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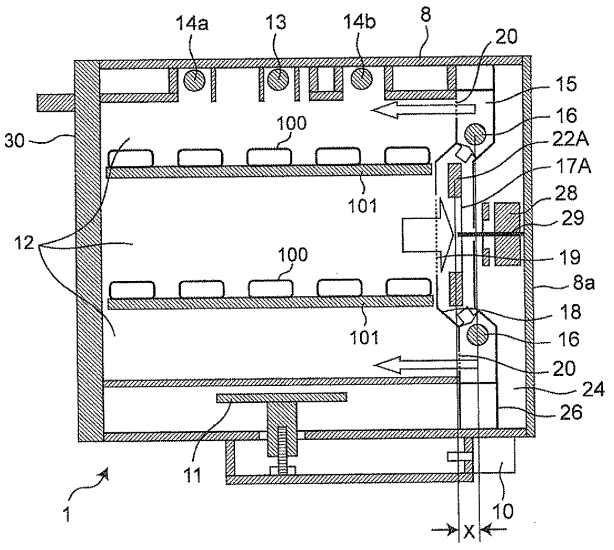
(54) HEATING DEVICE

(57) To provide a heating device that has a reduced dimension in the depth direction of the heating device while the volume required as a heating chamber is secured, and that is capable of heating an object highly efficiently, the heating device of the present invention is configured that a circulation fan (17A) provided in a heat-source chamber (15) of a heating device has a main plate (33A) and a plurality of vane portions (22A), each of the vane portions is structured with a plurality of vane pieces (21a, 21b) forming a right angle with a plane of the main plate, and a plane of a vane piece (21 b) closest to a rotation central axis of the circulation fan structuring an inlet angle and a plane of a vane piece (21a) farthest from the rotation central axis of the circulation fan forming an outlet angle are structured with planes different from each other.

Fig.1



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Description

Technical Field

[0001] The present invention relates to a heating device such as a microwave grilling oven that heats an object to be heated by a grilling function.

Background Art

[0002] As a cooking device, a heating device such as a microwave grilling oven, which is a microwave oven possessing a grilling function, is currently in use. One type of such a heating device is a cooking device with which food being an object to be heated can be cooked with the single device, using not only electromagnetic waves but also water vapor, hot air and the like. Since such a heating device can eliminate the necessity of preparing different cookware such as a pot, a pan, a steamer and the like in accordance with the recipe, use of such a heating device simplifies the cooking procedure. Hence, such a cooking device is becoming indispensable in daily life.

[0003] Fig. 14 is a side cross-sectional view showing the structure of a conventional heating device. As shown in Fig. 14, a conventional heating device 41 is provided with a door 60 on the front side of a casing 48, and is structured such that the front side opening of a heating chamber 47 is opened and closed by the door 60 for putting in and taking out an object 100 to be heated being food to and from the heating chamber 47. On the rear side (back side) of the heating chamber 47, a heat-source chamber 42 is provided adjacent to the heating chamber 47. Inside the heat-source chamber 42, a circulation fan 43, and an electrothermal heater 45 being an annular-shaped heat source which is concentric with the central axis of the circulation fan 43 are provided. The electrothermal heater 45 is disposed so as to surround the outer circumference of the circulation fan 43, and is set such that the width of vane portions 44 of the circulation fan 43 is accommodated inside a region defined by the width (the length in the depth direction) of the electrothermal heater 45.

[0004] In the space on the further rearward side (back side) of the heat-source chamber 42, a motor 46 is provided. The shaft 50 of the motor 46 penetrates through a backside wall 42a of the heat-source chamber 42, and the circulation fan 43 is attached to the tip of the shaft 50. That is, inside the space between a backside wall 42a of the heat-source chamber 42 and the backside wall 48a of the casing 48, the motor 46 is disposed.

[0005] As shown in Fig. 14, between the heating chamber 47 and the heat-source chamber 42, a flat partition plate 49 is provided. In the partition plate 49, air intake ports 51 are formed at the position facing the circulation fan 43 (i.e., at the central region), and air outlet ports 52 are formed at the outer circumferential region near the casing 48.

[0006] In the conventional heating device structured as described above, when the grill cooking is to be carried out, in order to evenly cook the food being the object 100 to be heated inside the heating chamber 47, the circulation fan 43 drives in parallel with the electrothermal heater 45 generating heat.

[0007] In carrying out the grill cooking, by the rotation of the vane portions 44 of the circulation fan 43, the air inside the heating chamber 47 is suctioned from the air intake ports 51 of the partition plate 49 into the heat-source chamber 42, and is sent in the outer circumferential direction which is the centrifugal direction of the circulation fan 43. The air shifted in the outer circumferential direction by the circulation fan 43 is heated by the electrothermal heater 45 disposed outside the circulation fan 43. The air heated by the electrothermal heater 45 passes through the air outlet ports 52 provided at the outer circumferential region of the partition plate 49, and sent inside the heating chamber 47.

