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(72) Inventors:  
• **TERAOKA, Hironobu**  
**Sakai-shi**  
**Osaka 591-8511 (JP)**  
• **TEI, Shimei**  
**Sakai-shi**  
**Osaka 591-8511 (JP)**

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(74) Representative: **HOFFMANN EITLE**  
**Patent- und Rechtsanwälte**  
**Arabellastraße 4**  
**81925 München (DE)**

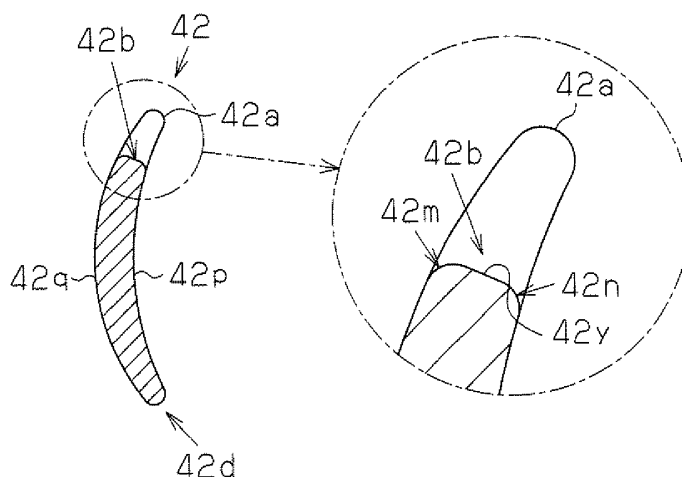
(71) Applicant: **Daikin Industries, Ltd.**  
**Osaka 530-8323 (JP)**

(54) **CROSS FLOW FAN AND AIR CONDITIONER EQUIPPED WITH SAME**

(57) A crossflow fan includes an impeller formed by plate-like blades 42. Each blade 42 is inclined such that the outer edge 42a is located on the leading side of the inner edge 42d with respect to the rotation direction of the impeller 41. The face of each blade 42 that is located on the leading side of the rotation direction forms a positive pressure surface 42p, and a face located on the trailing side forms a negative pressure surface 42q.

Notches 42b are formed at the outer edge 42a of the blade 42. The notches 42b are arranged at predetermined intervals along the rotation axis of the impeller. The bottom 42y of the notch 42b is connected to the positive pressure surface 42p at a positive pressure corner 42n and connected to the negative pressure surface 42q at a negative pressure corner 42m. The positive pressure corner 42n and the negative pressure corner 42m are both rounded.

**Fig.5**



## Description

### TECHNICAL FIELD

**[0001]** The present invention relates to a crossflow fan and an air conditioner having the crossflow fan.

### BACKGROUND ART

**[0002]** Crossflow fans are known as air blowers as used in an indoor unit of a wall-mounted air conditioner. Fig. 14 shows one example of a crossflow fan. As shown in Fig. 14, a crossflow fan 104 is a type of fan through which air flow crosses transversely, and includes an impeller 141 formed by a number of blades 142. The blades 142 are forward-swept blades, in each of which the outer edge is located on the leading side from the inner edge with respect to the rotation direction Z1. When the impeller 141 is rotated in the rotation direction Z1 by an electric motor, cooled or heated air flow X (that is, conditioned air flow) in an indoor unit 1 of the air conditioner transversely passes through the impeller 141, in a plane perpendicular to the rotation axis Z of the impeller 141.

**[0003]** In the impeller of such a crossflow fan, air passing through the blades of the impeller generates noise. In an attempt to reduce such noise with a simple structure, crossflow fans have been proposed that have a plurality of notches formed at an edge of each blade (for example, see Patent Document 1). Figs. 15(a) and 15(b) are perspective views showing an impeller blade of such a crossflow fan. As shown in Figs. 15(a) and 15(b), a plurality of notches 242b are formed at predetermined intervals at an outer edge 242a of a plate-like blade 242. A straight section 242c is formed between each adjacent pair of the notches 242b. As shown in Fig. 16, the bottom 242y of each notch 242b extends in a direction substantially perpendicular to the sides of the blade 242. The notches 242b, which are formed in the blade 242 as described above, reduce trailing vortices (not shown) generated at an outlet region M of a crossflow fan 204. In other words, a simple modification to the shape of the blade 242 effectively reduces the noise of the crossflow fan 204.

Patent Document 1: Japanese Laid-Open Patent Publication No. 2006-125390

### DISCLOSURE OF THE INVENTION

#### PROBLEMS THAT THE INVENTION IS TO SOLVE

**[0004]** As described in Patent Document 1, a simple structure where notches are formed at an edge of each blade can effectively reduce noise. However, when employed, this structure increases air resistance against rotation of the impeller 241. Specifically, when notches 242b are formed at the outer edge 242a of each blade 242 as shown in Fig. 16, rotation of the impeller 241 causes air flow X to strike the bottom 242y of each notch 242b,

which extends perpendicularly to both sides of the blade 242. Thus, compared to a case where no notches are formed at the outer edge 242a, collision of the air flow X generates greater air resistance against rotation of the impeller 241 at an inlet region N of the crossflow fan 204. As a result, to ensure a sufficient volume of discharged air from the crossflow fan 204, the power output of the electric motor, which drives the crossflow fan 204, needs to be increased.

**[0005]** Accordingly, it is an objective of the present invention to provide a crossflow fan that prevents the power output required from an electric motor driving the crossflow fan from being increased, and an air conditioner having the crossflow fan.

#### MEANS FOR SOLVING THE PROBLEMS

**[0006]** To achieve the foregoing objective and in accordance with one aspect of the present invention, a crossflow fan is provided that includes an impeller having a plurality of support plates located on a rotation axis of the impeller and a plurality of plate-like blades provided at peripheral portions of the support plates. The blades extend parallel to the rotation axis.

Each blade is inclined such that its outer edge is located on the leading side of its inner edge with respect to the rotation direction of the impeller. One of the faces of each blade that is on the leading side of the rotation direction of the impeller forms a positive pressure surface. The face on the trailing side of the rotation direction forms a negative pressure surface. A plurality of notches are formed at the outer edge of each blade. The notches are arranged at predetermined intervals along the rotation axis of the impeller. At least one of a positive pressure corner and a negative pressure corner, which connect the bottom of each notch with the positive pressure surface and the negative pressure surface, respectively, is rounded.

**[0007]** Since the notches are formed in the outer edge of the blade, noise is effectively reduced with a simple structure. At least one of the positive pressure corner and negative pressure corner, which connect the bottom of the notch with the positive pressure surface and the negative pressure surface, respectively, is rounded. Therefore, air that flows into the notches from the outer side of the blade is allowed to flow smoothly into the impeller along the negative pressure surface and the positive pressure surface. This reduces the collision loss generated when air flows in from outside of the blade. As a result, required increased power output from the electric motor driving the crossflow fan caused by the formation of the notches in the blades can be reduced. In the above, the predetermined intervals may be the same intervals or may vary according to the position in the longitudinal direction of the blade.

**[0008]** In accordance with the present invention, the negative pressure corner, which connects the bottom of each notch with the negative pressure surface, may be

rounded.

**[0009]** Also, in accordance with the present invention, the positive pressure corner, which connects the bottom of each notch with the positive pressure surface, may be rounded.

**[0010]** To achieve the foregoing objective and in accordance with one aspect of the present invention, a crossflow fan is provided that includes an impeller having a plurality of support plates located on a rotation axis of the impeller and a plurality of plate-like blades provided at peripheral portions of the support plates. The blades extend parallel to the rotation axis.

