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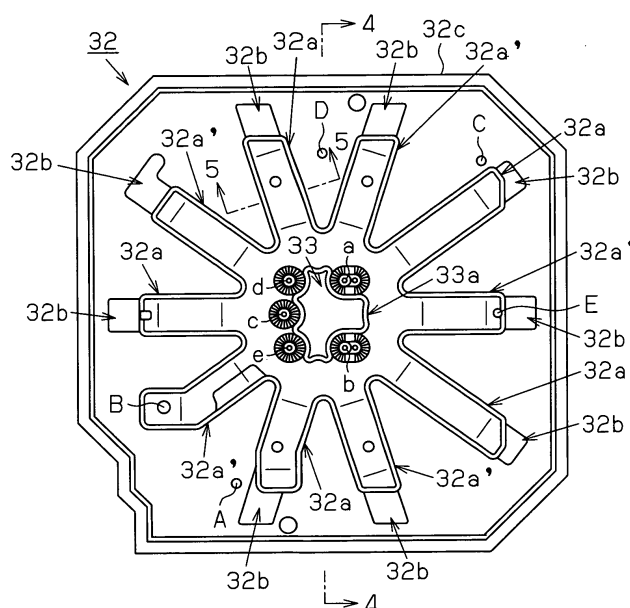
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(54) **TOP PLATE STRUCTURE OF AIR CONDITIONER FOR INSTALLATION AT HIGH LEVEL**

(57) A high location installation type air conditioner includes a body casing (3) for accommodating a fan (5), a fan motor (9), and a heat exchanger (4), and a top plate (32) forming a top surface of the body casing (3) for suspending the fan (5), the fan motor (9), and the heat exchanger (4). The top plate (32) includes a plurality of radial reinforcing ribs extending from a central portion of

the top plate (32) at which the fan motor (9) is supported to a peripheral portion of the top plate (32) at which the heat exchanger (4) is supported. The plurality of reinforcing ribs include a reinforcing rib (32a') protruding from a front surface of the top plate (32) and a reinforcing rib (32a) protruding from a rear surface of the top plate (32) to improve rigidity of the top plate (32).

**Fig.2**



**Description**

## TECHNICAL FIELD

5 **[0001]** The present invention relates to a top plate structure for a high location installation type air conditioner.

## BACKGROUND ART

10 **[0002]** An indoor unit for a high location installation type air conditioner, such as an air conditioner concealed in or suspended from a ceiling of a house, includes, for example, a metal top plate forming a top surface of a cassette body casing. The air conditioner is concealed in the ceiling or suspended from a lower surface of the ceiling by suspending heavy objects such as a heat exchanger, fan, and fan motor from the top plate and then suspending the main body casing with suspension bolts or the like.

15 **[0003]** Figs. 22 to 24 show a ceiling concealed air conditioner as one example of a high location installation type air conditioner. As shown in Figs. 22 to 24, the air conditioner includes an air conditioner body 1, which is arranged in an upper part of an opening 7 formed in a ceiling C, and a decorative panel 2, which is attached to the body 1 to cover the opening 7. The body 1 has a cassette body casing 3, in which a generally annular heat exchanger 4 is arranged. A fan (impeller) 5 and a fan motor 9 are arranged in a central portion of the heat exchanger 4 in the body casing 3 in such a manner that an air inlet side of the fan 5 faces downward and an air outlet side of the fan 5 faces the side of the heat exchanger 4. A bell mouth 6 made of synthetic resin is arranged at the air inlet side of the fan 5 in the body casing 3.

20 **[0004]** The fan 5 is formed by a centrifugal fan having a large number of blades 5b arranged between a hub 5a and a shroud 5c. A drain pan 8 is arranged below the heat exchanger 4. An air outlet passage 10 is formed around the periphery of the heat exchanger 4.

25 **[0005]** The body casing 3 is generally hexagonal and includes a side wall 31 and a top plate 32. The side wall 31 is formed from a heat insulating material. The top plate 32 covers an upper portion of the side wall 31. The heat exchanger 4 includes a pair of opposing open ends. A tube plate 11 is arranged on each open end of the heat exchanger 4. The tube plates 11 are connected to each other by a predetermined partition plate 12.

30 **[0006]** The top plate 32 of the body casing 3, the tube plates 11, the partition plate 12, and a switch box 13 attached to a lower surface of the bell mouth 6 are all formed from metal plates. As shown in Fig. 24, the top plate 32 and the switch box 13 are fixed to the top and bottom ends of the partition plate 12 by screws.

35 **[0007]** The bell mouth 6 has a recessed portion 14 for accommodating the switch box 13. An opening 16 is formed in a top surface 14a of the recessed portion 14. A switch box joint 15 formed on a lower end portion of the partition plate 12 is arranged in the opening 16. Two mounting pieces 17, which project integrally from two sides of an upper end portion of the partition plate 12, are connected to the top plate 32. The mounting pieces 17 are fixed to the top plate 32 from under the top plate 32 by screws 18.

40 **[0008]** Two mounting pieces 19, which project integrally from two sides of a lower end portion of the partition plate 12, are connected to the lower ends of the two tube plates 11. A mounting piece 15 connected to the switch box 13 is welded and fixed to an intermediate position of the partition plate 12. Each mounting piece 19 is fixed to the corresponding tube plate 11 from under the tube plate 11 by a screw 20. Each mounting piece 15 includes an L-shaped base portion 15a and a mounting portion 15b. The base portion 15a is connected to the partition plate 12. The mounting portion 15b extends downward from a distal end of the base portion 15a and is formed integrally with the base portion 15a. In a state in which the mounting portion 15b is arranged in the recessed portion 14 through the opening 16, each mounting piece 15 is fixed to a top surface 13a of the switch box 13 by screws 21.

45 **[0009]** The air conditioner includes a drain pump 22, a float switch 23, a drain pump accommodation portion 24 in which the drain pump 22 is arranged, a partition plate 25 partitioning the drain pump accommodation portion 24, and a lid 26 of the switch box 13.

**[0010]** The top plate 32 is hexagonal and shaped in correspondence with the body casing 3 of the air conditioner body 1. The top plate 32 has a peripheral portion along which a hook-shaped rim portion 32c is formed. The rim portion 32c is for fitting the top plate 32 and a peripheral portion at the upper end of the body casing 3 with each other.

50 **[0011]** The top plate 32 has a plurality of main reinforcing ribs 32a extending radially from a central portion 33 of the top plate 32 at which the fan 5 and the fan motor 9 are supported to a peripheral portion of the top plate 32 at which the generally annular heat exchanger 4 is supported. The main reinforcing ribs 32a are recessed in a downward direction. Each main reinforcing rib 32a has a predetermined width and a predetermined depth. Each main reinforcing rib 32a includes an outer part defining a heat exchanger support portion having a step portion 32b with a smaller recess depth. 55 The main reinforcing ribs 32a enable the top plate 32 to have the required levels of basic rigidity, strength, deflection, and vibration characteristics.

**[0012]** The interval between the main reinforcing ribs 32a increases toward the peripheral portion of the top plate 32. This made result in the top plate 32 having insufficient rigidity and strength. Accordingly, a plurality of sub-reinforcing

ribs 34 are arranged between the main reinforcing ribs 32a as shown in Fig. 24. The shape and dimensions of the sub-reinforcing ribs 34 are determined in accordance with the load that can be assumed to be applied to the top plate 32.

[0013] This structure is designed to reduce the static deflection of the top plate 32 to or below a fixed value and maintains the primary natural vibration frequency of the top plate 32 to or above a fixed value to avoid resonance caused by rotation of the fan motor 9.

[0014] The top plate 32 further includes a reinforcing rib 33a, which is triangular when viewed from above, arranged in at the central portion 33 where the fan 5 and the fan motor 9 are supported. This improves the rigidity, strength, deflection, and vibration characteristics of the supporting portion of the fan 5 and the fan motor 9 (refer to patent document 1).

[0015] The supporting portion of the fan 5 and the fan motor 9 includes a circular groove formed in each corner of the reinforcing rib 33a. The reinforcing rib 33a includes three fan motor mounting portions a, b, and c formed in central portions of the circular grooves. The fan motor 9 is suspended from and fixed to the fan motor mounting portions a, b, and c by mount members 11, which absorb vibrations, and a mounting bracket 9b. This rotatably supports the fan 5 by means of a motor shaft 9a.

Patent Document 1: Japanese Laid-Open Patent Publication No. 11-201496

[0016] In recent years, the cost of the air conditioner is required to be reduced from various perspectives. The cost of the top plate 32 used in the air conditioner is also required to be reduced. To reduce the cost of the top plate 32, the plate thickness of the entire the top plate 32 (for example, 0.8 mm) may be reduced (for example, to about 0.7 to 0.6 mm) to reduce material cost and facilitate formation of the ribs etc. However, reduction in the plate width would lower the rigidity and strength of the top plate 32 and require measures for suppressing vibrations of the top plate 32 generated when driving of the fan.

[0017] A top plate formed with a lower plate thickness than the existing plate decreases material cost and is easily deformed. This enables the force that is required for pressing and forming the top plate and facilitates formation of the top plate. However, when a thinner top plate includes the radial reinforcing ribs of the above-described conventional structure, the amount of static deflection increases and the primary natural vibration frequency resulting from rotation of the fan motor 9 decreases. As a result, the top plate would not satisfy the design standards.

## DISCLOSURE OF THE INVENTION

[0018] Accordingly, it is an object of the present invention to provide a top plate structure for an air conditioner that enables a top plate that is thin yet has the required rigidity, strength, and vibration characteristics.

[0019] A first aspect of the present invention provides a top plate structure for an air conditioner including a body casing for accommodating a fan, a fan motor, and a heat exchanger. A top plate forming a top surface of the body casing suspends the fan, the fan motor, and the heat exchanger. The top plate has a plurality of radial reinforcing ribs extending from a central portion of the top plate at which the fan motor is supported to a peripheral portion of the top plate at which the heat exchanger is supported. The plurality of reinforcing ribs include a reinforcing rib protruding from a front surface of the top plate and a reinforcing rib protruding from a rear surface of the top plate.

[0020] With such a top plate structure, even if the top plate is thinner than a conventional top plate, by optimally adjusting and setting the quantity, the cross-sectional shape (diaphragm shape), the depth, and the width of the reinforcing ribs, the top plate is provided with the required levels of rigidity, strength, deflection, and vibration characteristics. In particular, the structure in which the reinforcing rib portions protrude in two directions from the front surface and the rear surface of the top plate substantially doubles the vertical wall height dimensions of the top plate between the front and rear surfaces. This greatly improves rigidity of the top plate against deflection. As a result, the plate thickness of the top plate can be decreased, the formation of the top plate is facilitated, and the manufacturing cost of the top plate is decreased.

[0021] It is preferred that the reinforcing rib protruding from the front surface of the top plate and the reinforcing rib protruding from the rear surface are alternately arranged in a circumferential direction of the top plate. This improves the supporting rigidity of the top plate in a balanced manner throughout the entire top plate and uniformly reduces the maximum deflection amount of the top plate.

[0022] It is preferred that the plurality of reinforcing ribs include a plurality of long main reinforcing ribs and a plurality of short sub-reinforcing ribs arranged between the main reinforcing ribs, and the main reinforcing ribs protrude from one of a front surface and a rear surface of the top plate and the sub-reinforcing ribs protrude from the other one of the front surface and the rear surface of the top plate. This improves the supporting rigidity of the top plate in a balanced manner throughout the entire top plate and uniformly reduces the maximum deflection amount of the top plate.

[0023] It is preferred that the reinforcing ribs each have a depth that changes in a longitudinal direction of the reinforcing rib, and the depth at two end portions of each reinforcing rib is less than the depth between the two end portions. This further effectively reduces the maximum deflection amount of the top plate and further improves the resonance rotation

speed of the top plate. As a result, further reduction in the cost of the top plate resulting from lower material cost can be expected.

