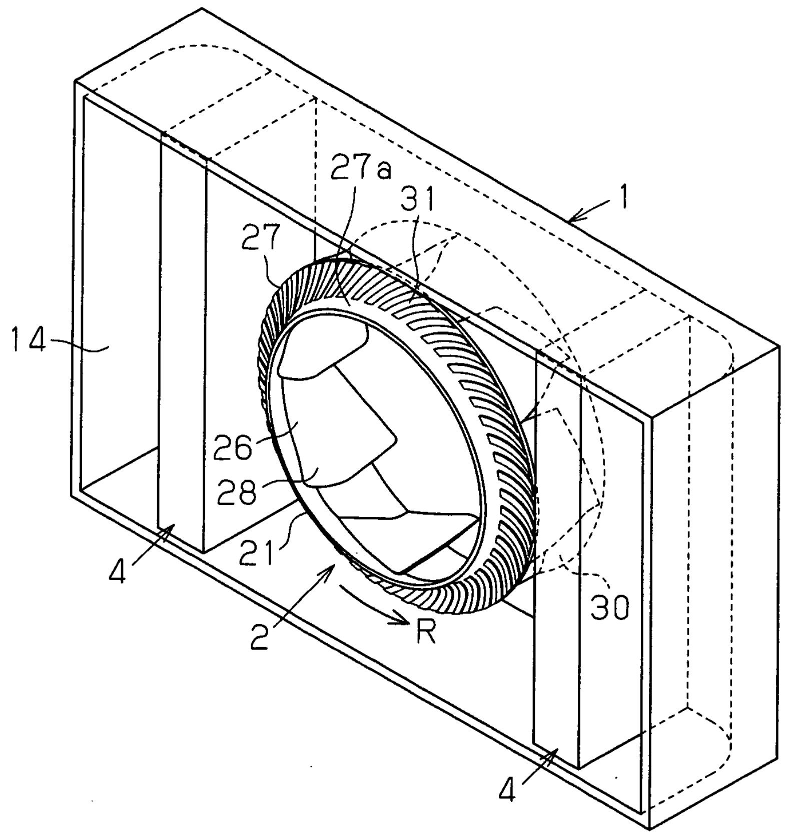

Fig.4

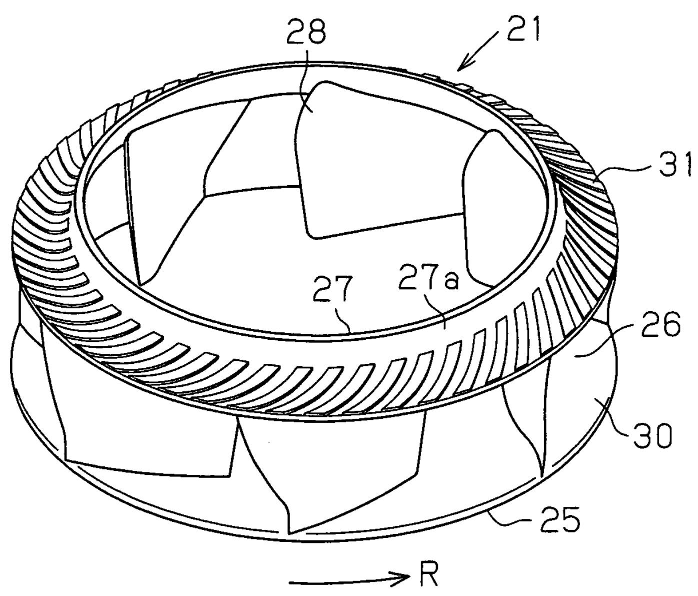

Fig.5

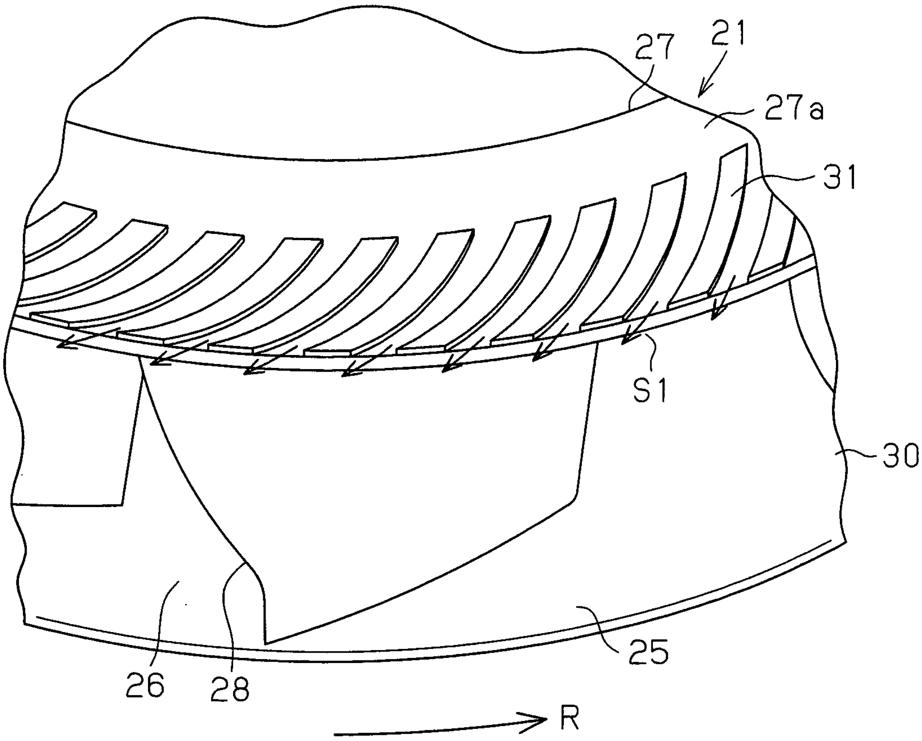
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