Each blade is inclined such that its outer edge is located on the leading side of its inner edge with respect to the rotation direction of the impeller. One of the faces of each blade that is on the leading side of the rotation direction of the impeller forms a positive pressure surface. The face on the trailing side of the rotation direction forms a negative pressure surface. A plurality of notches are formed at the outer edge of each blade. The notches are arranged at predetermined intervals along the rotation axis of the impeller. The bottom of each notch is formed as a smooth curved surface that protrudes as a whole outward of the impeller.

**[0011]** Since the notches are formed in the outer edge of the blade, noise is effectively reduced with a simple structure. Further, since the bottom of each notch is formed to be a smooth curved surface that protrudes as a whole toward the outer circumference of the impeller, air that flows into the notches from the outer side of the blade is allowed to flow smoothly into the impeller along the negative pressure surface and the positive pressure surface. This reduces the collision loss generated when air flows into the notches from outside of the blade. As a result, required increased power output from the electric motor driving the crossflow fan can be reduced. In the above, the predetermined intervals may be the same intervals or may vary according to the position in the longitudinal direction of the blade.

**[0012]** In the present invention, the notches are preferably V-shaped as viewed from the negative pressure surface and the pressure surface of the blade,

**[0013]** According to this configuration, a greater pressure receiving area of the blade is ensured compared to a case where the notch has a rectangular shape.

**[0014]** Further, the present invention also provides an air conditioner having a crossflow fan having the above described configuration.

#### Effects of the Invention

**[0015]** According to the present invention, since the notches are formed in the outer edge of the blade, noise is effectively reduced with a simple structure. At least one of the positive pressure corner and negative pressure corner, which connects the bottom of the notch with the positive pressure surface and the negative pressure surface, respectively, is rounded. Therefore, air that flows

into the notches from the outer side of the blade is allowed to flow smoothly into the impeller along the negative pressure surface and the positive pressure surface. This reduces the collision loss generated when air flows in from outside of the blade. As a result, required increased power output from the electric motor driving the crossflow fan caused by the formation of the notches in the blades can be reduced.

#### BRIEF DESCRIPTION OF THE DRAWINGS

##### **[0016]**

Fig. 1 is schematic diagram showing an indoor unit of an air conditioner having a crossflow fan according to one embodiment of the present invention;

Fig. 2 is a perspective view showing the crossflow fan according to the first embodiment;

Figs. 3(a) and 3(b) are perspective views showing an impeller blade of the crossflow fan;

Fig. 4 is a diagram for explanatory illustration of a blade with notches;

Fig. 5 is a cross-sectional view of the blade taken along line 5-5 of Fig. 4;

Fig. 6 is a perspective view showing a cross section of a notch;

Fig. 7 is a diagram for explanatory illustration of a manner in which air flows into notches;

Fig. 8 is a cross-sectional view showing a blade according to a modified embodiment;

Fig. 9 is a cross-sectional view showing a blade according to another modified embodiment;

Fig. 10 is a cross-sectional view showing a blade according to a further modified embodiment;

Figs. 11 (a) and 11 (b) are perspective views showing a blade according to yet another modification;

Fig. 12 is a diagram for explanatory illustration of the blade of the modified embodiment of Fig. 11;

Fig. 13 is a perspective view showing a cross section of a notch of the modification of Fig. 11;

Fig. 14 is a diagram for explanatory illustration of the prior art crossflow fan;

Figs. 15(a) and 15(b) are perspective views showing an impeller blade of the prior art crossflow fan;

Fig. 16 is a diagram for explanatory illustration of the prior art crossflow fan.

#### BEST MODE FOR CARRYING OUT THE INVENTION

**[0017]** One embodiment of the present invention will now be described with reference to Figs. 1 to 7.

**[0018]** As shown in Fig. 1, an air conditioner according to the present embodiment includes a wall-mounted indoor unit 1. The indoor unit 1 includes a main casing 2, a heat exchanger 3 arranged in the main casing 2, and a crossflow fan 4. The crossflow fan 4 has an impeller 41 having plate-like blades 42. The impeller 41 is driven by an electric motor (not shown) to compress and send

air from an inlet region N to an outlet region M.

**[0019]** Air inlet ports 21 are provided in upper and front face of the main casing 2. An air outlet port 22 is provided in a lower face of the main casing 2. At the air outlet port 22, vertical flaps 23 and a horizontal flap 24 for adjusting the direction of air discharged from the air outlet port 22 are provided.

**[0020]** A guide portion 25 is formed in the main casing 2 at a position in the vicinity of the outlet region M of the crossflow fan 4. The guide portion 25 defines the passage of air discharged by the crossflow fan 4. A backflow preventing tongue 26 is formed at the air outlet port 22. The backflow preventing tongue 26 separates the outlet region M and the inlet region N from each other, thereby preventing discharged air from flowing back.

The heat exchanger 3 is located between the air inlet port 21 and the impeller 41, and formed by a front heat exchanging section 3a and a back heat exchanging section 3b. The front heat exchanging section 3a is located in the main casing 2 near the front face. The back heat exchanging section 3b is continuously formed at the top of the front heat exchanging section 3a, and is located in the main casing 2 near the back face.

**[0021]** According to the above shown structure, when the impeller 41 of the crossflow fan 4 is driven by the electric motor, air in the room is drawn in to the main casing 2 through the inlet port 21. The air is cooled or heated by passing through the heat exchanger 3, and is discharged into the room through the air outlet port 22. Accordingly, conditioned air is delivered to the room.

**[0022]** As shown in Fig. 2, the impeller 41 of the crossflow fan 4 is formed by a great number of the blades 42, circular support plates 43, and an input shaft 44. The support plates 43 support the blades 42 and are located on the rotation axis A1 of the impeller 41. The input shaft 44 is connected to the electric motor and extends along the rotation axis A1. The support plates 43 are arranged parallel to each other at predetermined intervals along the rotation axis A1 of the impeller 41, or the longitudinal direction of the blades 42. The blades 42 are fixed to peripheral portions 43a of the support plates 43 and arranged between adjacent two support plates 43 to extend parallel to the rotation axis A1.

**[0023]** The structure of each blade 42 will be described with reference to Figs. 3 and 4. As shown in Fig. 2, the blades 42 are forward-swept. That is, each blade 42 is inclined such that the outer edge 42a is located on the leading side of the inner edge 42d with respect to a rotation direction Z1 of the impeller 41. As shown in Figs. 2 and 3, the face of each blade 42 that is located on the leading side of the rotation direction Z1 forms a positive pressure surface 42p, and a face located on the trailing side forms a negative pressure surface 42q. The blade 42 is also curved such that the outer edge 42a is located on the leading side of the inner edge 42d with respect to the rotation direction Z1 of the impeller 41.

**[0024]** Notches 42b are formed at the outer edge 42a of the blade 42. The notches 42b are arranged at prede-

termined intervals along the rotation axis A1 of the impeller 41. The notches 42b are V-shaped when viewed from the negative pressure surface 42q and the positive pressure surface 42p of the blade 42. A basic shape section 42c is formed between each adjacent pair of the notches 42b. The basic shape sections 42c form the curved basic shape of the blade 42. The width of the space between adjacent notches 42b may be constant or may vary. For example, as shown in Figs. 3 and 4, each end 6a of the blade 42 with respect to the rotation axis A1 is close to the corresponding support plate 43. Thus, the flow velocity of air flow X at each end 6a is greater than that in a center 6b of the blade 42 in the rotation axis A1. In the present embodiment, the space between notches 42b at each end 6a of the blade 42 is greater than the space between notches 42b at the center 6b of the blade 42. This ensures a sufficient pressure receiving area at each end 6a of the blade 42.