[0024] It is preferred that the top plate has a plate thickness that is set in a range of 0.6 to 0.7 mm. The material cost is lowered and press formation is facilitated as the plate thickness of the top plate 32 decreases. However, the strength and rigidity of the top plate 32 decreases and the deflection characteristics and vibration characteristics of the top plate 32 deteriorate as the plate thickness of the top plate 32 decreases. The sub-reinforcing ribs are effective in compensating for such a situation. However, the top plate 32 would still require a certain plate thickness.

[0025] In one aspect of the present invention, the plate thickness of the top plate 32 may be reduced to a range of 0.6 to 0.7 mm, which is less than the plate thickness of 0.8 mm of the conventional top plate. This also ensures sufficiently support rigidity for the top plate 32. Accordingly, the cost of the top plate is effectively reduced through material cost reduction.

[0026] More specifically, this range of plate thickness (0.6 mm to 0.7 mm) is the optimal range of plate thickness that reduces material cost, facilitates formation, and ensures the required quality performance in view of the relationship between the plate thickness of the conventional top plate and the reinforcing effect of the reinforcing ribs.

[0027] It is preferred that the reinforcing ribs each have a depth of 8.0 to 10.0 mm. In the prior art, the design standard requires the maximum deflection of the top plate to be reduced to 1.31 mm or less and the resonance rotation speed of the top plate to be maintained at 742.0 rpm or higher. To satisfy the design standard and to maintain robustness of the static and dynamic characteristics of the top plate with respect to the depth of the reinforcing ribs, the appropriate depth of each reinforcing rib is 8.0 to 10.0 mm.

## BRIEF DESCRIPTION OF THE DRAWINGS

### [0028]

Fig. 1 is a bottom view showing a top plate structure on which a heat exchanger is arranged in a high location installation type air conditioner according to a first embodiment of the present invention;

Fig. 2 is a bottom view showing the top plate structure without the heat exchanger;

Fig. 3 is a front view showing the top plate;

Fig. 4 is a vertical cross-sectional view taken along line 4-4 in Fig. 2;

Fig. 5 is a horizontal cross-sectional view taken along line 5-5 in Fig. 2 showing the structure of a reinforcing rib portion as an essential portion of the top plate;

Fig. 6 is a cross-sectional view of the top plate taken in a longitudinal direction of ribs;

Fig. 7 is a bottom view showing a top plate structure of a basic model having six ribs fabricated to check the top plate characteristics;

Fig. 8 is a perspective view taken from a diagonally downward direction showing a top plate structure of a first test sample fabricated using the basic model of Fig. 6 (having six reinforcing ribs) in which all the reinforcing ribs protrude from only a rear surface of the top plate;

Fig. 9 is a bottom view of a top plate structure of a basic model having eight ribs fabricated to check the top plate characteristics;

Fig. 10 is a perspective view taken from a diagonally downward direction showing a top plate structure of a second test sample fabricated using the basic model of Fig. 9 (having eight reinforcing ribs) in which all the reinforcing ribs protrude from only a rear surface of the top plate;

Fig. 11 is a perspective view taken from a diagonally downward direction showing a top plate structure of a third test sample fabricated using the basic model of Fig. 9 (having eight reinforcing ribs) in which the reinforcing ribs protrude from both front and rear surfaces of the top plate;

Fig. 12 is a bottom view of a top plate structure of a basic model having ten ribs fabricated to check the top plate characteristics;

Fig. 13 is a perspective view taken from a diagonally downward direction showing a top plate structure of a fourth test sample fabricated using the basic model of Fig. 12 (having ten reinforcing ribs) in which all the reinforcing ribs protrude from only a rear surface of the top plate;

Fig. 14 is a perspective view taken from a diagonally downward direction showing a top plate structure of a fifth test sample fabricated using the basic model of Fig. 12 (having ten reinforcing ribs) in which the reinforcing ribs protrude from both front and rear surfaces of the top plate;

Fig. 15 is a bottom view of a top plate structure of a basic model having twelve ribs fabricated to check the top plate characteristics;

Fig. 16 is a perspective view taken from a diagonally downward direction showing a top plate structure of a sixth test sample fabricated using the basic model of Fig. 14 (having twelve reinforcing ribs) in which all the reinforcing ribs protrude from only a rear surface of the top plate;

Fig. 17 is a graph showing the relationship between the quantity of ribs and the maximum deflection amount of top plates of first, second, fourth, and sixth test samples on which radial ribs are arranged only on one side of each top plate;

Fig. 18 is a graph showing the relationship between the quantity of ribs and the resonance rotation speed of top plates of first, second, fourth, and sixth test samples on which radial ribs are arranged only on one side of each top plate;

Fig. 19 is a graph showing the relationship between the depth of ribs and the maximum deflection amount of top plates of test samples 3 and 5 on which radial ribs are arranged on both sides of each top plate;

Fig. 20 is a graph showing the relationship between the depth of ribs and the resonance rotation speed of top plates of test samples 3 and 5 on which radial ribs are arranged on both sides of each top plate;

Fig. 21 is a bottom view showing a top plate structure for a high location installation type air conditioner according to a second embodiment of the present invention;

Fig. 22 is a vertical cross-sectional view taken along line 22-22 of Fig. 24 showing an overall structure of a conventional air conditioner;

Fig. 23 is a bottom view showing the conventional air conditioner from which a decorative panel and a body casing are removed and viewed from below; and

Fig. 24 is an exploded perspective view showing the attachment position relationship between a top plate and a bell mouth of the conventional air conditioner.

## BEST MODE FOR CARRYING OUT THE INVENTION

**[0029]** Figs. 1 to 6 show a top plate structure for a high location installation type air conditioner according to a first embodiment of the present invention.

**[0030]** A top plate 32 of the first embodiment is optimal for application to a body casing 3 of a ceiling concealed air conditioner (indoor unit) that is substantially the same as that of the conventional example described with reference to Figs. 22 to 24.

**[0031]** As shown in Fig. 4, the top plate 32 has a plate thickness  $D_4$  set at 0.7 mm, which is smaller than a thickness of 0.8 mm of a conventional top plate. As shown Figs. 1 and 2, the top plate 32 is hexagonal and shaped in correspondence with the cassette body casing 3 of the air conditioner. The top plate 32 has a peripheral portion along which a hook-shaped rim portion 32c is formed to be fitted with the peripheral portion of an upper end of the body casing 3.

**[0032]** In the same manner as in the conventional system shown in Figs. 22 to 24, the top plate 32 has a central portion 33 supporting a fan 5 and a fan motor 9 and a peripheral portion supporting a generally annular heat exchanger 4. As shown in Figs. 4 and 5, the top plate 32 includes two different kinds of reinforcing ribs, namely, a plurality of radially extending reinforcing ribs 32a and a plurality of radially extending reinforcing ribs 32a'. The reinforcing ribs 32a and 32a' extend from the central portion 33 to the peripheral portion of the top plate 32. The reinforcing ribs 32a and 32a' protrude alternately from front and rear surfaces of the top plate 32. The reinforcing ribs 32a and 32a' each have an inverted trapezoidal cross-sectional shape and each have a bottom surface width  $W_1$ , a top width  $W_2$ , a depth  $D_2$ , and an inclination angle  $\theta_2$ . A heat exchanger support portion located on the outer end of each reinforcing ribs 32a, among the reinforcing ribs 32a and 32a', has a step portion 32b. The step portion 32b of each reinforcing rib 32a is recessed downward with a depth  $D_3$  smaller than the depth  $D_2$  by a predetermined dimension.

**[0033]** The top plate 32 further has a reinforcing rib 33a having a depth  $D_1$  arranged on a supporting portion for the fan 5 and the fan motor 9 in the central portion 33. The depth  $D_1$  is equal to the depth  $D_2$ . The reinforcing rib 33a extends between five fan motor support portions a to e, which enable supporting at three points or four points, and is in contact with the fan motor support portions a to e. The reinforcing rib 33a effectively improves rigidity, strength, deflection, and vibration characteristics of the supporting portion of the fan 5 and the fan motor 9.

**[0034]** As shown in Fig. 1, heavy components including the heat exchanger 4, the fan 5, and the fan motor 9 are attached to the top plate 32 in the same manner as in the conventional structure.

**[0035]** As described above, the structure of the present embodiment includes the radial reinforcing ribs 32a' and 32a extending from the central portion 33 of the top plate 32 on which the fan motor 9 is supported to the peripheral portion of the top plate 32 on which the heat exchanger 4 is supported. The reinforcing ribs 32a' protrude from the front surface of the top plate 32, and the reinforcing ribs 32a protrude from the rear surface of the top plate 32.

**[0036]** With this top plate structure, even when the top plate 32 is formed to have a smaller plate thickness than the conventional top plate, by optimally adjusting and setting the quantity and the cross-sectional shape (diaphragm shape) of the reinforcing ribs 32a' and 32a in a wide range, the top plate 32 may be improved to the required levels for rigidity, strength, deflection characteristics, vibration characteristics, and the like. In particular, the structure in which the reinforcing rib portions protrude both from the front surface and the rear surface of the top plate 32 substantially doubles the vertical wall height dimensions of the top plate 32 between its front and rear surfaces and greatly improves rigidity of the top plate 32 against deflection. This structure reduces the plate thickness of the top plate 32 and facilitates the

formation of the top plate 32, thereby reducing the manufacturing cost of the top plate 32.

**[0037]** Further, the reinforcing ribs 32a' protruding from the front surface of the top plate 32 and the reinforcing ribs 32a protruding from the rear surface of the top plate 32 are arranged alternately in the circumferential direction. This structure improves the supporting rigidity of the top plate 32 in a balanced manner throughout the entire top plate 32 and uniformly reduces the maximum deflection amount of the top plate 32 throughout the entire top plate 32.

**[0038]** The reinforcing ribs 32a' and 32a are each formed to have a depth  $h$  that changes so as to decrease as the two end portions in the longitudinal direction (radial direction) become closer and increase as the portion between the two end portions become closer. When  $h_1$  represents the depth of the two end portions of each reinforcing rib and  $h_2$  represents the depth of the intermediate portion between the two end portions,  $h_1 < h_2$  is satisfied.

**[0039]** In this manner, the depth of each of the reinforcing ribs 32a and 32a' changes in the longitudinal direction to have a smaller depth in the two end portions and a larger depth in the intermediate portion between the two end portions. This further effectively reduces the maximum deflection amount of the top plate 32, improves the resonance rotation speed of the top plate 32, and reduces the cost of the top plate 32 by lowering material cost.

**[0040]** In the present embodiment, the plate thickness of the top plate 32 is set in the range of 0.6 to 0.7 mm. The material cost for the top plate 32 decreases and press formation of the top plate 32 is facilitated as the plate thickness of the top plate 32 decreases. However, the strength and rigidity of the top plate 32 decreases and the deflection and vibration characteristics of the top plate 32 deteriorate as the plate thickness of the top plate 32 decreases. The reinforcing ribs 32a' and 32a having the above-described structure effectively prevent such characteristics of the top plate 32 from deteriorating. However, the top plate 32 still needs to have a certain level of plate thickness.

**[0041]** Various experiments have been conducted from the viewpoints described above. The experimental results indicate that the top plate structure using the reinforcing ribs 32a' and 32a described above enables the plate thickness of the top plate 32 to be reduced to a range of 0.6 to 0.7 mm. The structure enables the top plate 32 with such reduced plate thicknesses to have sufficiently high supporting rigidity and stable vibration characteristics. As a result, the cost of the top plate 32 can be expected to be effectively decreased by the lowered material cost.