[0008] The hot air sent inside the heating chamber 47 circulates inside the heating chamber 47, to uniformly raise the ambient temperature inside the heating chamber 47. Therefore, the food being the object to be heated inside the heating chamber 47 can evenly be grill-cooked. Example of such a conventional technique is a heating device disclosed in Japanese Unexamined Patent Application Publication No. 2008-14619.

[0009] Figs. 15 and 16 each disclose a circulation fan 43 of a conventional heating device 41 disclosed in Japanese Unexamined Patent Application Publication No. 2008-14619. Fig. 15 is a front view showing a circulation fan 43 and an electrothermal heater 45 of the conventional heating device 41. Fig. 16 is a perspective view showing the tip portion of a vane portion 44 of the circulation fan 43. As shown in Fig. 16, the vane portion 44 of the circulation fan 43 is structured with a bottom plate 44a having a plane parallel to the plane including the rotary direction, and a vane plate 44b provided substantially perpendicularly to the bottom plate 44a.

Citation List

Patent Literatures

[0010]

PLT 1: Japanese Unexamined Patent Application Publication No. 2008-14619

Summary of Invention

Technical Problem

[0011] In order to allow the circulation fan 43 to produce air of an ample volume in the conventional heating device structured as above, the width of the vane plate 44b, that is, the dimension (the length denoted by the reference character W in Fig. 16) in the rotary shaft direction (the depth direction) is widened to, e.g., 12 mm to 19 mm, and the rotation speed of the circulation fan 43 is set at high speeds. With the heating device set in this manner, it is necessary to use the motor 46 whose driving torque is great. Thus, the conventional heating device involves a problem in an increase in the size of the device, particularly in the dimension in the depth direction, because the circulation fan 43 having the great vane plate 44b is disposed in the heat-source chamber 42 formed on the back side of the heating chamber 47, and additionally, the motor 46 whose driving torque is great is disposed in the space on the back side of the heat-source chamber 42. With a heating device whose dimension in the depth direction is great, it is necessary to secure a large region as the installation space. In some cases, this invites a case where installation of the heating device 41 in a cupboard cannot be carried out, for example.

[0012] The present invention is to solve the problem involved with the conventional heating device described above, and an object thereof is to provide a heating device with a reduced dimension in the depth direction of the heating device, while the volume required as a heating chamber can be secured, and with which heating can be carried out highly efficiently.

[0013] It is to be noted that, in the following description, the dimension of the circulation fan in the rotary shaft direction (depth direction) which is dependent on the width (W) of each vane portion is referred to as the thickness of the circulation fan. That is, the greater the width (W) of each vane portion, the thicker the circulation fan; the smaller the width (W) of each vane portion, the thinner the circulation fan.

Solution to Problem

[0014] A heating device according to a first aspect of the present invention includes:

a heating chamber that accommodates an object to be heated;
a heat-source chamber that is adjacent to the heating chamber, and that supplies hot air into the heating chamber; and
a partition plate that has air intake ports and air outlet ports, and that partitions the heating chamber and the heat-source chamber,

wherein

the heat-source chamber is provided with a circulation fan attached to a rotary shaft of a motor, and a heat source that heats air shifted by the circulation fan,
the circulation fan has a main plate and a plurality of vane portions provided to the main plate,
each of the vane portions is structured with a plurality of vane pieces forming a right angle with a plane of the main plate, and
in a plurality of the vane pieces, a plane of a vane piece (corresponding to a second vane piece 21b according to a first embodiment which will be described later) closest to a rotation central axis (corresponding to a center P according to the first embodiment which will be described later) of the circulation fan fixing an inlet angle and a plane of a vane piece (corresponding to a first vane piece 21a according to the first embodiment which will be described later) farthest from the rotation central axis of the circulation fan fixing an outlet angle are structured with planes different from each other. The heating device according to the first aspect structured in this manner exhibits improved power of the circulation fan, and is capable of starting to rotate with small driving torque, and sending the air to the heat source highly efficiently. Accordingly, the heating device according to the first aspect can shorten the time required for raising the temperature inside the heating chamber to a prescribed temperature. As a result, it becomes possible to shorten the heating time.