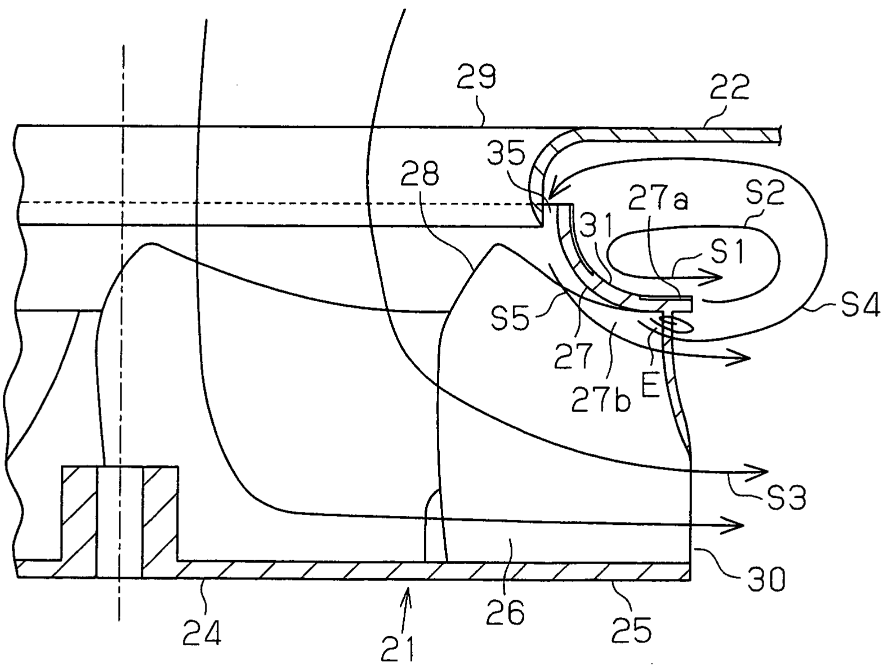
Fig.6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S2
31
S1
S5
S4
27
E
27b
S3
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Fig.7