**[0042]** This range of plate thickness is optimum for lowering the material cost of the top plate 32, facilitating formation of the top plate 32, and ensuring the required quality performance. This plate thickness range is determined based on the relationship between the plate thickness of the conventional top plate and the reinforcing effect of the reinforcing ribs described above.

**[0043]** The top plate structure for the high location installation type air conditioner according to the preferred embodiment enables the top plate to have stable supporting rigidity, supporting strength, and low-noise performance while reducing the thickness of the top plate and reducing the cost of the top plate.

(Test Examples)

**[0044]** Analytical experiments described below verify the effect of the radial reinforcing ribs 32a' and 32a protruding from the front and rear surfaces of the top plate.

(1) Test Samples

**[0045]** First, four models of top plates that differ from one another in the quantity of reinforcing ribs shown in Fig. 7 (six ribs), Fig. 9 (eight ribs), Fig. 12 (ten ribs), and Fig. 15 (12 ribs) irrespective of the protruding direction of the ribs are used as basic models. A top plate having ribs 32a arranged only on one side and a top plate having ribs 32a' and 32a arranged on two sides were prepared using each of the basic models of Fig. 9 (eight ribs) and Fig. 12 (ten ribs). A top plate having ribs 32a arranged only on one side was prepared using each of the basic models of Fig. 7 (six ribs) and Fig. 15 (twelve ribs). The six top plates 32A to 32F of test samples 1 to 6 were prepared in total. All the top plates 32A to 32F have the plate thickness of 0.7 mm. Refer to Table 1 for the specifications of the top plates 32A and 32F.

**[0046]** In Table 1, the root R (mm) indicates the radius of an arc linking basal ends of a pair of adjacent reinforcing ribs.

Table 1

| Sample No.    | 1     | 2    | 3    | 4    | 5    | 6   |
|---------------|-------|------|------|------|------|-----|
| Quantity      | 6     | 8    | 8    | 10   | 10   | 12  |
| Width W (mm)  | 60.0  |      |      |      |      |     |
| Length L (mm) | 696.0 |      |      |      |      |     |
| Root R (mm)   | 81.0  | 39.0 | 39.0 | 20.0 | 20.0 | 9.5 |

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(continued)

| Sample No.   |           | 1   | 2   | 3   | 4   | 5   | 6   |
|--------------|-----------|-----|-----|-----|-----|-----|-----|
| Quantity     |           | 6   | 8   | 8   | 10  | 10  | 12  |
| Depth h (mm) | One Side  | 9.5 | 6.0 | -   | 9.5 | -   | 9.5 |
|              | Two Sides | -   | -   | 8.0 | -   | 9.5 | -   |

## a) First Top Plate 32A

**[0047]** As shown in Fig. 7, the first top plate 32A includes six reinforcing ribs 32a that are arranged at equal intervals of 60 degrees in the circumferential direction. The dimension (length) between the two distal ends of two opposing reinforcing ribs 32a arranged at an interval of 180 degrees is 696.0 mm. Each reinforcing rib 32a has a groove width W of 60.0 mm. The reinforcing ribs 32a protrude from only either one of the front surface and the rear surface of the top plate 32A (refer to Fig. 8).

## b) Second Top Plate 32B

**[0048]** As shown in Fig. 9, the second top plate 32B includes eight reinforcing ribs 32a that are arranged at equal intervals of 45 degrees in the circumferential direction. The dimension (length) between the two distal ends of two opposing reinforcing ribs 32a arranged at an interval of 180 degrees is 696.0 mm. Each reinforcing rib 32a has a groove width W of 60.0 mm. The reinforcing ribs 32a protrude from only either one of the front surface and the rear surface of the top plate 32B (refer to Fig. 10).

## (c) Third Top Plate 32C

**[0049]** As shown in Fig. 9, the third top plate 32C includes eight reinforcing ribs 32a' and 32a that are arranged at equal intervals of 45 degrees in the circumferential direction. The dimension (length) between the two distal ends of two opposing reinforcing ribs 32a' and 32a arranged at an interval of 180 degrees is 696.0 mm. Each of the reinforcing ribs 32a' and 32a has a groove width W of 60.0 mm. The reinforcing ribs 32a' and 32a protrude alternately from both the front surface and the rear surface of the top plate 32C (refer to Fig. 11).

## d) Fourth Top Plate 32D

**[0050]** As shown in Fig. 12, the fourth top plate 32D includes ten reinforcing ribs 32a that are arranged at equal intervals of 36 degrees in the circumferential direction. The dimension (length) between the two distal ends of two opposing reinforcing ribs 32a' and 32a arranged at an interval of 180 degrees is 696.0 mm. Each reinforcing rib 32a has a groove width W of 60.0 mm. The reinforcing ribs 32a protrude from only either one of the front surface and the rear surface of the top plate 32D (refer to Fig. 13).

## e) Fifth Top Plate 32E

**[0051]** As shown in Fig. 12, the fifth top plate 32E includes ten reinforcing ribs 32a' and 32a that are arranged at equal intervals of 36 degrees in the circumferential direction. The dimension (length) between the two distal ends of two opposing reinforcing ribs 32a' and 32a arranged at an interval of 180 degrees is 696.0 mm. Each of the reinforcing ribs 32a' and 32a has a groove width W of 60.0 mm. The reinforcing ribs 32a' and 32a protrude alternately from both the front surface and the rear surface of the top plate 32E (refer to Fig. 14).

## f) Sixth Top Plate 32F

**[0052]** As shown in Fig. 15, the sixth top plate 32F includes twelve reinforcing ribs 32a that are arranged at equal intervals of 30 degrees in the circumferential direction. The dimension (length) between the two distal ends of two opposing reinforcing ribs 32a arranged at an interval of 180 degrees is 696.0 mm. Each reinforcing rib 32a has a groove width W of 60.0 mm. The reinforcing ribs 32a protrude from only either one of the front surface and the rear surface of the top plate 32F (refer to Fig. 16).

1) Influence of Quantity of Radial Ribs Arranged Only on One Side

[0053] The influence of the quantity of ribs on the maximum deflection amount and the resonance rotation speed of each top plate 32 having the radial reinforcing ribs 32a protruding from only one side are shown in Table 2 and the graphs in Figs. 17 and 18. The reinforcing ribs 32a all have the same width W, length L, and depth h.

Table 2

| Rib Specifications |            | Maximum Deflection (mm) | Resonance Rotation Speed |           |
|--------------------|------------|-------------------------|--------------------------|-----------|
| Quantity           | Depth (mm) |                         | Primary                  | Secondary |
| 6                  | 9.5        | 1.60                    | 784.0                    | 990.0     |
| 8                  | 9.5        | 1.35                    | 907.0                    | 990.0     |
| 10                 | 9.5        | 1.32                    | 914.0                    | 940.0     |
| 12                 | 9.5        | 1.41                    | 890.0                    | 917.0     |

[0054] The following findings were obtained from the analysis results shown in Table 2 and the graphs in Figs. 17 and 18.

[0055] The overall static characteristics and dynamic characteristics of the top plate 32 including eight reinforcing ribs 32a and the top plate 32 including ten reinforcing ribs 32a are superior to the static and dynamic characteristics of the top plate 32 including six reinforcing ribs 32a and the top plate 32 including twelve reinforcing ribs 32a.

[0056] The top plate 32 including eight reinforcing ribs 32a and the top plate 32 including ten reinforcing ribs 32a have substantially the same deflection amount (1.35/1.32 mm) and substantially the same primary resonance rotation speed (907.0/914.0 rpm). However, the top plate 32 including eight ribs has the secondary resonance rotation speed of 990.0 rpm, and the top plate 32 including ten ribs has the secondary resonance rotation speed of 940.0 rpm, which is 5.0% lower than the secondary resonance rotation speed of the top plate 32 including eight ribs. The top plate 32 including eight reinforcing ribs 32a is assumed to have the best static and dynamic characteristics.

2) Influence of Depth of Radial Ribs and Influence of Radial Ribs Arranged on One Side or Two Sides

[0057] The influence of the depth h of the radial ribs on the maximum deflection amount and the resonance rotation speed of the top plate 32 including eight radial reinforcing ribs protruding from one side (32a) and the top plate 32 including radial reinforcing ribs protruding from two sides (32a' and 32a) is shown in Table 3 and the graphs in Figs. 19 and 20.

Table 3

| Rib Specifications |            | Maximum Deflection (mm) |           | Resonance Rotation Speed (rpm) |          |           |          |
|--------------------|------------|-------------------------|-----------|--------------------------------|----------|-----------|----------|
| Quantity           | Depth (mm) | One Side                | Two Sides | Primary                        |          | Secondary |          |
|                    |            |                         |           | Two Sides                      | One Side | Two Sides | One Side |
| 8                  | 6.0        | 1.89                    | 2.03      | 786.0                          | 754.0    | 925.0     | 816.0    |
|                    | 8.0        | 1.39                    | 1.57      | 899.0                          | 848.0    | 1033.0    | 915.0    |
|                    | 9.5        | 1.16                    | 1.35      | 970.0                          | 907.0    | 1115.0    | 990.0    |
| 10                 | 9.5        | 1.17                    | 1.32      | 936.0                          | 914.0    | 1061.0    | 940.0    |

[0058] The following findings are obtained from the analysis results.

[0059] The top plates 32 having the single-side rib arrangement (32a) and the double-side rib arrangement (32a' and 32a) both have a smaller maximum deflection amount and a higher resonance rotation speed as the depth of their ribs increases. This indicates that an increase in the rib depth improves the static characteristics of the top plates 32.

[0060] Table 3 and the graphs in Figs. 19 and 20 show that the top plates 32 having the double-side rib arrangement have better static and dynamic characteristics than the top plates 32 having the single-side rib arrangement.

[0061] The inventors of the present application further researched changes in the maximum deflection amount and the resonance rotation speed resulting from different rib depths of the top plate 32 when using a plurality of parallel ribs in lieu of the radial ribs described above. More specifically, the inventors measured the maximum deflection amount and the resonance rotation speed of the top plates 32 having a single-side rib arrangement of parallel ribs and a double-side



rib arrangement of parallel ribs.

**[0062]** The measurement results show that the maximum deflection amount and the resonance rotation speed of the top plate 32 are significantly affected by the rib depth when the depth of the parallel ribs is 2.0 to 6.0 mm and relatively shallow. This indicates that small differences in the rib depth greatly change the maximum deflection amount and the resonance rotation speed of the top plates 32 when the rib depth is relatively small. Thus, robustness of the static and dynamic characteristics of the top plates 32 with respect to the rib depth is low when the rib depth is relatively small.

**[0063]** When the rib depth is 8.0 to 12.0 mm and relatively large, the influence of the rib depth on the maximum deflection amount and the resonance rotation speed of the top plates 32 decreases. This indicates that small differences in the rib depth do not greatly change the maximum deflection amount and the resonance rotation speed of the top plate 32 when the rib depth is relatively large. Thus, robustness of the static and dynamic characteristics of the top plates 32 with respect to the rib depth is high when the rib depth is relatively large.

**[0064]** When the rib depth is 14.0 to 18.0 mm and deep, the influence of the rib depth on the maximum deflection amount and the resonance rotation speed of the top plates 32 is limited. This indicates that differences in the rib depth only slightly change the maximum deflection amount and the resonance rotation speed of the top plate 32 when the rib depth is large. Thus, robustness of the static and dynamic characteristics of the top plates 32 with respect to the rib depth is high when the rib depth is large.

**[0065]** These findings are also substantially applicable to top plates including radial reinforcing ribs.

**[0066]** The design standard requires that the maximum deflection amount of the top plate 32 be suppressed at 1.31 mm or less and that the resonance rotation speed be maintained at 742.0 rpm or higher.

**[0067]** The rib depth is preferably 8.0 to 10.0 mm to satisfy the design standard while maintaining robustness of the static and dynamic characteristics of the top plate 32 with respect to the rib depth.