[0015] In the heating device according to a second aspect of the present invention in the structure according to the first aspect,
the inlet angle is an angle formed between a straight line connecting between a point closest to the rotation central axis of the circulation fan on a first intersection line (corresponding to a bending line F according to the first embodiment which will be described later) and the rotation central point and the first intersection line, the first intersection line being a line where the plane of the vane piece closest to the rotation central axis of the circulation fan and the plane of the main plate intersect with each other,

the outlet angle OA is an angle formed between a tangent in a rotary direction at a point farthest from the rotation central axis of the circulation fan on a second intersection line (corresponding to a bending line E according to the first embodiment which will be described later) and the second intersection line, the second intersection line being a line where the plane of the vane piece farthest from the rotation central axis of the circulation fan and the plane of the main plate intersect with each other, and

the inlet angle is set to fall within a range from 50 degrees to 60 degrees, and the outlet angle is set to fall within a range from 40 degrees to 50 degrees. The heating device according to the second aspect structured in this manner is capable of employing the thinner circulation fan and the motor of the smaller driving torque as compared to the conventional device. Accordingly, it becomes possible to achieve miniaturization of the entire device while realizing the excellent start-up performance and power-saving performance of the circulation fan.

[0016] In the heating device according to a third aspect of the present invention in the structure according to the first aspect, a plurality of the vane pieces of each of the vane portions of the circulation fan are each formed by part of a cut out main plate material being bent at a right angle, and the vane pieces are formed by a part of the main plate material being separately bent. The heating device according to the third aspect structured in this manner is capable of forming the circulation fan from a single plate material through press working, and therefore, a reduction in the costs for the circulation fan can be achieved.

[0017] In the heating device according to a fourth aspect of the present invention in the structure according to the first aspect, a plurality of the vane pieces of each of the vane portions of the circulation fan are each formed by a part of a cut out main plate material being bent, and a plurality of the vane pieces of each of the vane portions are formed by a single plate material being bent. The heating device according to the fourth aspect structured in this manner is capable of forming the circulation fan from a single plate material through press working, and therefore, a reduction in the costs for the circulation fan can be achieved.

[0018] In the heating device according to a fifth aspect of the present invention in the structure according to the third or fourth aspect, the circulation fan may have a complementary plate that closes notches produced by the part of the main plate being bent, and an auxiliary plate that clamps a plurality of the vane pieces with the main plate. The heating device according to the fifth aspect structured in this manner is capable of employing the thinner circulation fan and the motor of the smaller driving torque as compared to the conventional device. Accordingly, it becomes possible to achieve miniaturization of the entire device while realizing the excellent start-up performance and power-saving performance of the circulation fan.

[0019] In the heating device according to a sixth aspect of the present invention in the structure according to the first aspect, part of the vane pieces of the circulation fan may project from the main plate in a centrifugal direction. The heating device according to the sixth aspect structured in this manner can increase an air volume directed toward the rear side (back side) of the main plate.

[0020] In the heating device according to a seventh aspect of the present invention in the structure according to the first aspect, part of the vane pieces of the circulation fan may project from the main plate in a centrifugal direction, and the heat source may be disposed at a position outer than the vane pieces of the circulation fan, and displaced rearward than the circulation fan. The heating device according to the seventh aspect structured in this manner can increase an air volume directed toward the rear side (back side) of the main plate, and hence a highly efficient air blowing operation to the heat source can be achieved.

[0021] In the heating device according to an eighth aspect of the present invention in the structure according to the first aspect, the inlet angle of each of the vane pieces of the circulation fan may be set to 55 degrees, and the outlet angle of each of the vane pieces of the circulation fan may be set to 45 degrees. The heating device according to the eighth aspect structured in this manner is capable of employing the thinner circulation fan and the motor of the smaller driving torque as compared to the conventional device. Accordingly, it becomes possible to achieve miniaturization of the entire device while realizing the excellent start-up performance and power-saving performance of the circulation fan.

[0022] In the heating device according to a ninth aspect of the present invention in the structure according to the first aspect, the vane pieces of the circulation fan may each have a width (W) in an axial direction of the rotary shaft of the motor set to fall within a range from 6 mm to 15 mm. The heating device according to the ninth aspect structured in this manner is capable of employing the thinner circulation fan and the motor of the smaller driving torque as compared to the conventional device. Accordingly, it becomes possible to achieve miniaturization of the entire device while realizing the excellent start-up performance and power-saving performance of the circulation fan.

[0023] In the heating device according to a tenth aspect of the present invention in the structure according to the first aspect, the circulation fan may have the vane portions of six to sixteen in number. The heating device according to the tenth aspect structured in this manner is capable of employing the thinner circulation fan and the motor of the smaller driving torque as compared to the conventional device. Accordingly, it becomes possible to achieve miniaturization of the entire device while realizing the excellent start-up performance and power-saving performance of the circulation fan.