**[0025]** The notches 42b may have the same size, but may have different sizes depending on position on the rotation axis A1. In the present embodiment, notches 42b at each end 6a of the blade 42 in the rotation axis A1 have a smaller size than notches 42b at the center 6b of the blade 42. This ensures a sufficient pressure receiving area at each end 6a of the blade 42.

**[0026]** As described above, the notches 42b formed at the outer edge 42a of the blade 42 at predetermined intervals, and the basic shape sections 42c are each formed between adjacent notches 42b as shown in Fig. 4. This reduces trailing vortices (not shown) generated at the outlet region M of the crossflow fan 4, so that noise is reduced with a simple structure.

**[0027]** The notches 42b are V-shaped when viewed from the negative pressure surface 42q and the positive pressure surface 42p of the blade 42. Thus, compared to a case where notches 42b have rectangular shapes, the pressure receiving area of the blade 42 is enlarged.

**[0028]** Fig. 5 is a cross-sectional view of the blade 42 taken along line 5-5 of Fig. 4, and Fig. 6 is a perspective view showing a cross section of a notch 42b. As shown in Figs. 5 and 6, the bottom 42y of the notch 42b is connected to the negative pressure surface 42q at a negative pressure corner 42m, and connected to the positive pressure surface 42p at a positive pressure corner 42n. The negative pressure corner 42m and the positive pressure corner 42n are both rounded.

**[0029]** More specifically, the bottom 42y of each notch 42b, which extends perpendicularly to the negative pressure surface 42q of the blade 42, and the negative pressure surface 42q are smoothly connected to each other by the negative pressure corner 42m. The bottom 42y of each notch 42b, which extends perpendicularly to the positive pressure surface 42p of the blade 42, and the positive pressure surface 42p are smoothly connected to each other by the positive pressure corner 42n. Therefore, the length of the bottom 42y, which extends perpendicularly to the positive pressure surface 42p and the negative pressure surface 42q, is less than that of the

bottom 242y of the prior art notch 242b (see Fig. 16).

**[0030]** As described above, the negative pressure corner 42m and the positive pressure corner 42n are rounded to form smooth and curved surfaces. This allows the air flow X that flows into the notches 42b from outside of the blade 42 to flow smoothly along the negative pressure surface 42q and into the impeller 41. As a result, the collision loss generated when the air flow X flows from outside of the blade 42 into the notches 42b is reduced.

**[0031]** The crossflow fan 4 according to the present embodiment has the following advantages.

(1) The positive pressure corner 42n and the negative pressure corner 42m, which connect the bottom 42y of the notch 42b to the positive pressure surface 42p and the negative pressure surface 42q, respectively, are rounded to have a smooth and curved surface. This allows the air flow X that flows into the notches 42b from outside of the blade 42 to flow smoothly into the impeller 41 along the negative pressure surface 42q and the positive pressure surface 42p. This reduces the collision loss generated when air flow X flows from outside of the blade 42 to the notches 42b. As a result, the required increase in power output from the electric motor driving the crossflow fan 4 caused by the formation of the notches in the blades 42 can be reduced. Particularly, since the negative pressure corner 42m and the positive pressure corner 42n are both rounded in the present embodiment, the collision loss generated when the air flow X flows from outside of the blade 42 is reduced, and required increased power output from the electric motor driving the crossflow fan can be reduced.

(2) The notches 42b are V-shaped when viewed from the negative pressure surface 42q and the positive pressure surface 42p of the blade 42. Thus, a sufficient pressure receiving area for the blade 42 is ensured.

**[0032]** The air conditioner of the present embodiment has the crossflow fan 4, which achieves the advantages (1) and (2). The air conditioner therefore achieves the same advantages as the advantages (1) and (2).

**[0033]** The present invention is not limited to the above embodiment, but can be modified in various forms within the spirit of the present invention. The modifications are not excluded from the scope of the present invention. For example, the above embodiments may be modified as follows.

**[0034]** In the above embodiment, the negative pressure corner 42m and the positive pressure corner 42n are both rounded. Instead, only one of the negative pressure corner 42m and the positive pressure corner 42n may be rounded. Fig. 8 illustrates a configuration in which only the negative pressure corner 42m is rounded. Fig. 9 illustrates a configuration in which only the positive pressure corner 42n is rounded. Even with these config-

urations, the increase in power output required from the electric motor driving the crossflow fan 4 caused by the formation of the notches in the blades 42 can be reduced.

**[0035]** As shown in Fig. 10, the bottom 42y of the notch 42b may be formed as a smooth curved surface that protrudes outward as a whole. This structure allows the air flow X that flows into the notches 42b from outside of the blade 42 to flow smoothly along the negative pressure surface 42q or the positive pressure surface 42p and into the impeller 41. This further reduces the collision loss generated when air flows into the notches 42b from outside of the blade 42. As a result, required increased power output from the electric motor driving the crossflow fan can be reduced.

**[0036]** In the above illustrated embodiments, the notches 42b are V-shaped when viewed from the negative pressure surface 42q and the positive pressure surface 42p of the blade 42. However, this configuration may be changed. For example, as shown in Figs. 11 to 13, notches 42b may have a rectangular shape as viewed from the negative pressure surface 42q and the positive pressure surface 42p of the blade 42. A cross sectional view taken along line 5-5 of Fig. 12 is the same as Fig. 5. Even if the notches 42b are rectangular, the increase of the power output of the electric motor driving the crossflow fan 4 caused by the formation of the notches in the blades 42 can be reduced, as long as at least one of the negative pressure corner 42m and the positive pressure corner 42n is rounded. Further, when the notches 42b are formed to be rectangular, the bottom 42y of the notch 42b may be formed as a smooth curved surface that protrudes as a whole outward of the impeller 41.

## Claims

1. A crossflow fan comprising an impeller having a plurality of support plates located on a rotation axis of the impeller and a plurality of plate-like blades provided at peripheral portions of the support plates, the blades extending parallel to the rotation axis, each blade being inclined such that its outer edge is located on the leading side of its inner edge with respect to the rotation direction of the impeller, one of the faces of each blade that is on the leading side of the rotation direction of the impeller forms a positive pressure surface, the face on the trailing side of the rotation direction forms a negative pressure surface, the crossflow fan being **characterized in that** a plurality of notches are formed at the outer edge of each blade, the notches being arranged at predetermined intervals along the rotation axis of the impeller, wherein at least one of a positive pressure corner and a negative pressure corner, which connect the bottom of each notch with the positive pressure surface and the negative pressure surface, respectively, is rounded.