(Second Embodiment)

**[0068]** Fig. 21 shows a top plate structure for a high location installation type air conditioner according to a second embodiment of the present invention.

**[0069]** A top plate 32 of the second embodiment is also optimal for application to a body casing 3 of a ceiling concealed air conditioner (indoor unit) that is substantially the same as that in the conventional example shown in Figs. 22 to 24.

**[0070]** The top plate 32 is formed to have a plate thickness of about 0.7 mm, which is smaller than the thickness of 0.8 mm of the conventional top plate. The top plate 32 is hexagonal and shaped in correspondence with the cassette body casing 3 of the air conditioner shown in Figs. 22 to 24. The top plate 32 has a peripheral portion along which a hook-shaped rim portion 32c is formed to be fitted with the peripheral portion of an upper end of the body casing 3.

**[0071]** A fan 5 and a fan motor 9 identical to the structures shown in Figs. 22 to 24 are supported on a central portion 33 of the top plate 32. A generally annular heat exchanger 4 is supported on the peripheral portion of the top plate 32. In the same manner as in the first embodiment, the top plate 32 includes a plurality of radially extending main reinforcing ribs 32a extending from the central portion 33 to the peripheral portion of the top plate 32. The main reinforcing ribs 32a protrude from a rear surface of the top plate 32. The main reinforcing ribs 32a each have an inverted trapezoidal cross-section and each have a bottom surface width  $W_1$ , a top width  $W_2$ , a depth  $D_2$ , and an inclination angle  $\theta_2$ . A heat exchanger support portion located on the outer side of each main reinforcing rib 32a has a step portion 32b. The step portion 32b is recessed downward with a depth  $D_3$  that is smaller than the depth  $D_2$  by a predetermined dimension (the dimension not shown).

**[0072]** The top plate 32 further has a reinforcing rib 33a having a depth  $D_1$  arranged on a supporting portion for the fan 5 and the fan motor 9 in the central portion 33. The depth  $D_1$  is equal to the depth  $D_2$ . The reinforcing rib 33a extends between five fan motor support portions a to e, which enable supporting at three points or four points, and is in contact with the fan motor support portions a to e.

**[0073]** This structure effectively improves basic rigidity, strength, deflection, and vibration characteristics of the supporting portion of the fan 5 and the fan motor 9. However, the interval between the main reinforcing ribs 32a in the peripheral portion of the top plate 32 is large. As a result, the peripheral portion of the top plate 32 may have insufficient rigidity, strength, etc.

**[0074]** Therefore, the top plate 32 further has a plurality of sub-reinforcing ribs 34 arranged between the main reinforcing ribs 32a as shown in the drawing. The shape and dimensions of the sub-reinforcing ribs are determined in accordance with the load assumed to be applied to the top plate 32. In the structure of the present embodiment, the main reinforcing ribs 32a protrude from the rear surface of the top plate 32, and the sub-reinforcing ribs 34 protrude from the surface opposite to the surface from which the main reinforcing ribs 32a protrude.

**[0075]** This structure reduces the static deflection of the top plate 32 to a fixed value or lower and maintains the primary natural vibration frequency of the top plate 32 at a fixed value or greater to avoid resonance caused by rotation of the fan motor 9.

**[0076]** Heavy components including the heat exchanger 4, the fan 5, and the fan motor 9 are attached to the top plate

32 having the above-described structure in the same manner as in the conventional structure.

[0077] As described above, the plurality of reinforcing ribs in the second embodiment include the long main reinforcing ribs 32a and the short sub-reinforcing ribs 34 arranged between the long reinforcing ribs 32a, and the main reinforcing ribs 32a protrude from either one of the front surface and the rear surface of the top plate 32, and the sub-reinforcing ribs 34 protrude from the surface opposite the surface from which the main reinforcing ribs 32a protrude.

[0078] The structure having the sub-reinforcing ribs 32a also has the same advantages as described in the first embodiment. This structure improves the supporting rigidity of the top plate 32 in a balanced manner throughout the entire top plate 32 and uniformly reduces the maximum deflection amount of the top plate 32.

[0079] This structure also reduces the sufficient plate thickness of the top plate 32 to 0.6 to 0.7 mm.

## Claims

1. A top plate structure for an air conditioner including a body casing (3) for accommodating a fan (5), a fan motor (9), and a heat exchanger (4), and a top plate (32) forming a top surface of the body casing for suspending the fan (5), the fan motor (9), and the heat exchanger (4), wherein the top plate (32) has a plurality of radial reinforcing ribs extending from a central portion of the top plate at which the fan motor (9) is supported to a peripheral portion of the top plate at which the heat exchanger (4) is supported, the top plate structure being **characterized in that**:

the plurality of reinforcing ribs include a reinforcing rib (32a') protruding from a front surface of the top plate (32) and a reinforcing rib (32a) protruding from a rear surface of the top plate.

2. The top plate structure according to claim 1, **characterized in that** the reinforcing rib (32a') protruding from the front surface of the top plate (32) and the reinforcing rib (32a) protruding from the rear surface are alternately arranged in a circumferential direction of the top plate (32).

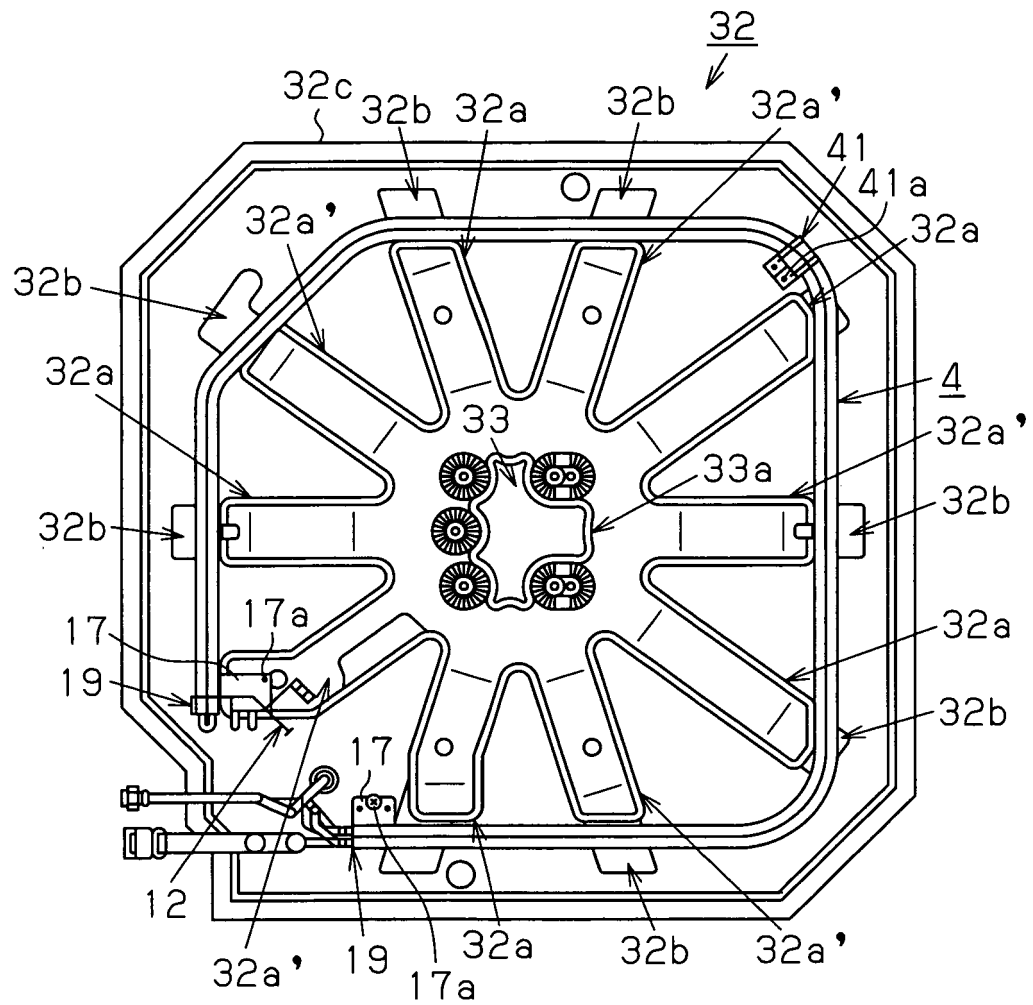
3. The top plate structure according to claim 1 or 2, **characterized in that** the plurality of reinforcing ribs include a plurality of long main reinforcing ribs (32a) and a plurality of short sub-reinforcing ribs (34) arranged between the main reinforcing ribs (32a), and the main reinforcing ribs protrude from one of a front surface and a rear surface of the top plate (32) and the sub-reinforcing ribs (34) protrude from the other one of the front surface and the rear surface of the top plate.

4. The top plate structure according to any one of claims 1 to 3, **characterized in that** the reinforcing ribs (32a'), (32a), (34) each have a depth that changes in a longitudinal direction of the reinforcing rib, and the depth at two end portions of each reinforcing rib is less than the depth between the two end portions.

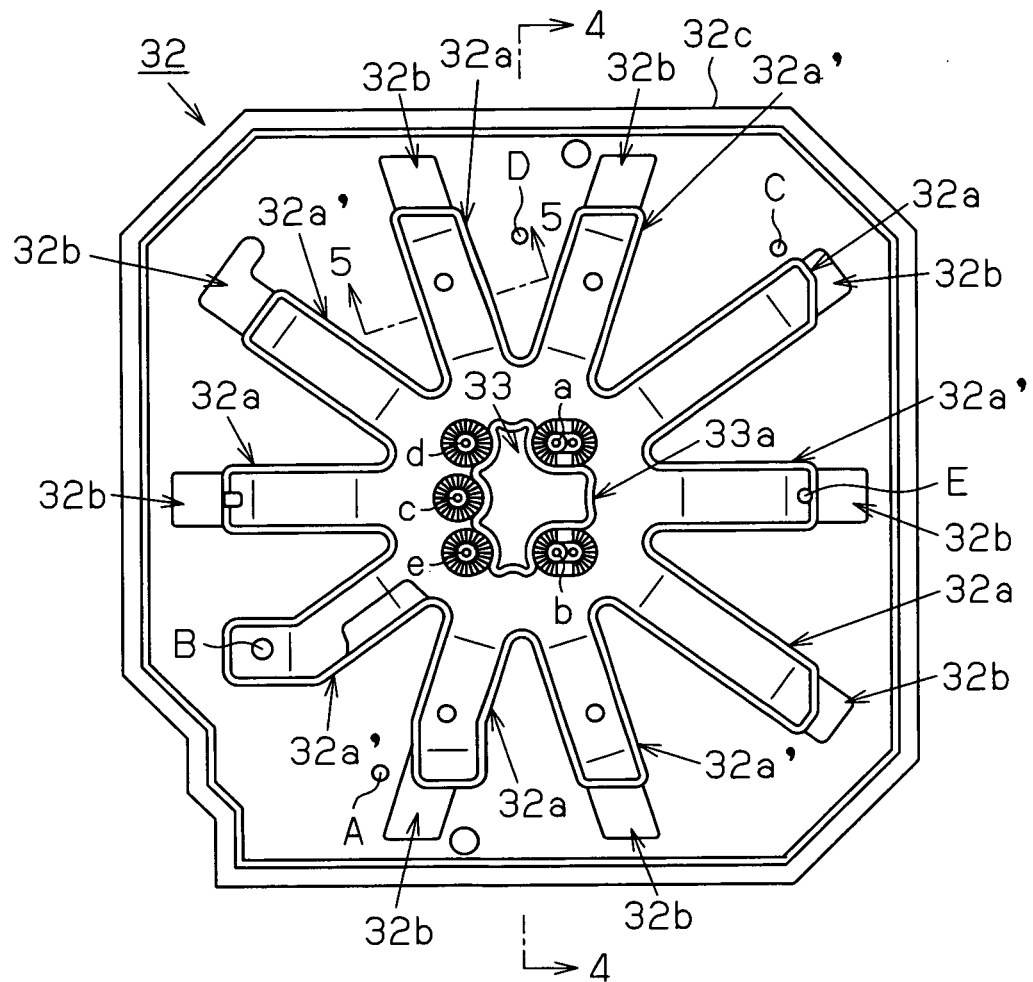
5. The top plate structure according to any one of claims 1 to 4, **characterized in that** the top plate (32) has a plate thickness that is set in a range of 0.6 to 0.7 mm.