[0024] In the heating device according to an eleventh aspect of the present invention in the structure according to the first aspect, a length of a first intersection line (corresponding to a length D in the first embodiment whose description

will be described later) where the plane of the vane piece closest to the rotation central axis of the circulation fan and the plane of the main plate intersect with each other may be set to fall within a range from 2.5 times to 3.0 times as long as a length of a second intersection line (corresponding to a length C in the first embodiment which will be described later) where the plane of the vane piece farthest from the rotation central axis of the circulation fan and the plane of the main plate intersect with each other. The heating device according to the eleventh aspect structured in this manner is capable of employing the thinner circulation fan and the motor of the smaller driving torque as compared to the conventional device. Accordingly, it becomes possible to achieve miniaturization of the entire device while realizing the excellent start-up performance and power-saving performance of the circulation fan.

[0025] In the heating device according to a twelfth aspect of the present invention in the structure according to the first aspect, a ratio of a distance (corresponding to a distance B/2 according to the first embodiment which will be described later) from a point closest to the rotation central axis on a first intersection line where the plane of the vane piece closest to the rotation central axis of the circulation fan and the plane of the main plate intersect with each other to a distance (corresponding to a distance A/2 according to the first embodiment which will be described later) from a point farthest from the rotation central axis on a second intersection line where the plane of the vane piece farthest from the rotation central axis of the circulation fan and the plane of the main plate intersect with each other to the rotation central axis may be set to fall within a range from 0.5 to 0.7. The heating device according to the twelfth aspect structured in this manner is capable of employing the thinner circulation fan and the motor of the smaller driving torque as compared to the conventional device. Accordingly, it becomes possible to achieve miniaturization of the entire device while realizing the excellent start-up performance and power-saving performance of the circulation fan.

[0026] In the heating device according to a thirteenth aspect of the present invention in the structure according to the first aspect, the vane pieces of the vane portions of the circulation fan may each be structured with two pieces including a vane piece structuring the inlet angle and a vane piece structuring the outlet angle, and a radius of curvature of a boundary portion between the two vane piece may be set to fall within a range from 20 mm to 30 mm. The heating device according to the thirteenth aspect structured in this manner is capable of employing the thinner circulation fan and the motor of the smaller driving torque as compared to the conventional device. Accordingly, it becomes possible to achieve miniaturization of the entire device while realizing the excellent start-up performance and power-saving performance of the circulation fan.

Advantageous Effects of Invention

[0027] The heating device of the present invention has a reduced dimension in the depth direction of the heating device while the volume required as a heating chamber is secured, and is capable of heating an object highly efficiently.

Brief Description of Drawings

[0028]

Fig. 1 is a side cross-sectional view showing the schematic internal configuration of the heating device according to a first embodiment of the present invention;

Fig. 2 is a front view showing a partition plate partitioning a heating chamber and a heat-source chamber in the heating device according to the first embodiment;

Fig. 3 shows a front view (a) and a side view (b) each showing the structure of vane portions of a circulation fan in the heating device according to the first embodiment;

Fig. 4 is a plan view showing the state of a main plate before the vane portions of the heating device according to the first embodiment are formed;

Fig. 5 is a graph showing the pressure loss characteristic in which the rotation speeds are shown in a dimensionless expression for comparing the structures of the vane portions of the circulation fans of the heating devices;

Fig. 6 shows a front view (a) and a side view (b) each showing the blade structure of vane portions of a circulation fan as a comparison example;

Fig. 7 is a plan view showing the structure of a circulation fan in a heating device according to a second embodiment of the present invention;

Fig. 8 is a plan view showing the state of a main plate before vanes portion of the circulation fan of the heating device according to the second embodiment are formed;

Fig. 9 shows a plan view (a) and a side view (b) each showing the structure of a circulation fan of a heating device according to a third embodiment of the present invention;

Fig. 10 is a graph showing the pressure loss characteristic in which the rotation speeds are shown in a dimensionless expression for comparing the structures of the vane portions of the circulation fans of the heating devices;

Fig. 11 is a plan view showing the structure of a circulation fan in a heating device according to a fourth embodiment

of the present invention;
Fig. 12 is a perspective view of the circulation fan of the heating device according to the fourth embodiment;
Fig. 13 is a plan view showing the state of a main plate before vane portions of the circulation fan of the heating device according to the fourth embodiment are formed;
Fig. 14 is a side cross-sectional view showing the structure of a conventional heating device;
Fig. 15 is a front view showing a circulation fan and an electrothermal heater of the conventional heating device; and
Fig. 16 is a perspective view showing the tip portion of a vane portion of the circulation fan of the conventional heating device.

Description of Embodiments

[0029] In the following, with reference to the accompanying drawings, a description will be given of a microwave grilling oven as each embodiment of a heating device of the present invention. It is to be noted that, the heating device of the present invention is not limited to the structure of the microwave grilling oven described in the following embodiments, and it includes a heating device structured based on a technical idea and a common general technical knowledge in the present technical field which are equivalent to the technical idea which will be described in connection with the following embodiments.