2. The crossflow fan according to claim 1, **characterized in that** the negative pressure corner, which connects the bottom of each notch with the negative pressure surface, is rounded. 5
3. The crossflow fan according to claim 1 or 2, **characterized in that** the positive pressure corner, which connects the bottom of each notch with the positive pressure surface, is rounded. 10
4. A crossflow fan comprising an impeller having a plurality of support plates located on a rotation axis of the impeller and a plurality of plate-like blades provided at peripheral portions of the support plates, the blades extending parallel to the rotation axis, each blade being inclined such that its outer edge is located on the leading side of its inner edge with respect to the rotation direction of the impeller, one of the faces of each blade that is on the leading side of the rotation direction of the impeller forms a positive pressure surface, the face on the trailing side of the rotation direction forms a negative pressure surface, the crossflow fan being **characterized in that** a plurality of notches are formed at the outer edge of each blade, the notches being arranged at predetermined intervals along the rotation axis of the impeller, wherein the bottom of each notch is formed as a smooth curved surface that protrudes as a whole outward of the impeller. 15 20 25 30
5. The crossflow fan according to any one of claims 1 to 4, **characterized in that** each notch is V-shaped as viewed from the negative pressure surface and the pressure surface of the blade. 35
6. An air conditioner **characterized by** the crossflow fan according to any one of claims 1 to 5. 40

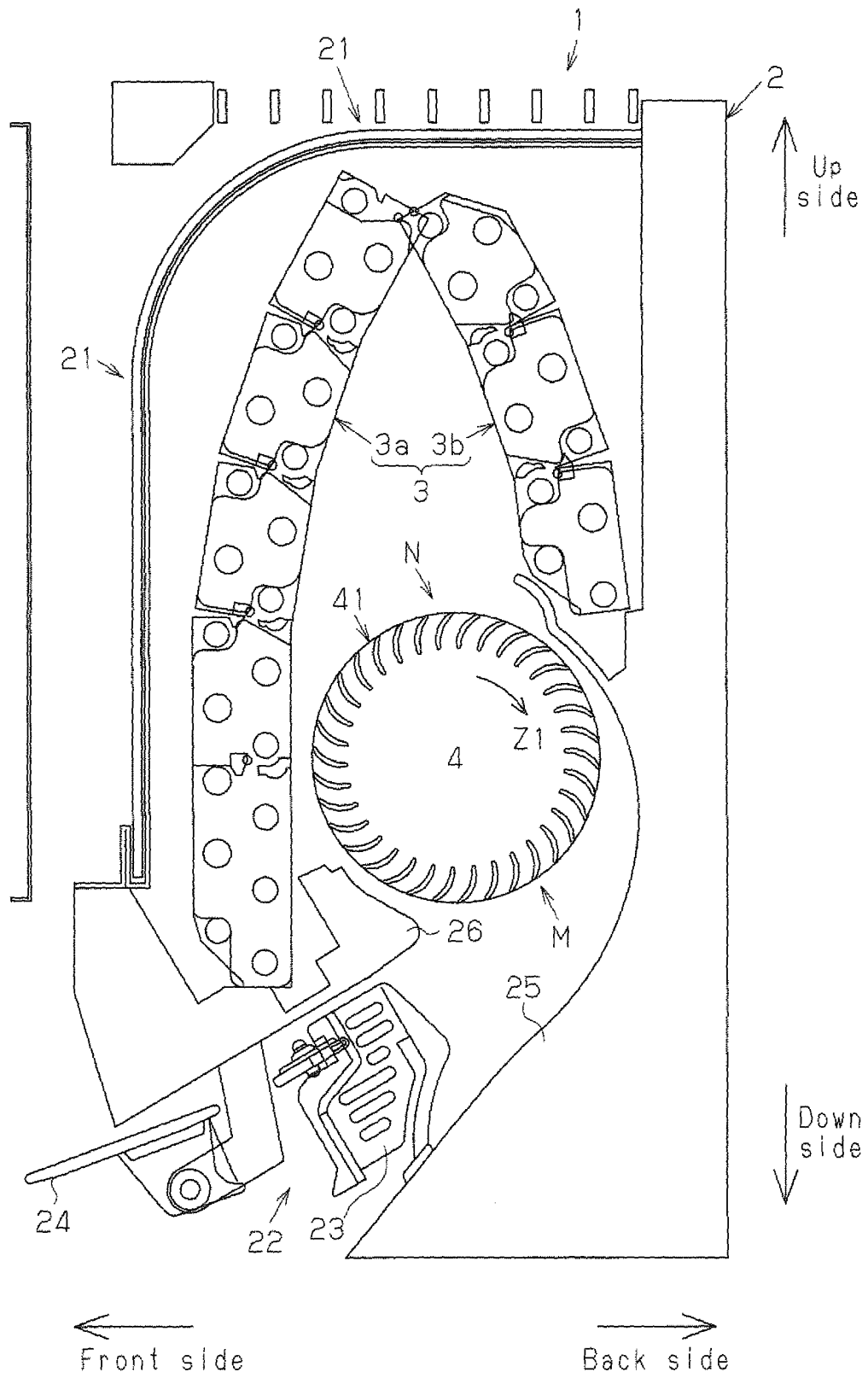
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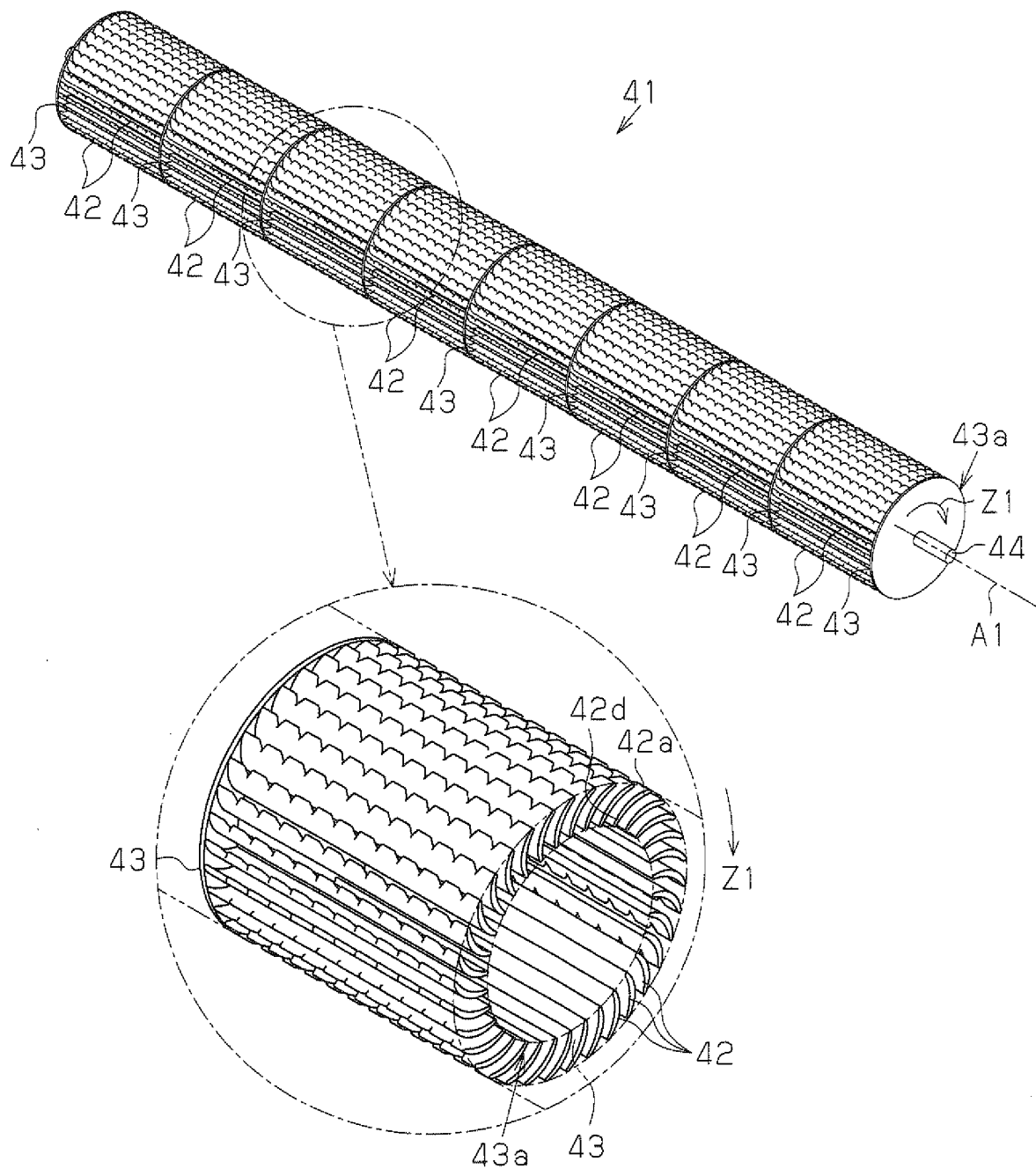
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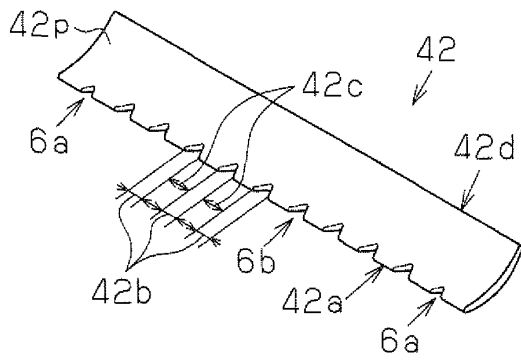
**Fig.1**