6. The top plate structure according to any one of claims 1 to 5, **characterized in that** the reinforcing ribs (32a'), (32a), (34) each have a depth of 8.0 to 10.0 mm.

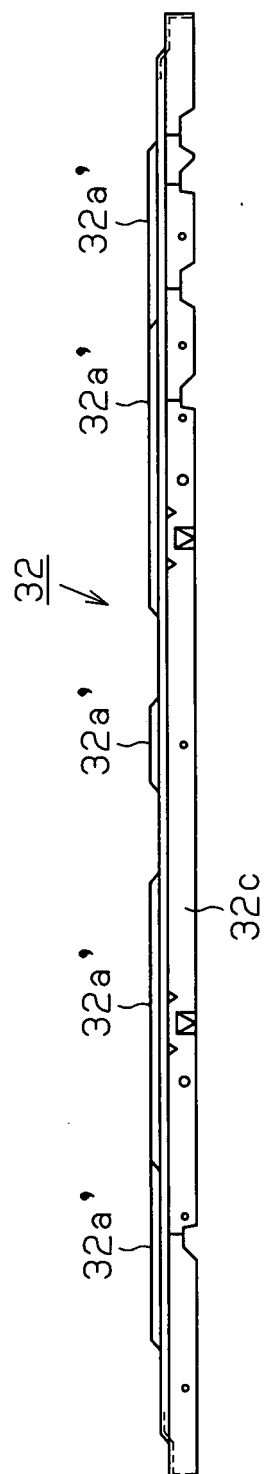
**Fig.1**



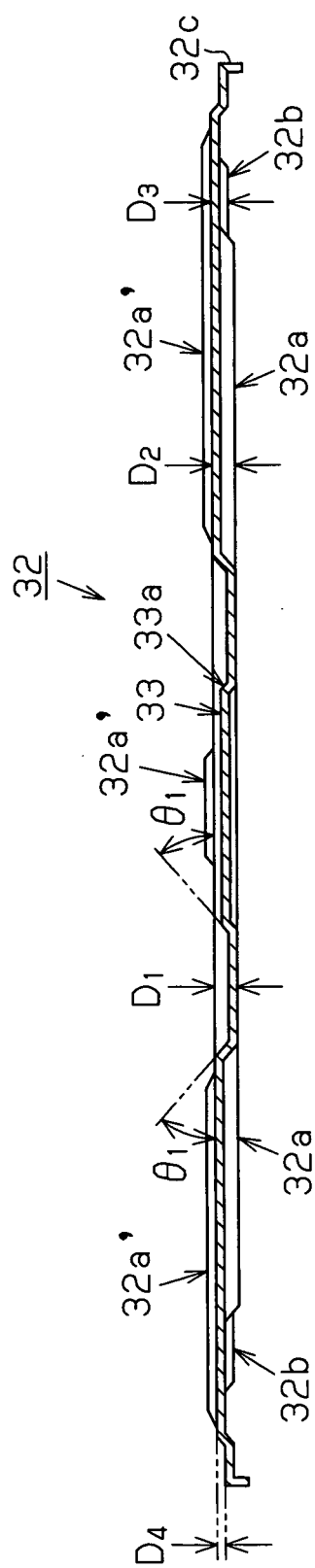
**Fig.2**



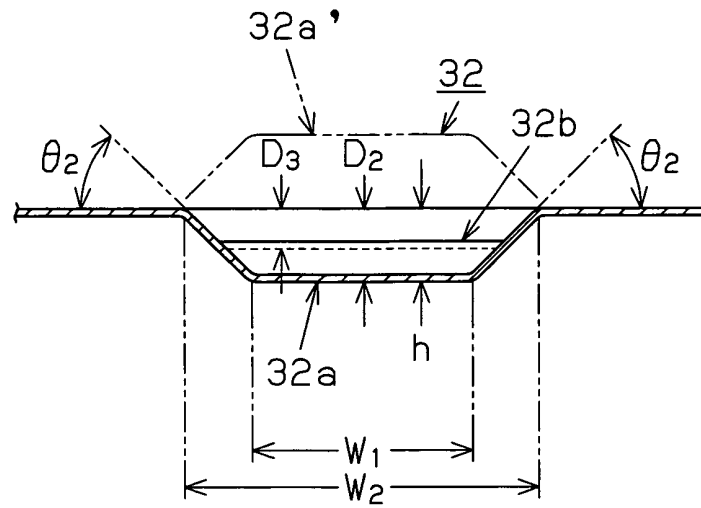
**Fig. 3**



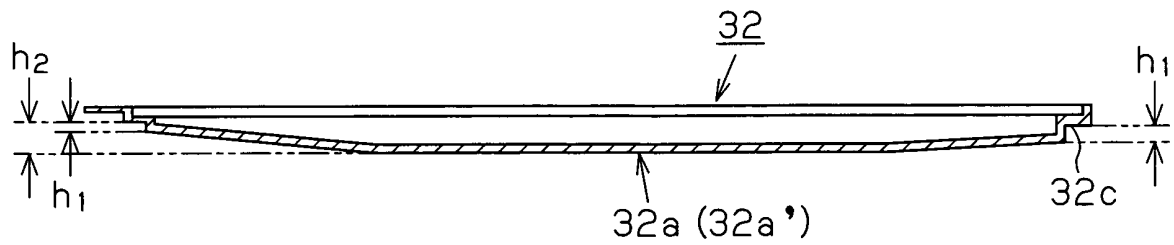