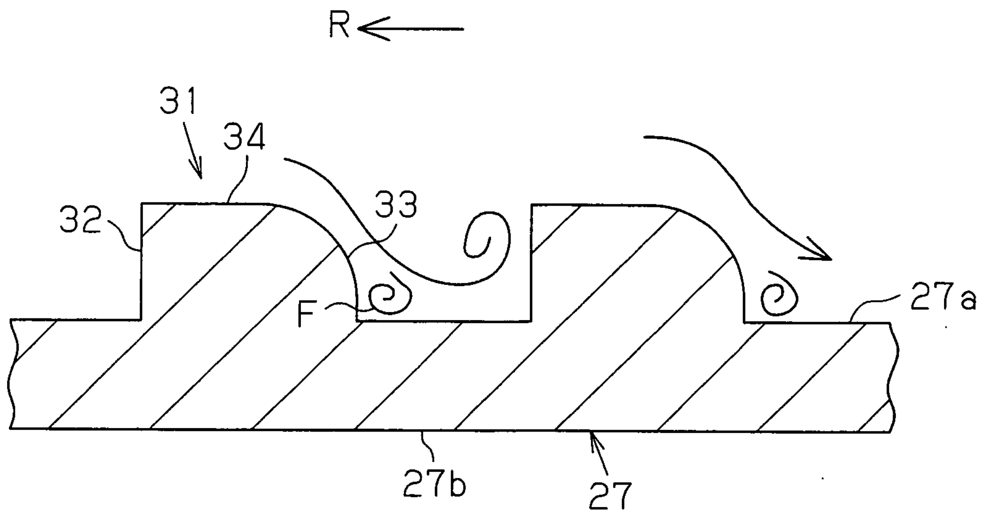

Fig.8

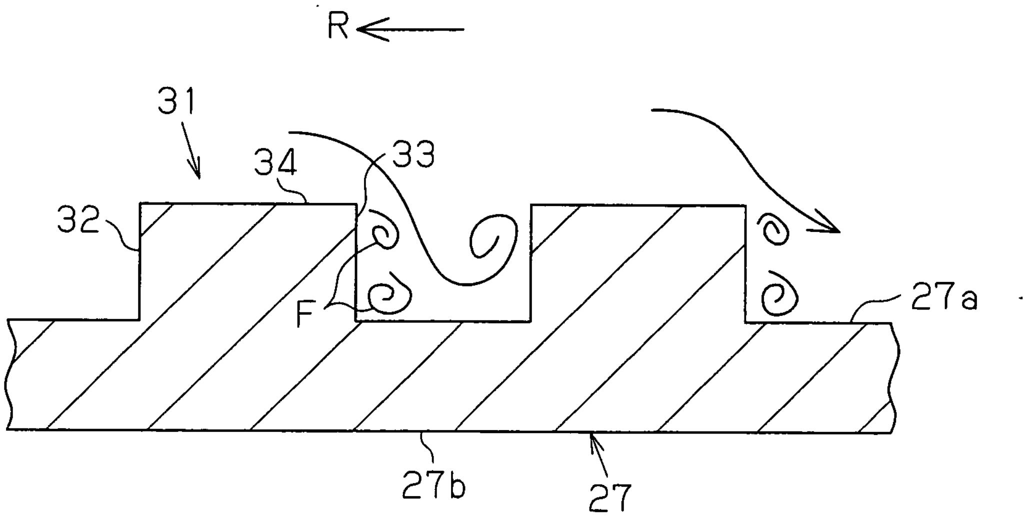

Fig.9

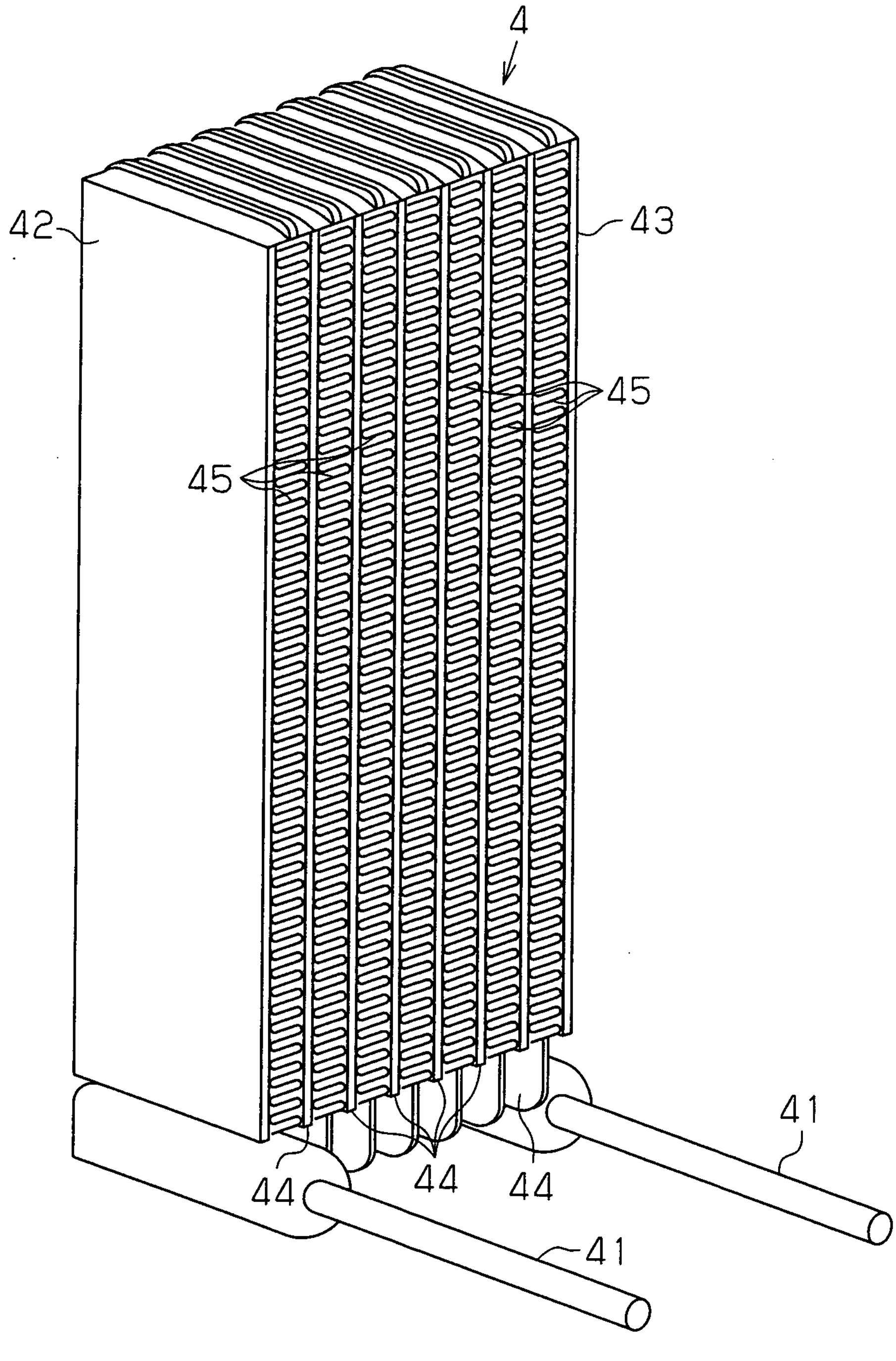

Fig.10

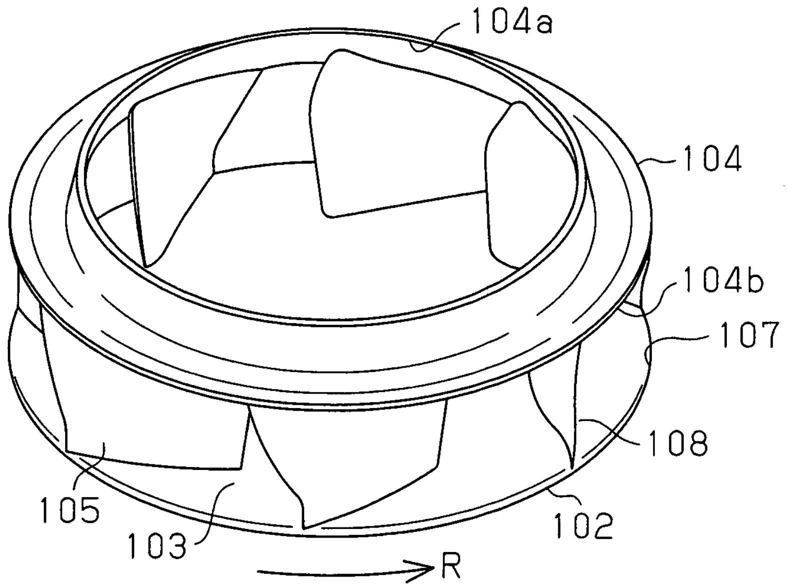
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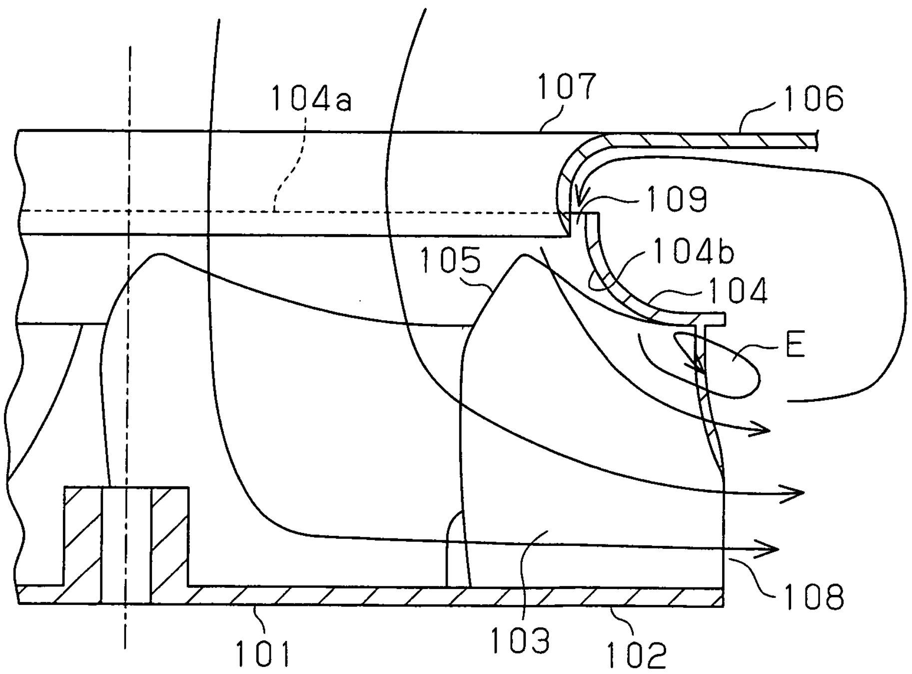
Fig.11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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2006/318932

A. CLASSIFICATION OF SUBJECT MATTER
F04D29/28(2006.01)i, *F24F1/00*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F04D29/28, F24F1/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2006
Kokai Jitsuyo Shinan Koho	1971-2006	Toroku Jitsuyo Shinan Koho	1994-2006