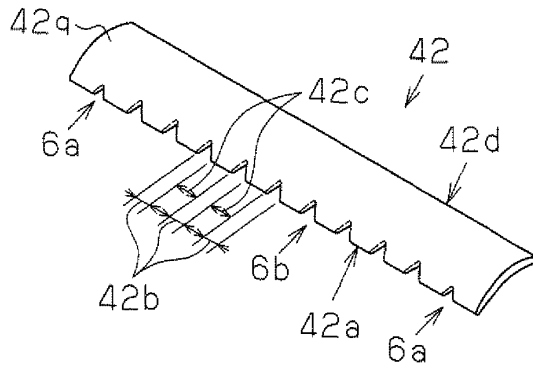
**Fig.2**



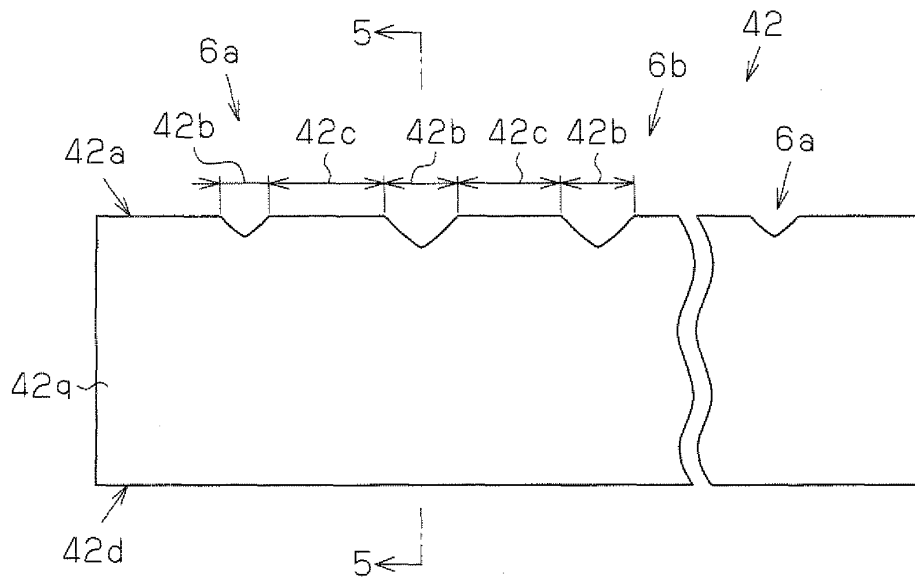
**Fig.3 (a)**



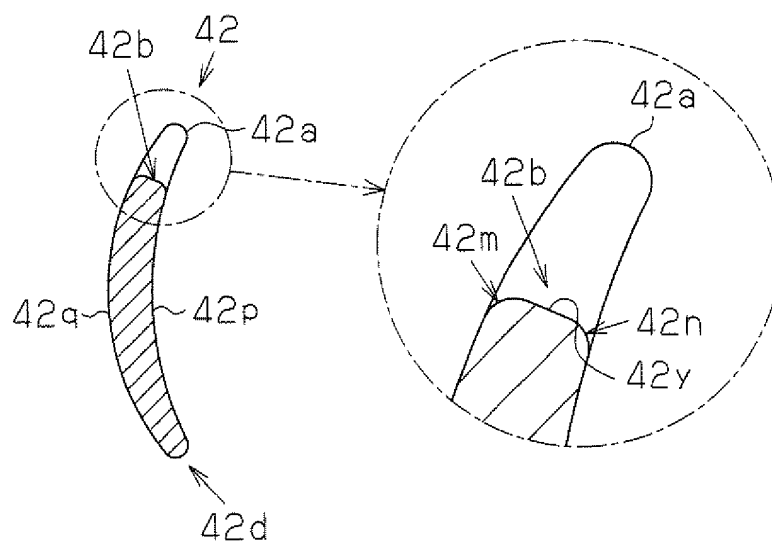
**Fig.3 (b)**



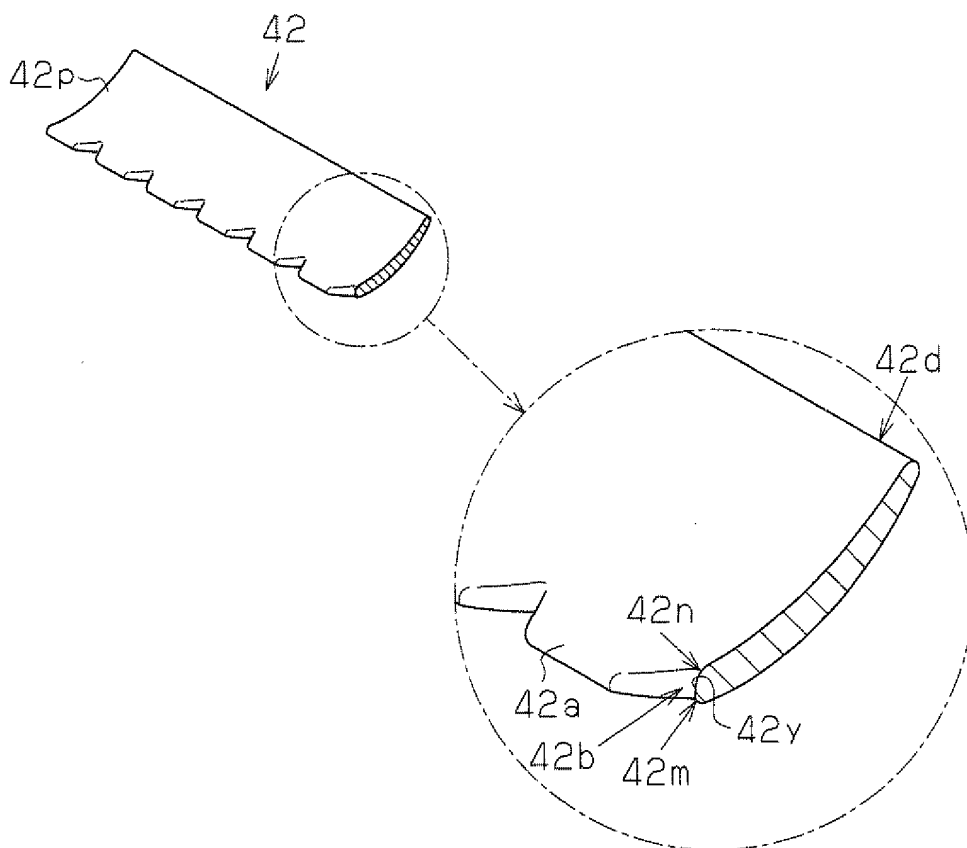
**Fig.4**



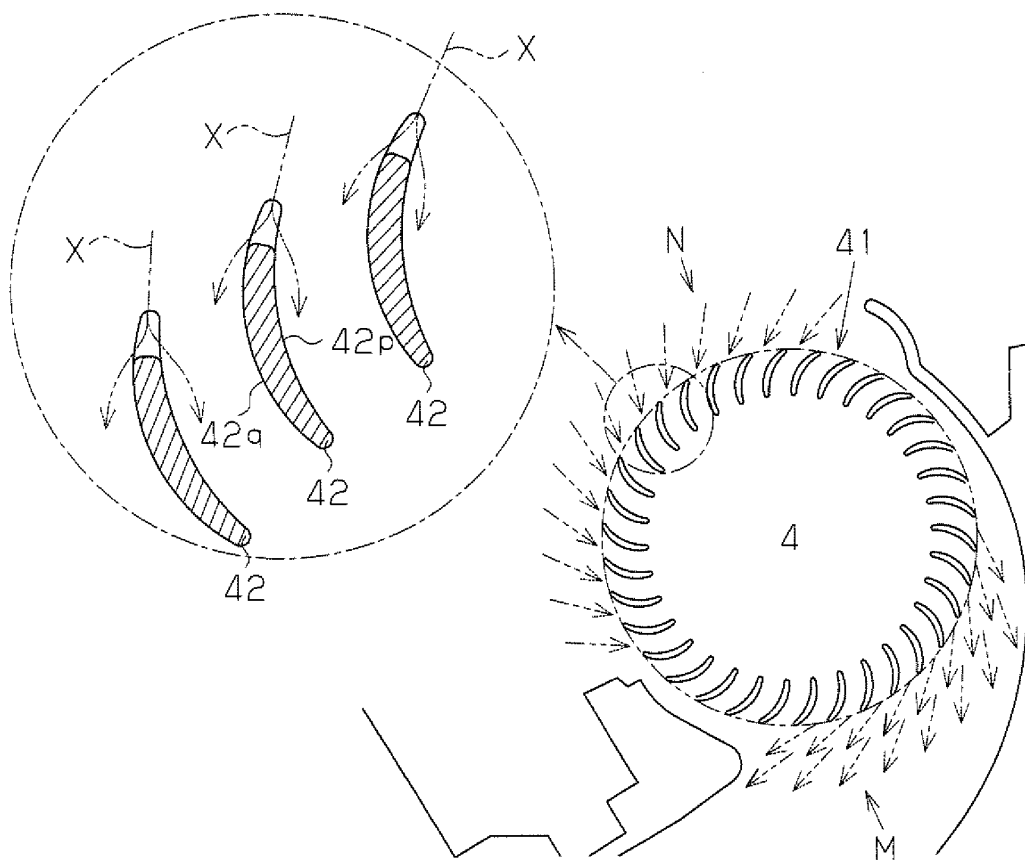