**Fig. 4**



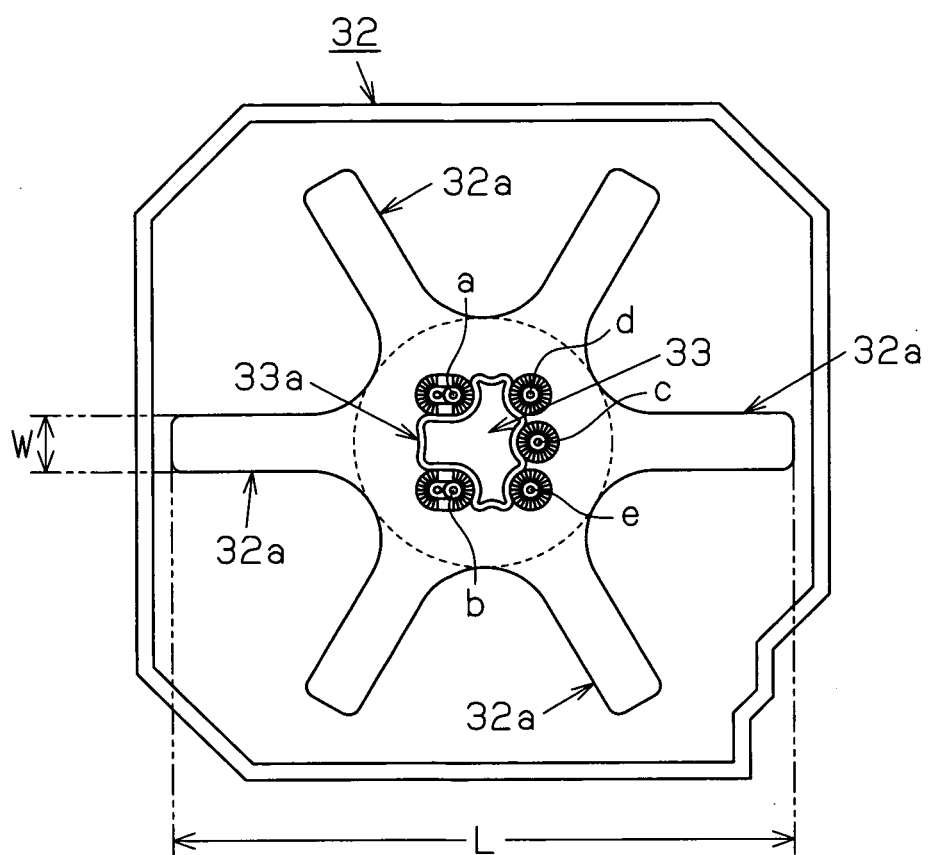
**Fig.5**



**Fig.6**

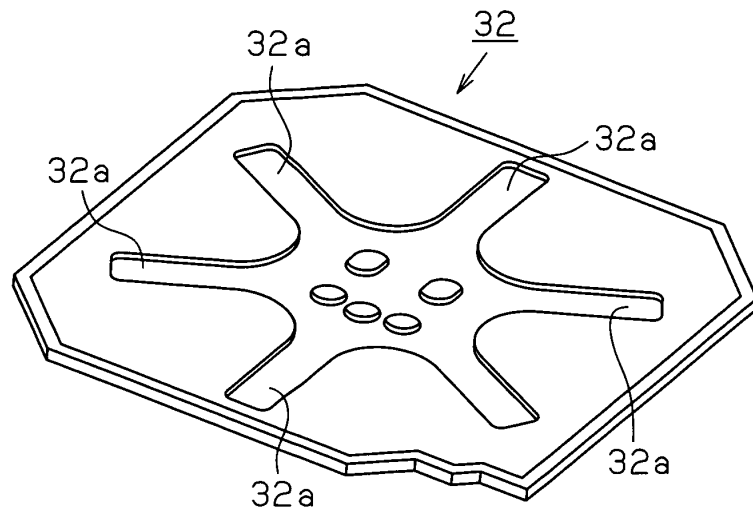


**Fig.7**

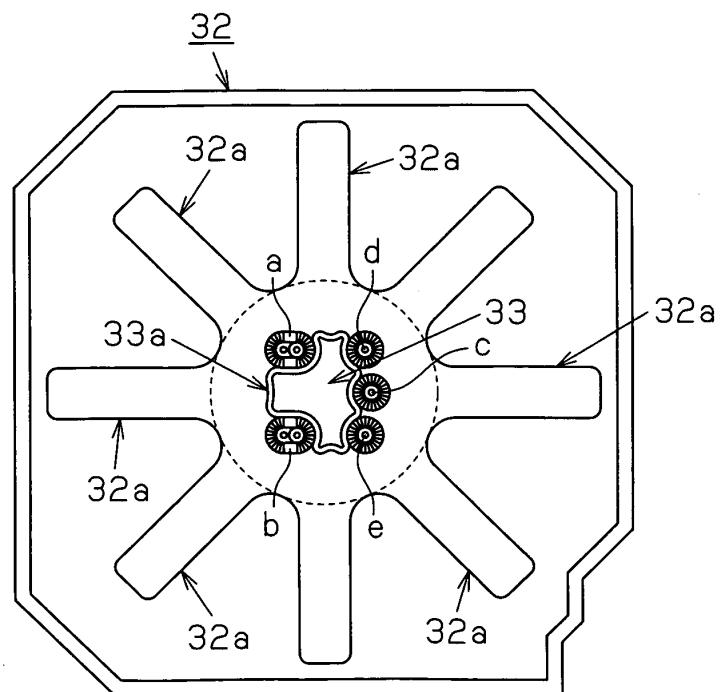




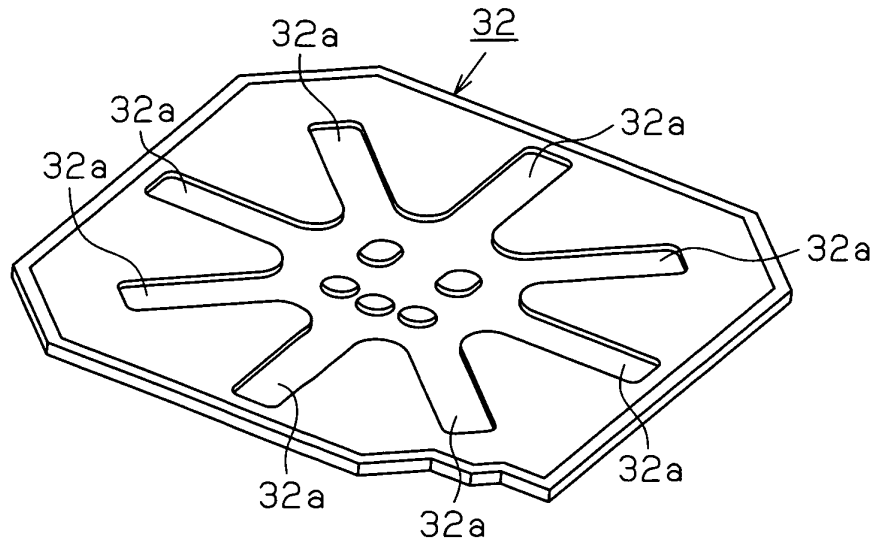
**Fig.8**



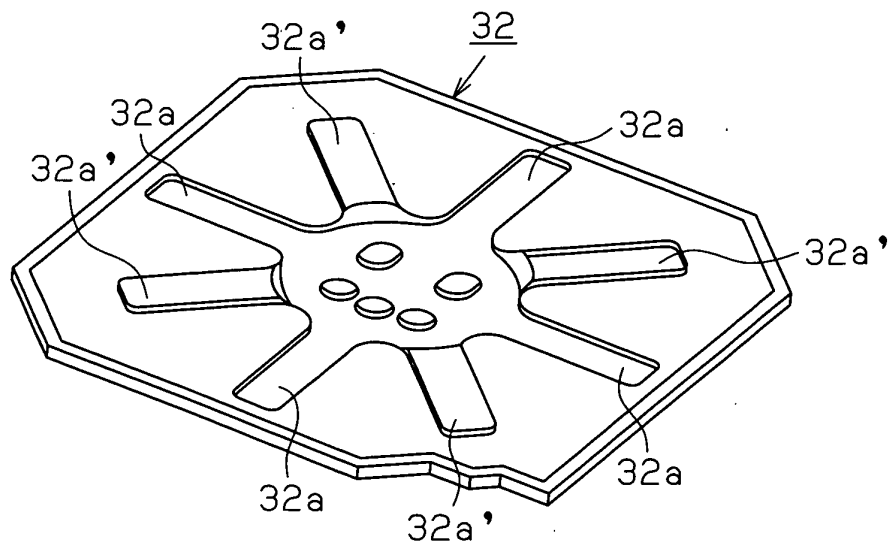
**Fig.9**



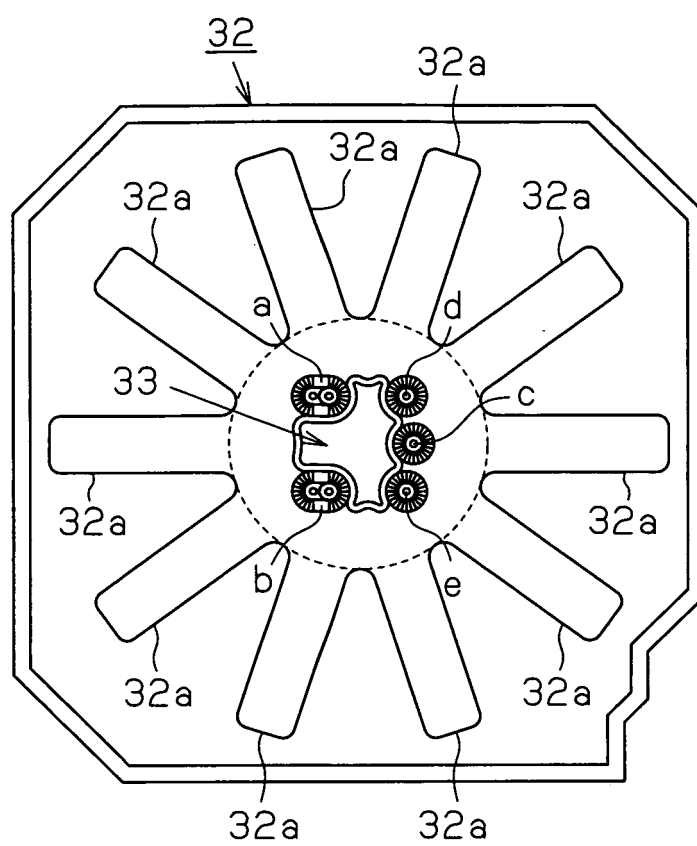
**Fig.10**



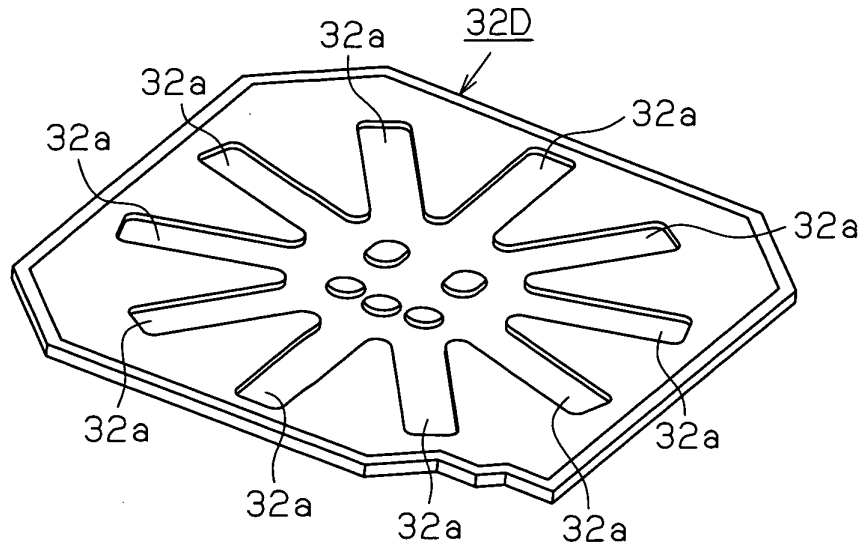