(First Embodiment)

[0030] Figs. 1, to 3 each show the structure of a microwave grilling oven as a heating device according to a first embodiment of the present invention, Fig. 1 is a side cross-sectional view showing the schematic internal configuration of the heating device according to the first embodiment. Fig. 2 is a front view showing a partition plate that partitions a heating chamber in which an object to be heated is disposed and a heat-source chamber that accommodates sheathed heater being a heat source in the heating device according to the first embodiment. Fig. 3 shows the structure of vane portions of a circulation fan provided in the heat-source chamber.

[0031] In the following, a detailed description will be given of a microwave grilling oven as the heating device according to the first embodiment of the present invention.

[0032] As shown in Fig. 1, a heating device 1 according to the first embodiment is provided with, inside a casing 8, a heating chamber 12 that has a substantially rectangular parallelepiped structure for accommodating objects 100 to be heated being food. The heating chamber 12 is structured with wall plates forming the ceiling plane, the bottom plane, the left-side plane, the right-side plane, and the back plane with a metal material, a door 30 opened and closed for putting in and taking out the objects 100 to be heated, and placement tables 101 for placing the objects 100 to be heated. In the heating device 1 of the first embodiment, the placement tables 101 are structured such that they can be disposed at two levels, one above the other.

[0033] Below the heating chamber 12, a magnetron 10 and an antenna 11 are disposed, such that an electromagnetic wave generated by the magnetron 10 is radiated inside the heating chamber 12 via the antenna 11. With the heating chamber 12 structured as described above, the door 30 being closed confines the electromagnetic wave supplied into the heating chamber 12 inside the heating chamber 12.

[0034] Further, the heating device 1 according to the first embodiment is provided with one argon lamp heater 13 that generates near-infrared radiation and two coil heaters 14a and 14b that generate far-infrared radiation, each as a rod-like grilling heater at the ceiling plane corresponding to the top portion inside the heating chamber 12.

[0035] Further, the heating device 1 according to the first embodiment is provided with a heat-source chamber 15 adjacent to the heating chamber 12, on the back side being the rear side of the heating chamber 12. Inside the heat-source chamber 15, a circulation fan 17A being a centrifugal fan and a sheathed heater 16 heating the air sent by the rotary operation of the circulation fan 17A are disposed. The sheathed heater 16 in the heating device 1 according to the first embodiment is disposed on the outer side relative to vane portions 22A of the circulation fan 17A. The sheathed heater 16 is disposed at a position being displaced toward the back side, and has a substantially square frame shape, It is to be noted that, in the first embodiment, though the description is given of an example where the sheathed heater 16 has a substantially square frame shape, the present invention is not limited to such a structure, and other shape, e.g., an annular frame shape may be employed.

[0036] In a driving chamber 24 being a space on the further rear side (back side) of the heat-source chamber 15, a motor 28 being a drive source is disposed. A shaft 29 of the motor 28 penetrates through a heat-source chamber backside wall 26 structuring the back side of the heat-source chamber 15. To the tip of the shaft 29, the circulation fan 17A is attached. In this manner, the heat-source chamber 15 where the sheathed heater 16 being a heat source is disposed, and the driving chamber 24 where the motor 28 being a drive source is disposed are partitioned by the heat-source chamber backside wall 26 and thermally insulated.

[0037] Further, a partition plate 18 is provided between the heating chamber 12 and the heat-source chamber 15. The

partition plate 18 spatially partitions between the heating chamber 12 and the heat-source chamber 15.

[0038] The partition plate 18 is provided with air intake ports 19 at positions (central region) facing around the center of the circulation fan 17A, and air outlet ports 20 are formed at a plurality of places in the outer circumferential region of the circulation fan 17A, which is the region close to the casing 8.

[0039] As shown in Fig. 1, in the heating device 1 according to the first embodiment, the partition plate 18 and the heat-source chamber backside wall 26 are not flat-plate shaped, and are each concave-shaped in which the region near the casing 8 being the outer circumferential portion is positioned on the driving chamber 24 side where the motor 28 is provided. In other words, the heat-source chamber backside wall 26 is provided with a convex portion at its central region, such that the central portion facing the motor 28 projects toward the heating chamber. Into the space formed by the convex portion, the motor 28 partially enters. Further, similarly to the heat-source chamber backside wall 26, the partition plate 18 is provided with a convex portion at the central region thereof. That is, the partition plate 18 and the heat-source chamber backside wall 26 are identical to each other in cross-sectional shape, and the interval between the partition plate 18 and the heat-source chamber backside wall 26 (the length in the depth direction) is maintained substantially the same between the central region and the outer circumferential region.