**Fig.5**



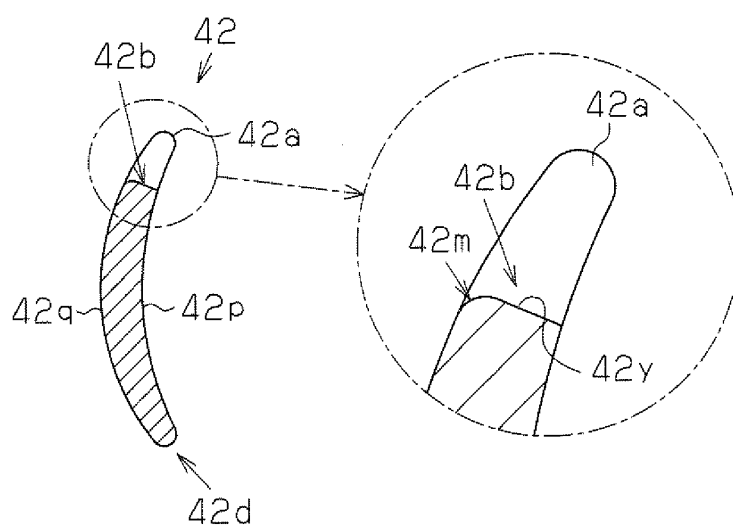
**Fig.6**



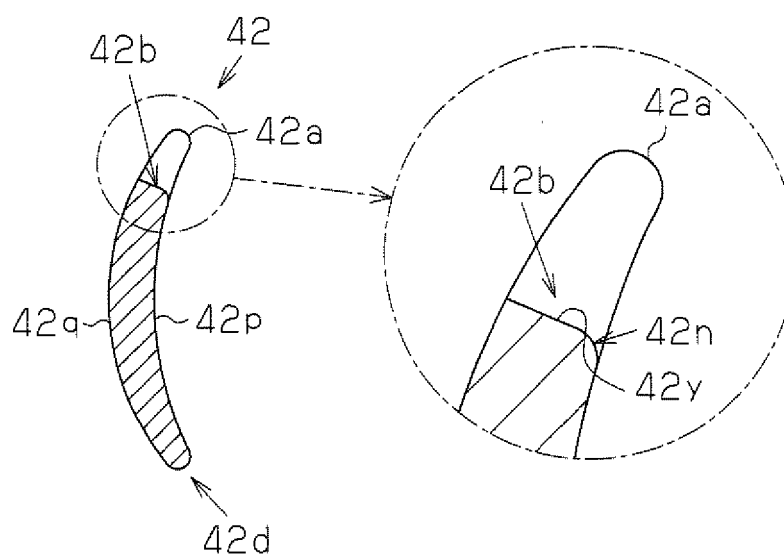
**Fig.7**



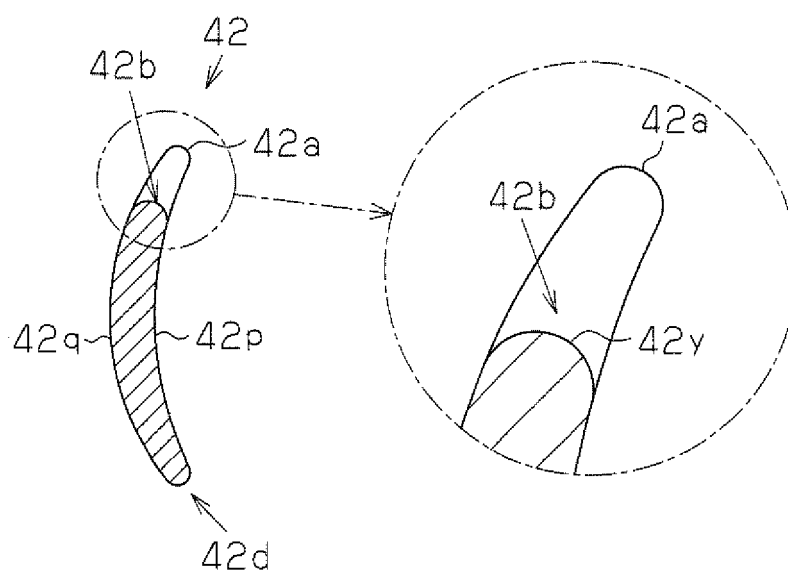
**Fig.8**



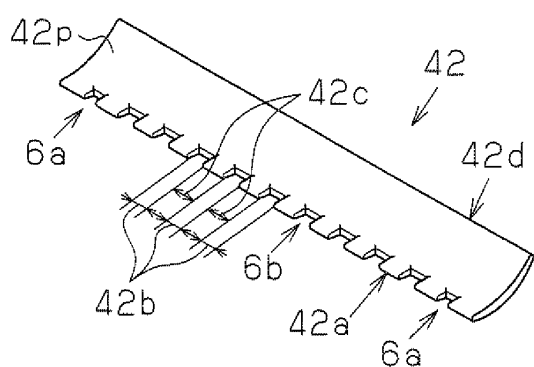
**Fig.9**



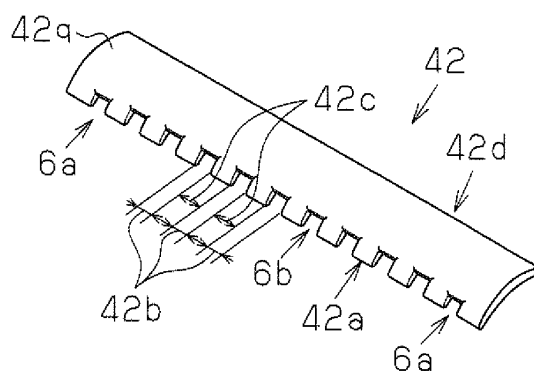