**Fig.11**



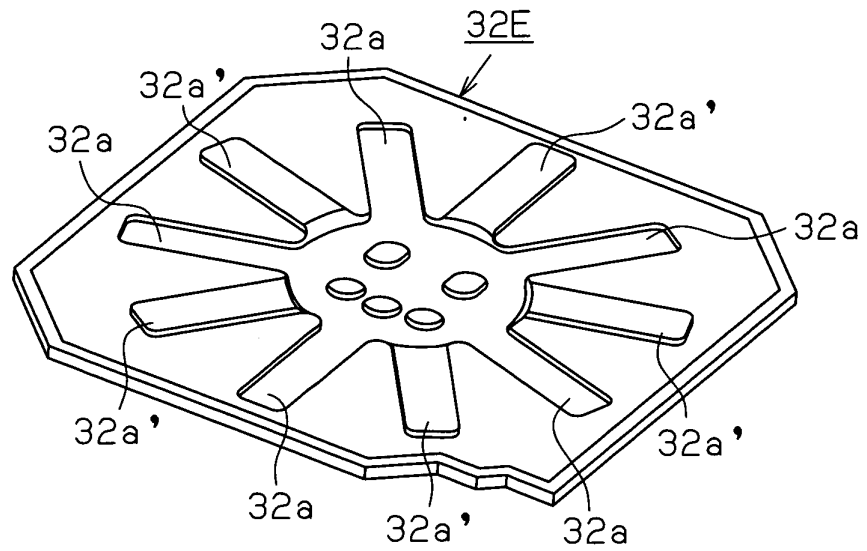
**Fig.12**



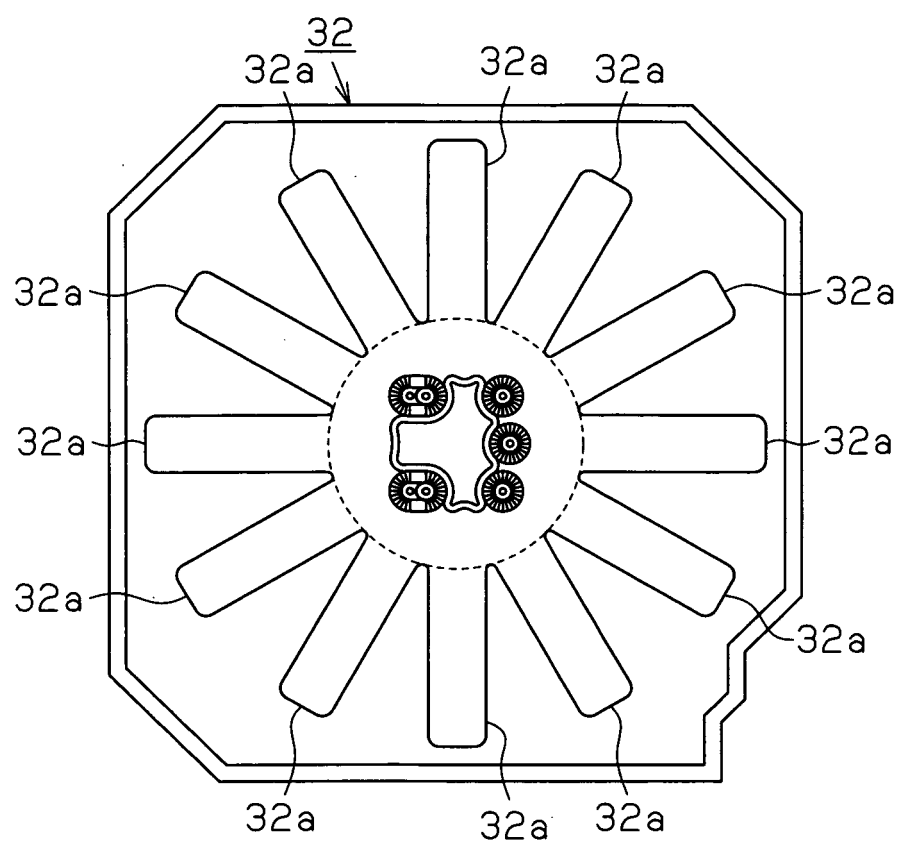
**Fig.13**



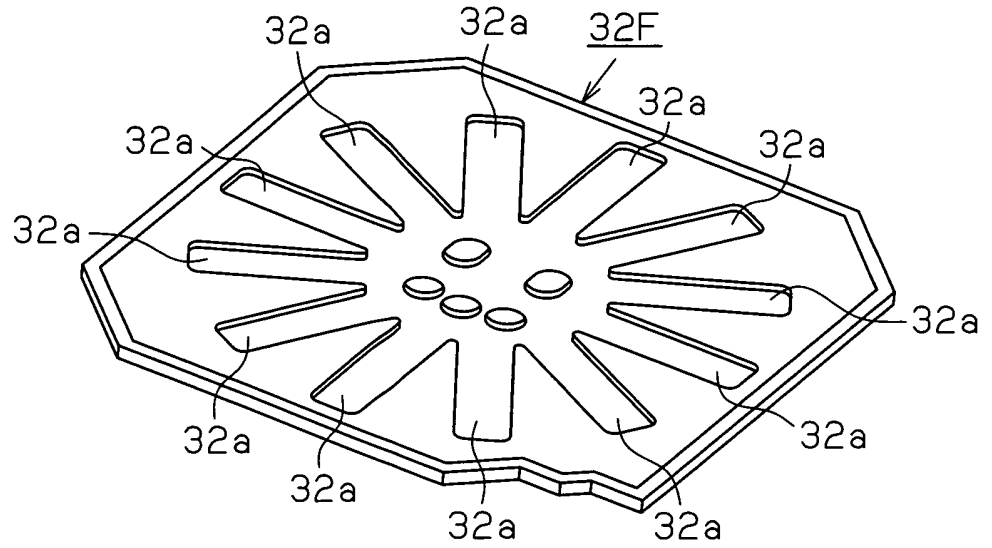
**Fig.14**



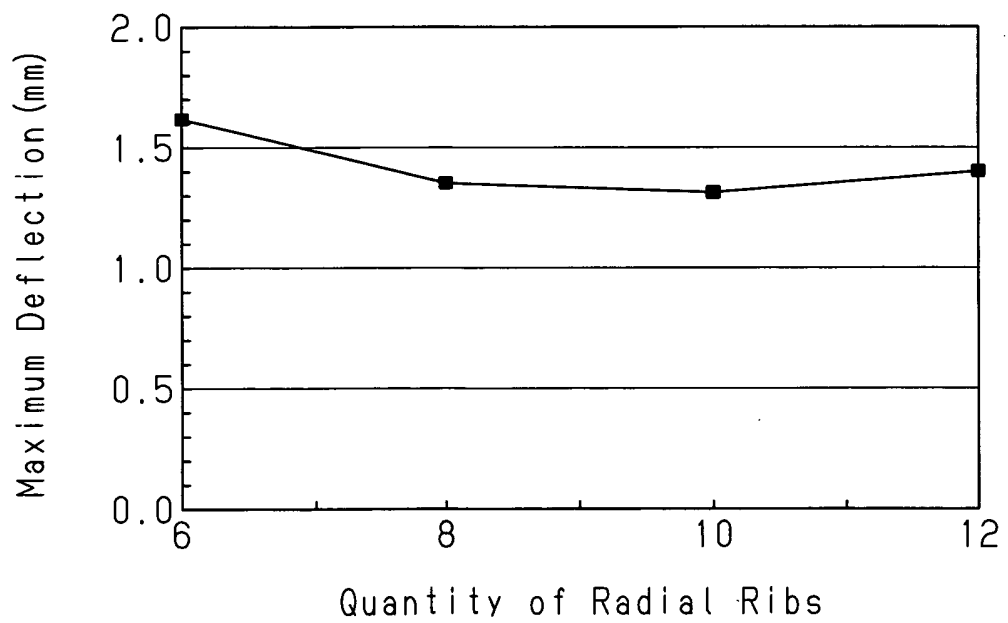
**Fig.15**

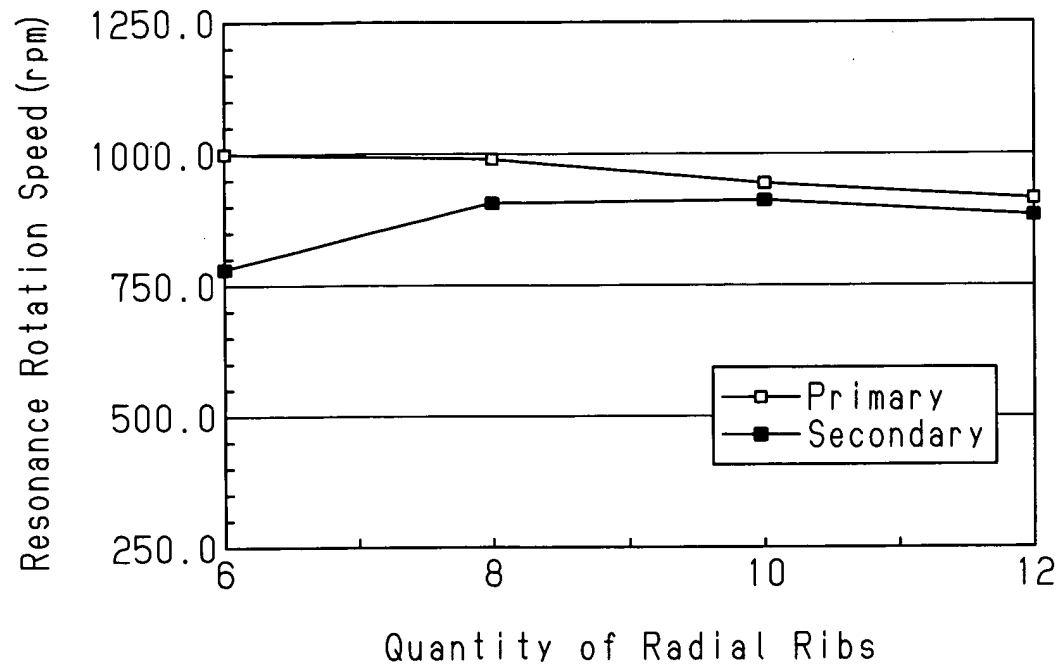
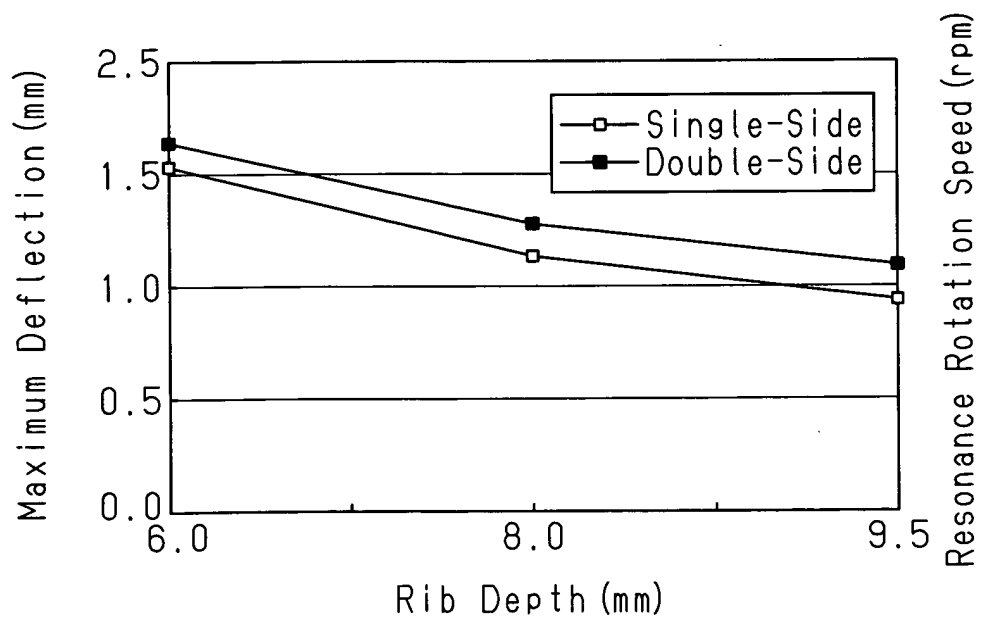


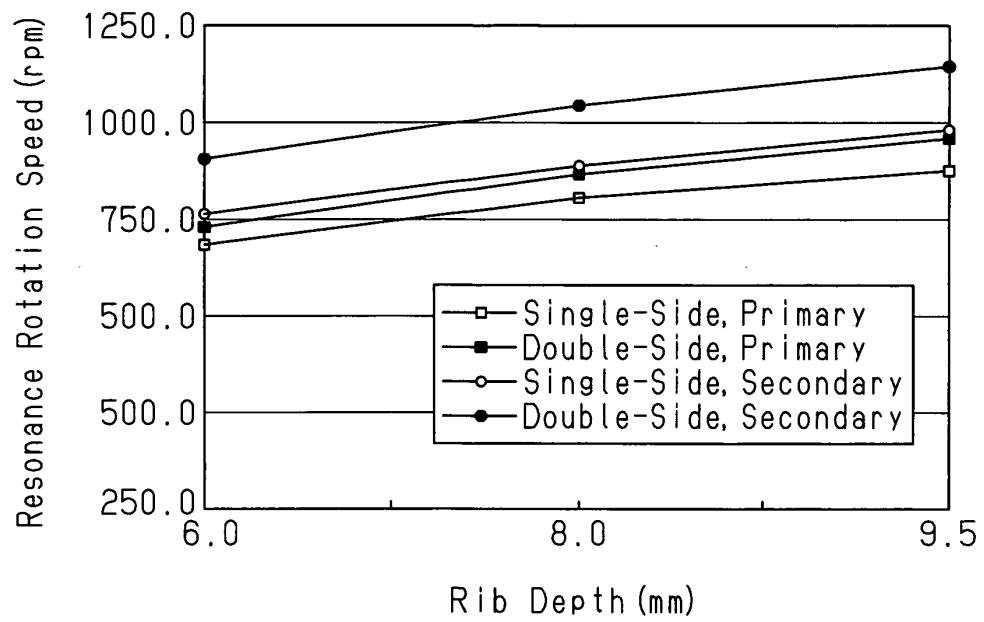
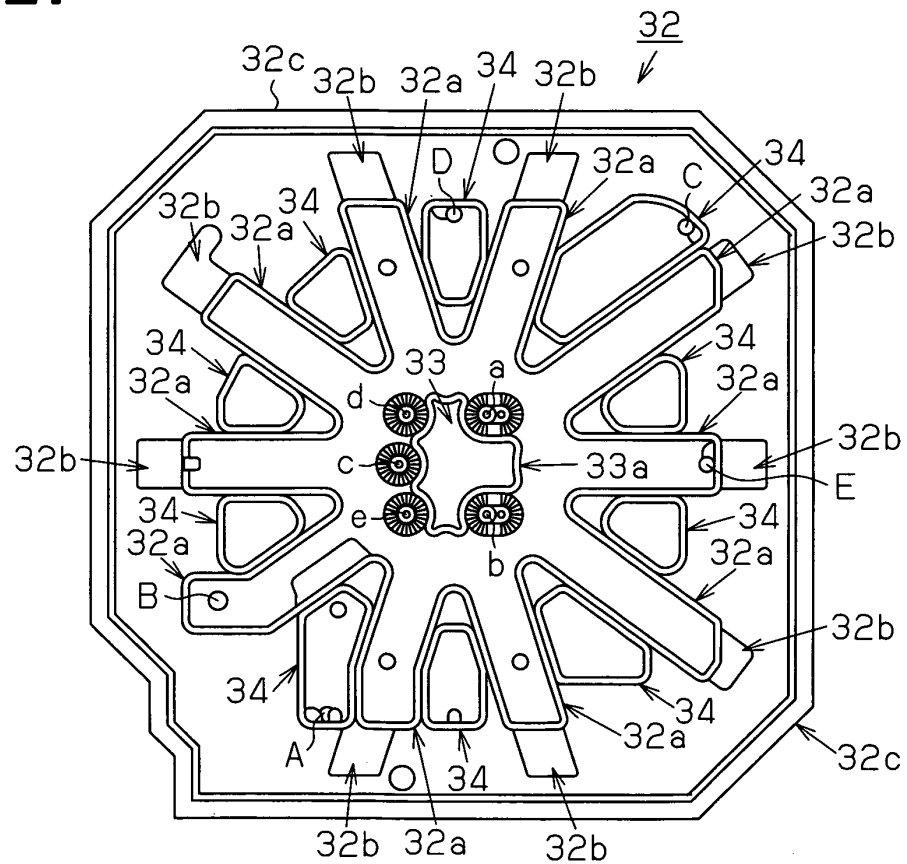
**Fig.16**