[0040] Further, as will be described later, in the heating device 1 according to the first embodiment, the width (the length in the depth direction of the heating device 1) of the vane portions 22A of the circulation fan 17A is formed to be small. Therefore, the length in the depth direction of the heat-source chamber 15 is also structure to be short. That is, the interval in the depth direction between the partition plate 18 and the heat-source chamber backside wall 26 is structured to be narrow, and hence the heat-source chamber 15 is a very small space as compared to the heating chamber 12 accommodating the objects 100 to be heated.

[0041] Next, a description will be given of the disposition position of the sheathed heater 16 in the structure of the heating device 1 according to the first embodiment.

[0042] As shown in Fig. 1, the sheathed heater 16 is disposed at the position which is rearward relative to the conventional arrangement, that is, at an offset position displaced toward the motor 28 side. In other words, a plane (a heat line plane) that includes a heat line (a frame-like line that continues at the center of the heat generating portion) of the frame-like sheathed heater 16 is disposed such that it is positioned rearward relative to the surface of revolution of a point where force is applied (plane of application of force) in the vane portions 22A of the circulation fan 17A. That is, as shown in Fig. 1, the heat line plane of the sheathed heater 16 is displaced at the offset position by a distance X toward the back side with reference to the application point plane of the circulation fan 17A. Here, the point where force is applied in each vane portion 22A refers to a virtual point of force applied to the surface of the blade of each vane portion 22A when the circulation fan 17A rotates.

[0043] Fig. 2 is a front view showing the partition plate 18 partitioning the heating chamber 12 and the heat-source chamber 15. As shown in Fig. 2, at the central region of the partition plate 18, a plurality of air intake ports 19 for suctioning air from the heating chamber 12 side toward the heat-source chamber 15 side are formed. Further, at the outer circumferential region of the partition plate 18, a plurality of air outlet ports 20 for blowing hot air from the heat-source chamber 15 side toward the heating chamber 12 side are formed. As shown in Fig. 2, the outlet regions where a plurality of air outlet ports 20 are formed are formed at a plurality of portions of the partition plate 18, and the formation position of each of the outlet regions is set in accordance with the specification of the heating device 1. The air intake ports 19 and the air outlet ports 20 are formed with a plurality of punched holes.

[0044] Fig. 3 shows the blade structure of the vane portions 22A of the circulation fan 17A. (a) of Fig. 3 is a front view of the circulation fan 17A, and (b) of Fig. 3 is a side view of the circulation fan 17A.

[0045] As shown in Fig. 3, the circulation fan 17A includes a flat main plate 33A attached to the tip portion of the shaft 29 of the motor 28, and eight vane portions 22A provided to the main plate 33A. To the central point (point of the center of gravity) P of the main plate 33A, the tip portion of the shaft 29 of the motor 28 is fixed.

[0046] Each vane portion 22A is structured with two pieces, i.e., a first vane piece 21a and a second vane piece 21b, which are formed by providing prescribed slits to the main plate 33A which has been cut into a disk-like prescribed shape. The first vane piece 21a and the second vane piece 21b are formed by being bent in the substantially perpendicular direction to the plane of the main plate 33A. That is, in the circulation fan 17A, by carrying out bending work at two places of the main plate 33A having been cut out, the first vane piece 21a and the second vane piece 21b are formed. By carrying out bending work along the line denoted by reference character E in Fig. 3, the first vane piece 21a is formed. Then, by carrying out bending work along the line denoted by reference character F, the second vane piece 21b is formed. Fig. 4 is a plan view showing the state of the main plate 33A before the first vane pieces 21a and the second vane pieces 21b being the vane portions 22A are formed, and shows a metal plate being cut out in order to form the circulation fan 17A. In Fig. 4, the broken lines (E, F) represent the portion to be bent.

[0047] By the rotation of the circulation fan 17A structured as above, the vane portions 22A cause the air in the heat-source chamber 15 to flow in the centrifugal direction. Accordingly, the air inside the heating chamber 12 passes through the air intake ports 19 formed at the partition plate 18, and suctioned into the heat-source chamber 15. In the heat-source chamber 15, the air that flowed and shifted in the centrifugal direction by the rotary operation of the circulation fan 17A

shifts toward the sheathed heater 16 along the inner wall of the heat-source chamber 15 and heated. The hot air heated by the sheathed heater 16 passes through the air outlet ports 20 formed at the outer circumferential region of the partition plate 18, and is sent inside the heating chamber 12.