**Fig.10**



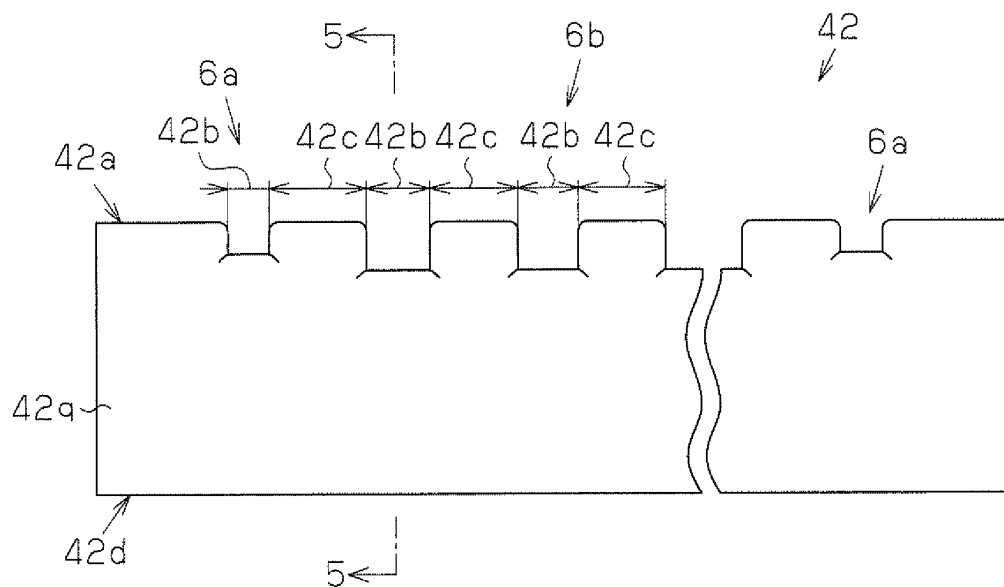
**Fig.11 (a)**



**Fig.11 (b)**



**Fig.12**



**Fig.13**

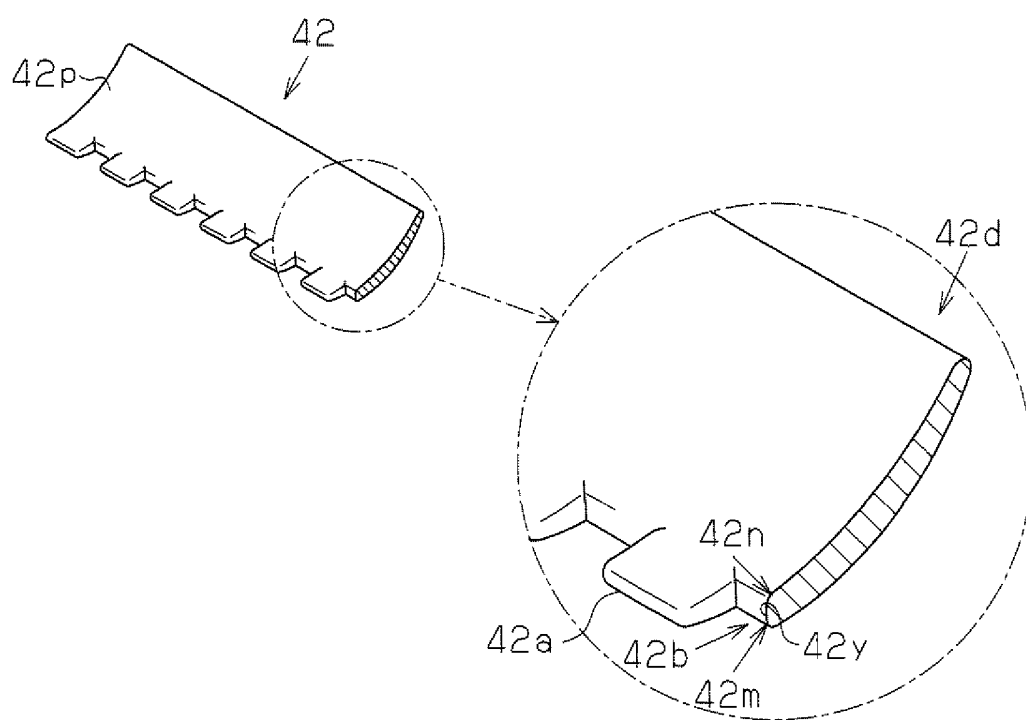
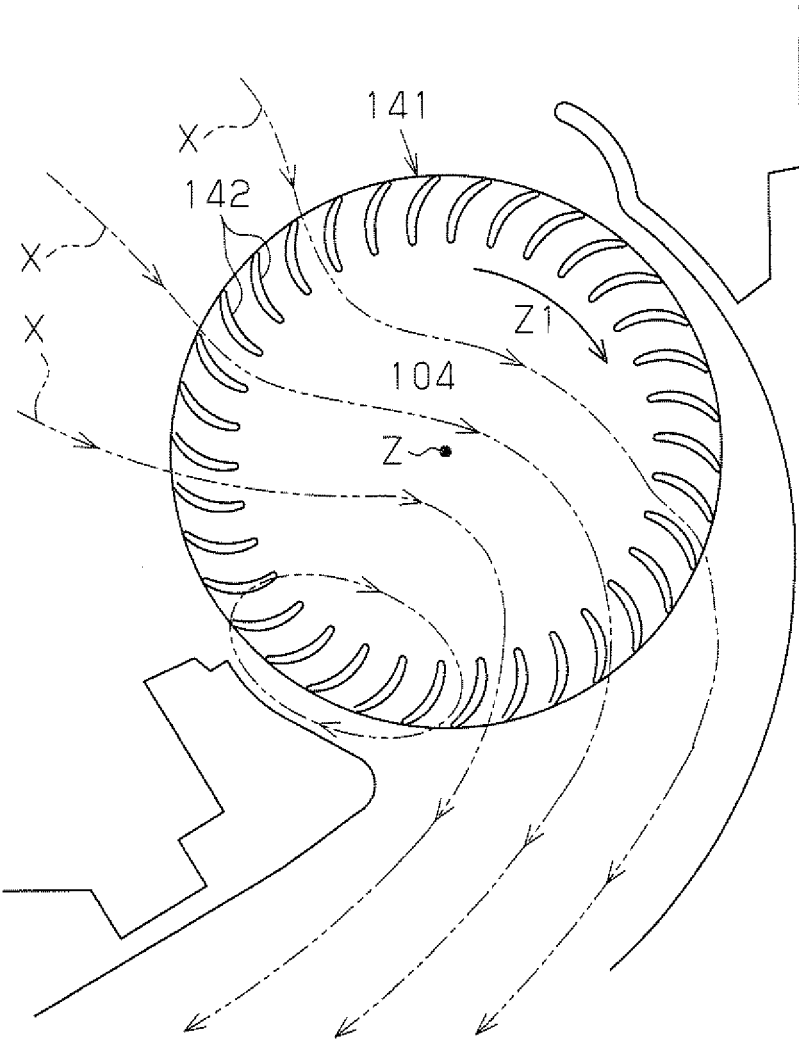
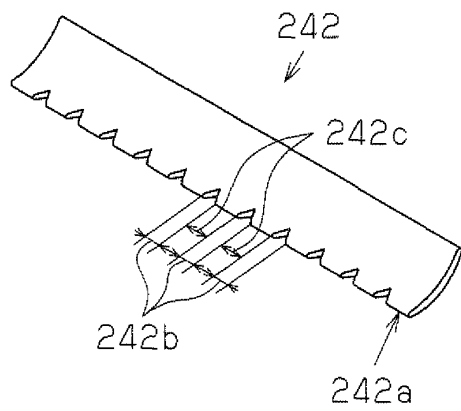