**Fig.17**

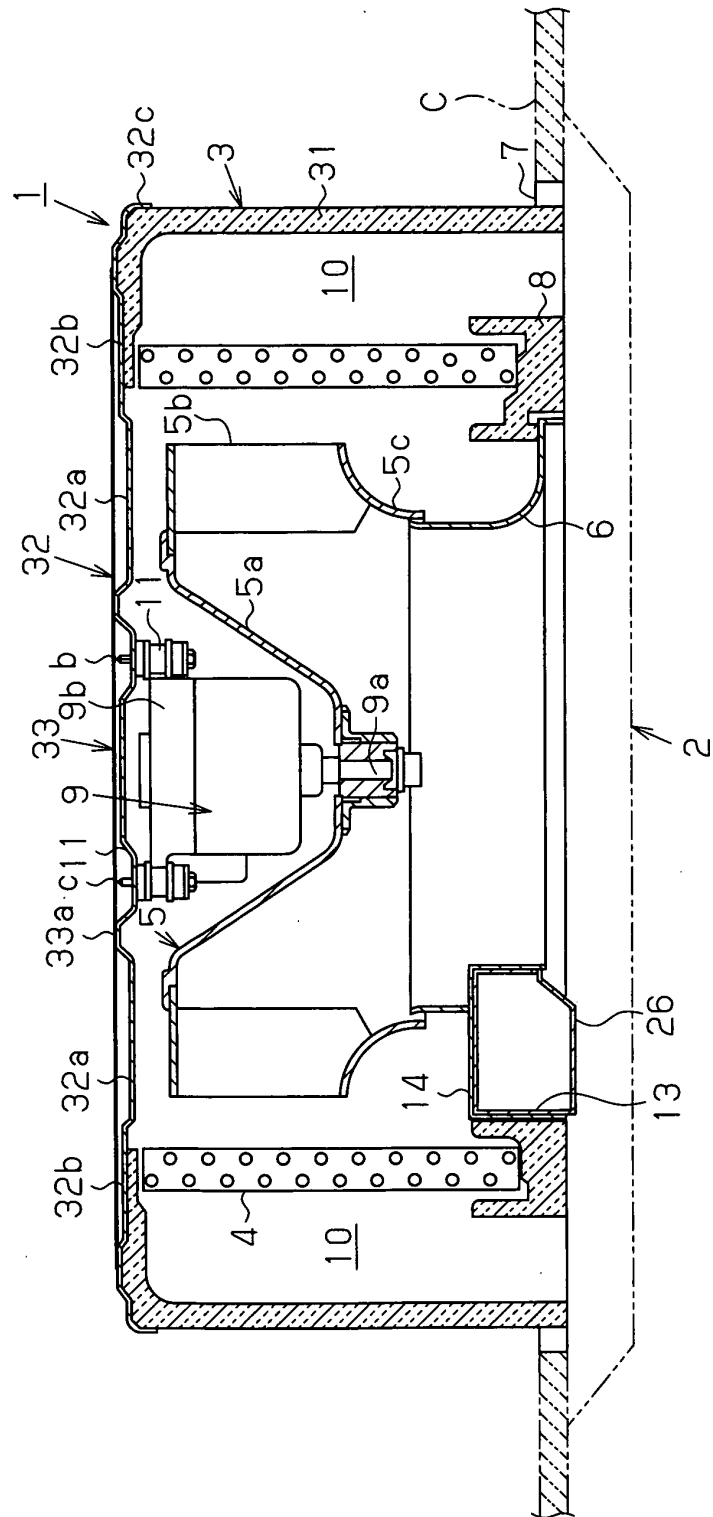


**Fig.18****Fig.19**

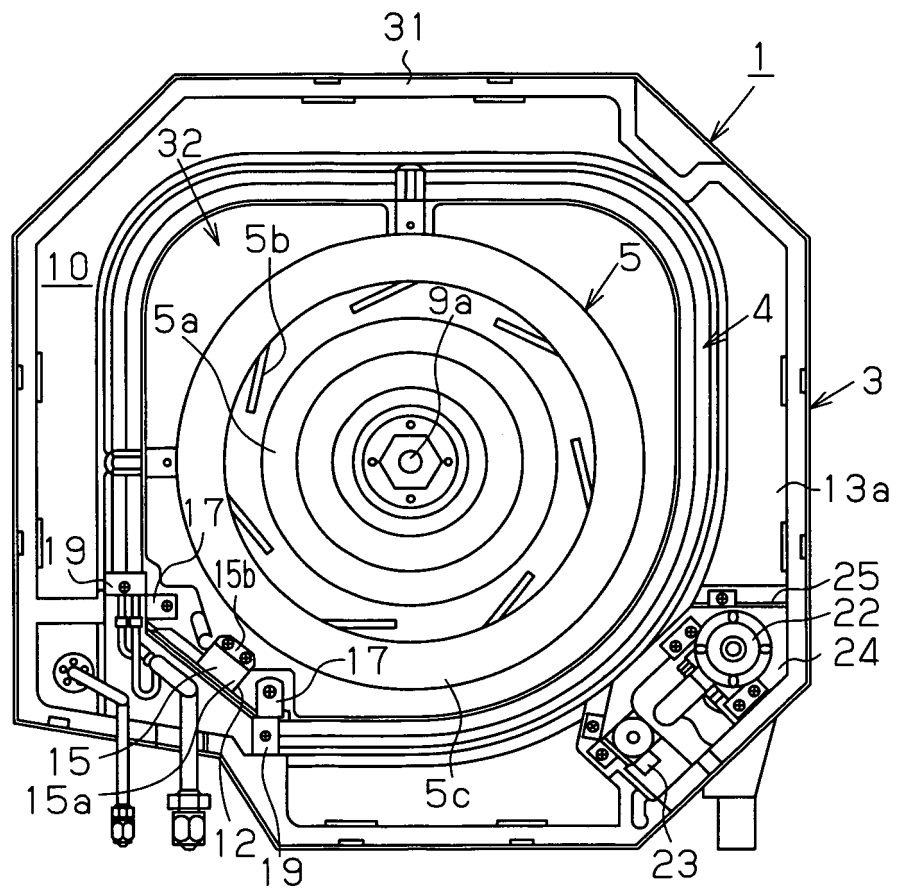
**Fig.20****Fig.21**



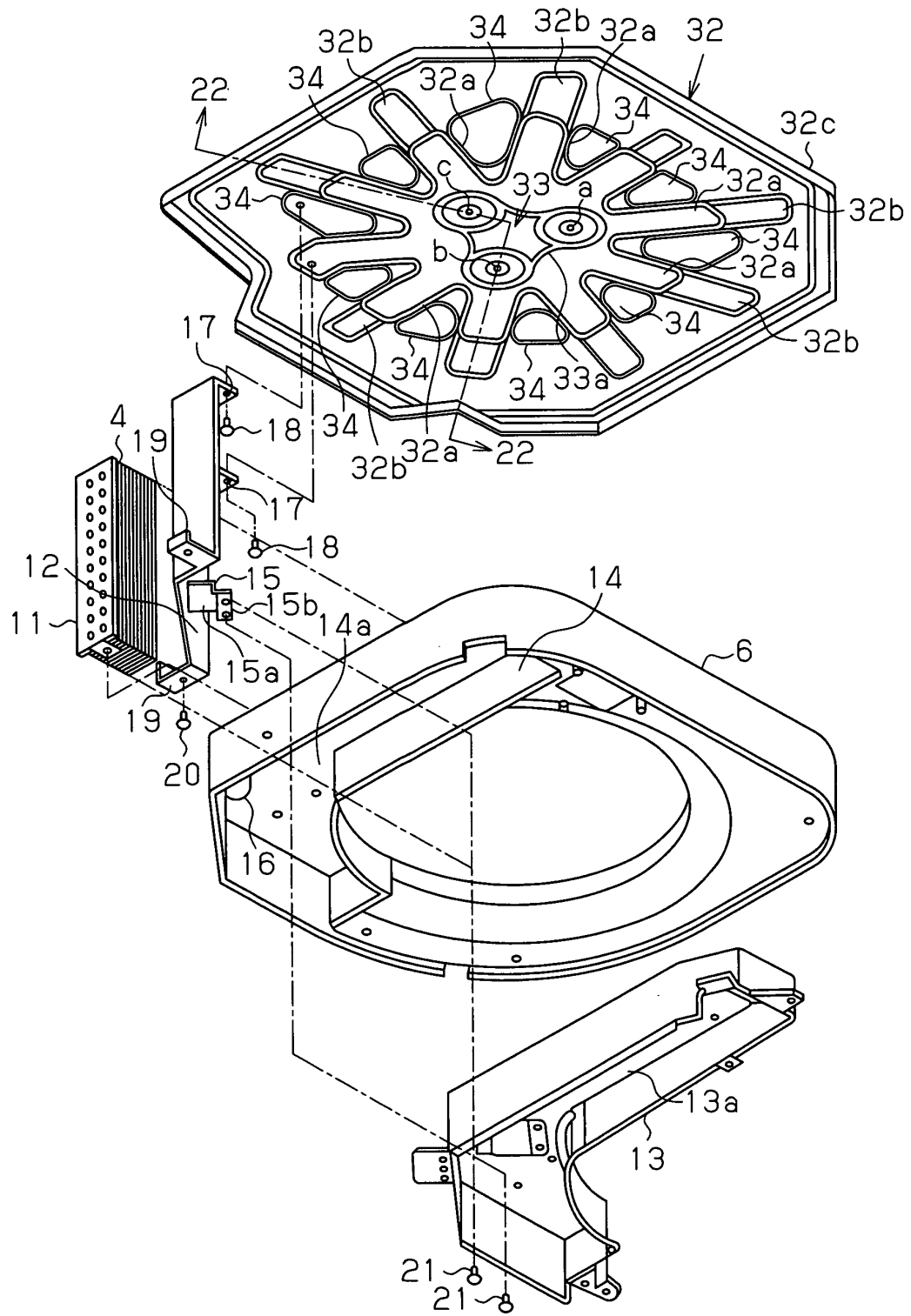
**Fig. 22**



**Fig. 23**



**Fig.24**



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2006/307462

| A. CLASSIFICATION OF SUBJECT MATTER<br><b>F24F1/00</b> (2006.01)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                |                                                                                |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|
| 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)<br><b>F24F1/00</b> (2006.01)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                |                                                                                |
| Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched<br>Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2006<br>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.                                                          |
| Y<br>A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | CD-ROM of the specification and drawings annexed to the request of Japanese Utility Model Application No. 12004/1992 (Laid-open No. 73415/1993) (Daikin Industries, Ltd.), 08 October, 1993 (08.10.93), Par. No. [0017]; Fig. 1 (Family: none) | 1, 4-6<br>2, 3                                                                 |
| Y<br>A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | JP 6-221606 A (Hitachi, Ltd.), 12 August, 1994 (12.08.94), Par. Nos. [0034], [0035]; Fig. 14 (Family: none)                                                                                                                                    | 1, 4-6<br>2, 3                                                                 |
| <input type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                |                                                                                |
| * Special categories of cited documents:<br>"A" document defining the general state of the art which is not considered to be of particular relevance<br>"E" earlier application or patent but published on or after the international filing date<br>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)<br>"O" document referring to an oral disclosure, use, exhibition or other means<br>"P" document published prior to the international filing date but later than the priority date claimed<br>"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<br>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone<br>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art<br>"&" document member of the same patent family |                                                                                                                                                                                                                                                |                                                                                |
| Date of the actual completion of the international search<br>20 June, 2006 (20.06.06)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                | Date of mailing of the international search report<br>27 June, 2006 (27.06.06) |
| Name and mailing address of the ISA/<br>Japanese Patent Office                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                | Authorized officer                                                             |
| Facsimile No.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                | Telephone No.                                                                  |

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**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

- JP 11201496 A [0015]