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	JP 5-332293 A (Nippondenso Co., Ltd.), 14 December, 1993 (14.12.93), Par. Nos. [0009] to [0015], [0024]; Figs. 1 to 3 (Family: none)	1-4 6-9 5
X A	JP 4-179899 A (Matsushita Electric Industrial Co., Ltd.), 26 June, 1992 (26,06.92), Page 2, upper right column, line 16 to lower right column, line 12; Figs. 1 to 4 (Family: none)	1-4 5-9

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 October, 2006 (16.10.06)	31 October, 2006 (31.10.06)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2006/318932

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 622/1975(Laid-open No. 86666/1976) (Matsushita Electric Industrial Co., Ltd.), 12 July, 1976 (12.07.76), Description; page 3, lines 8 to 19; Figs. 1 to 2 (Family: none)	1-2 3-9
X A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 29257/1985(Laid-open No. 145899/1986) (Matsushita Seiko Co., Ltd.), 09 September, 1986 (09.09.86), Description; page 4, line 18 to page 5, line 4; Fig. 1 (Family: none)	1-2 3-9
X A	JP 53-32406 A (Hitachi, Ltd.), 27 March, 1978 (27.03.78), Page 2, upper left column, lines 2 to 8; Figs. 1 to 3 (Family: none)	1-2 3-9
Y	JP 3100254 U (Shigo Denno Kofun Yugen Koshi), 13 May, 2004 (13.05.04), Par. Nos. [0019] to [0020]; Fig. 4 (Family: none)	6-9

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 5312189 A **[0008]**