[0048] The hot air sent into the heating chamber 12 in this manner circulates inside the heating chamber 12, and hence is capable of raising the ambient temperature in the heating chamber 12 uniformly in a short time. Thus, with the heating device 1 according to the first embodiment, the circulation fan 17A of the special shape is employed, and the sheathed heater 16 disposed at the position in the outer circumference of the circulation fan 17A to be displaced toward the back side forms hot air of a desired temperature. The hot air circulating inside the heating chamber 12 makes it possible to carry out excellent grill cooking with the miniaturized device possessing a power-saving performance.

[0049] In the following, a description will be given of a specific shape of the vane portions 22A of the heating device 1 according to the first embodiment. It is to be noted that, the specific numerical value described in the following is merely an example, and is not intended to specify the shape of the vane portions of the heating device of the present invention.

[0050] In the circulation fan 17A shown in Fig. 3, an angle formed between a straight line connecting a point on the bending line F of the second vane piece 21 b and being closest to the center P and a point of the center P, and the bending line F of the second vane piece 21b is a vane inlet angle. This angle is defined as an inlet angle IA. Further, an angle formed between a tangent line at an intersection point between the outer circumference of the main plate 33A and the bending line E of the first vane piece 2 1 a and being the farthest point from the center, and the bending line E of the first vane piece 21a is a vane outlet angle. This angle is defined as an outlet angle OA. In the heating device 1 according to the first embodiment, the inlet angle IA is set to 55 degrees, and the outlet angle is set to 45 degrees.

[0051] Further, in the circulation fan 17A, the eight vane portions 22A are formed at identical angle intervals with reference to the center P in the main plate 33A, and the vane portions 22A are symmetrically formed with reference to the center P of the main plate 33A. Accordingly, the vane portions 22A in the main plate 33A are formed to oppose to each other with reference to the center P. Here, as to the first vane pieces 21a and 21a of the two vane portions 22A and 22A opposite to each other, a distance between the farthest ends from the center P, i.e., the outer diameter of the main plate 33A, is defined as A. Then, as to the second vane pieces 21 b of the two vane portions 22A and 22A opposite to each other, a distance (inner diameter) between the nearest ends to the center P is defined as B. In the circulation fan 17A of the heating device 1 according to the first embodiment, the ratio between the inner diameter and the outer diameter (B/A), which is the proportion of the inner diameter (B) to the outer diameter (A), is set to approximately 0.6. The ratio between the inner diameter and the outer diameter (B/A) is preferably between 0.5 and 0.7. It is to be noted that, though the ratio between the inner diameter and the outer diameter (B/A) is expressed by the ratio between the outer diameter A and the inner diameter B each being a diameter of the main plate 33A, a distance (B/2) from the point nearest to the center P on the bending line F of the second vane piece 21b and a radius (A/2) may be used.

[0052] Defining the length of the bending line E of the first vane piece 21a as C, and defining the length of the bending line F of the second vane piece 21b as D, the ratio (C/D), that is, the ratio (C/D) of the length between the first vane piece 21a and the second vane piece 21b is 1/2.8 in the circulation fan 17A of the heating device according to the first embodiment. As a result of an experiment, with the length (D) of the bending line F of the second vane piece 21 b falling within a range of 2.5 times to 3.0 times as long as the length (C) of the bending line E of the first vane piece 21a, a preferable result was obtained.

[0053] It is to be noted that, the width W (the length in the depth direction, see (b) of Fig. 3) of each of the first vane piece 21a and the second vane piece 21b is set to 8 mm. The width W is preferably between 6 mm and 15 mm.

[0054] Each first vane piece 21a and each second vane piece 21b formed at the main plate 33A are brought into contact with each other without any gap, and are preferably formed with a curved plane so as to be continuous, to achieve, e.g., R 25. The preferable range of this radius of curvature is from 20 mm to 30 mm.

[0055] Fig. 5 is a graph showing the pressure loss characteristic (dimensionless PQ characteristic) in which the rotation speeds are shown in a dimensionless expression. The vertical axis indicates the static pressure coefficient, and the horizontal axis indicates the flow rate coefficient. Fig. 5 is a graph in which the pressure loss characteristic (solid line) of a case where the circulation fan 17A of the heating device according to the first embodiment of the present invention and a pressure loss characteristic (broken line) of a case where a circulation fan as a comparison example whose description will follow are compared against each other. That is, the pressure loss characteristics shown in Fig. 5 each represent the relationship between the air volume (horizontal axis) and the static pressure (vertical axis) in a case where the air volume is varied using the circulation fan 17A according to the first embodiment and the circulation fan as the comparison example.

[0056] Fig. 6 shows the blade structure of a circulation fan 170 and an annual electrothermal heater 45 as the comparison example. (a) of Fig. 6 is a front view of the circulation fan 170, and (b) of Fig. 6 is a side view of the circulation fan 170.