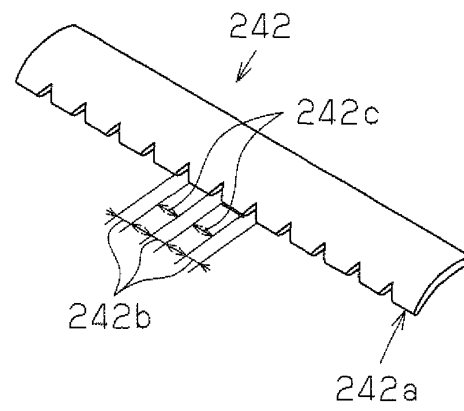
Fig.14



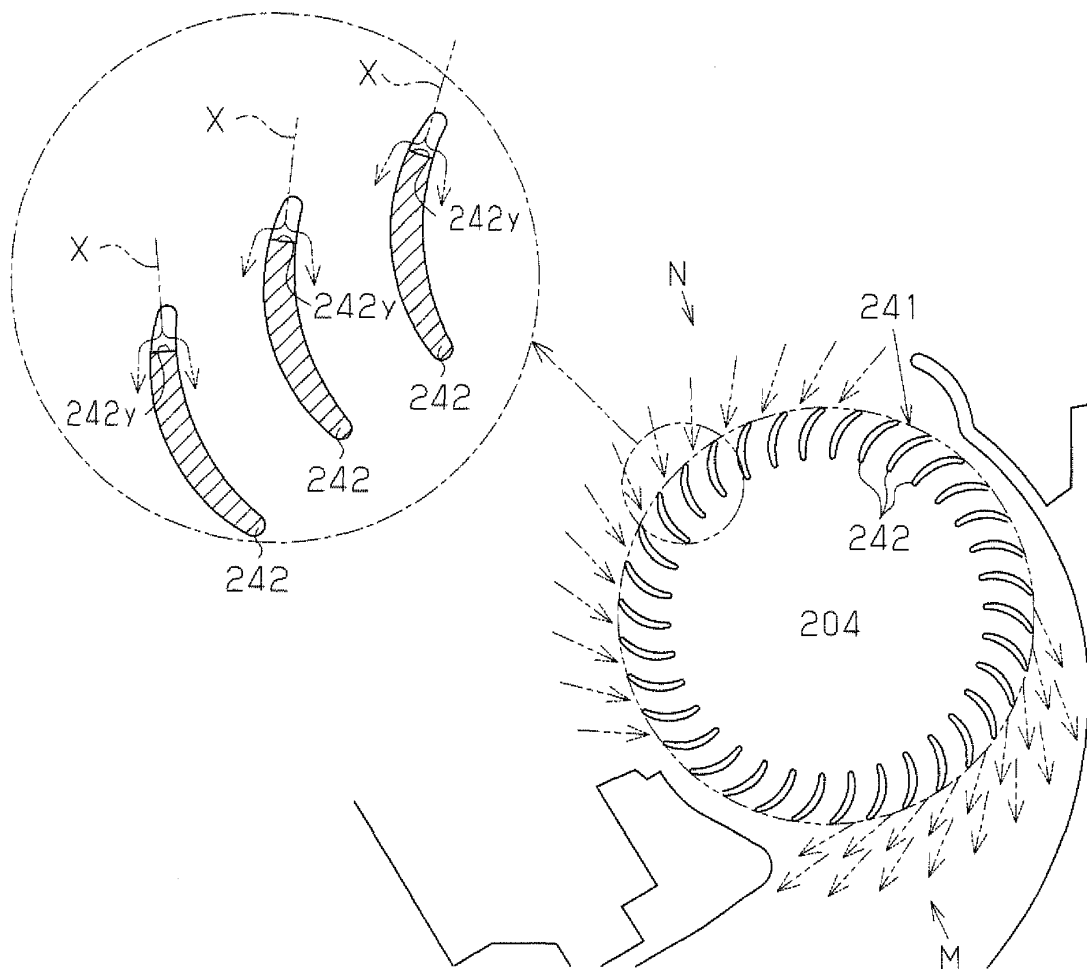
**Fig.15 (a)**



**Fig.15 (b)**



**Fig.16**



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2009/058448

## A. CLASSIFICATION OF SUBJECT MATTER

F04D17/04 (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)

F04D17/04, 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 | 1996-2009 |
| Kokai Jitsuyo Shinan Koho | 1971-2009 | Toroku Jitsuyo Shinan Koho | 1994-2009 |

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. |
|-----------|------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| A         | JP 10-252689 A (Mitsubishi Electric Corp.),<br>22 September, 1998 (22.09.98),<br>Full text; all drawings<br>(Family: none)               | 1-6                   |
| A         | JP 3-210094 A (Matsushita Electric Industrial Co., Ltd.),<br>13 September, 1991 (13.09.91),<br>Full text; all drawings<br>(Family: none) | 1-6                   |
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☒ Further documents are listed in the continuation of Box C.☐ See patent family annex.

## \* Special categories of cited documents:

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"&amp;" document member of the same patent family

Date of the actual completion of the international search  
04 August, 2009 (04.08.09)Date of mailing of the international search report  
18 August, 2009 (18.08.09)Name and mailing address of the ISA/  
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.  
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| C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT |                                                                                                                                            |                       |
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| Category*                                             | Citation of document, with indication, where appropriate, of the relevant passages                                                         | Relevant to claim No. |
| A                                                     | WO 2007/037216 A1 (Daikin Industries, Ltd.),<br>05 April, 2007 (05.04.07),<br>Full text; all drawings<br>& JP 2007-92594 A & EP 1939455 A1 | 1-6                   |

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**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

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