[0057] As shown in Fig. 6, the circulation fan 170 as the comparison example includes a flat main plate 330 to be attached to the tip portion of the shaft of a motor, to which main plate 330 eight vane portions 210 are formed. The vane portions 210 are each formed by carrying out bending work at one straight linear bending portion to the main plate 330. Therefore, each vane portion 210 is structured by one flat vane piece. The width W (the length in the depth direction in

the heating device) of the vane piece is approximately 20 mm. Further, the outer shape dimension of the main plate 330 of the circulation fan 170 is the same as the outer diameter dimension (A) of the main plate 33A of the circulation fan 17A according to the first embodiment. The electrothermal heater 45 is disposed so as to surround the outer circumference of the circulation fan 170, and is set such that the width of the vane portions 210 of the circulation fan 170 is accommodated inside the region defined by the width (length in the depth direction) of the electrothermal heater 45.

[0058] The circulation fan 170 as the comparison example structured as described above has the vane portions 210 that is greater than the vane portions 22A of the circulation fan 17A according to the first embodiment, similarly to the circulation fan 43 of the conventional example whose description has been given in the section of BACKGROUND ART. Comparing the pressure loss characteristic between the comparison example structured as described above, and the circulation fan 17A of the heating device according to the first embodiment, as shown in Fig. 6, it can be seen that the air volume characteristic of the circulation fan 17A is greatly improved than that of the circulation fan 170 of the comparison example.

[0059] As compared to the circulation fan 170 of the comparison example, the circulation fan 17A of the heating device according to the first embodiment exhibits an improved air volume characteristic, despite the narrowed width (W) of the shape of the vane portions 22A, that is, despite the thinned vane portions 22A with the narrowed blade plane of each vane portion 22A. Accordingly, the heating device according to the first embodiment can achieve an excellent start-up performance and a power-saving performance of the circulation fan despite the use of the motor of small driving torque for driving the circulation fan 17A. Further, miniaturization of the entire device can be achieved, and in particular, the depth dimension can be shortened. As a result, even when the heating device according to the first embodiment is disposed on, e.g., a kitchen cupboard, the door of the heating device or the like will not stick out from the kitchen cupboard to put obstruction in the user's way. This can achieve an outer dimension with which disposition on the kitchen cupboard is secured.

[0060] The circulation fan 17A of the heating device according to the first embodiment has a structure in which the plurality of vane portions 22A are formed by simple bending work carried out to one metal plate. Accordingly, though the circulation fan 17A according to the first embodiment is structured to have such a special shape, it is not necessary to increase the manufacturing cost, and a reduction in the price of such a device possessing high function can be achieved.

[0061] As described above, the description has been given of the heating device according to the first embodiment as to the exemplary case in which the inlet angle IA is set to 55 degrees and the outlet angle OA is set to 45 degrees in the circulation fan 17A. However, setting the inlet angle IA to 50 degrees and setting the outlet angle OA to 40 degrees, the air volume of the circulation fan 17A can further be increased. Further, setting the inlet angle IA to 60 degrees and setting the outlet angle OA to 50 degrees, the pressure of the circulation fan can be increased, whereby it becomes useable even in an air blow path where the pressure loss is great. Thus, the heating device of the present invention can set the inlet angle IA and the outlet angle OA in the circulation fan to a desired angle in accordance with the specification of the heating device, to achieve a higher function and to save energy.

[0062] Further, though the description has been given of the heating device according to the first embodiment having the eight vane portions 22A of the circulation fan 17A, with the heating device of the present invention including a circulation fan having about six to sixteen vane portions also, the similar effect can be achieved by employing the similar structure as the vane portions 22A according to the first embodiment. Therefore, the present invention is not limited by the number of vane portions whose description has been given as the heating device according to the first embodiment.

(Second Embodiment)

[0063] In the following, a description will be given of a heating device of a second embodiment of the present invention. Fig. 7 is a plan view showing the blade structure of a circulation fan 17B to be installed in a heating device according to a second embodiment of the present invention. Fig. 8 is a plan view showing the state of a main plate 33B before vane portions 22B of the circulation fan 17B are formed, and shows a metal plate being cut out in order to form the circulation fan 17B. In Fig. 8, the broken line portions represent bending places. It is to be noted that, as to the heating device according to the second embodiment, identical reference characters are allotted to the components having identical function and structure as those of the heating device according to the first embodiment, and the description thereof is omitted.

[0064] As shown in Fig. 7, the heating device according to the second embodiment is different in the structure from the heating device according to the first embodiment in that each vane portion 22B of the circulation fan 17B is formed by a first vane piece 21a and a second vane piece 21b being one vane piece.

[0065] That is, with the heating device according to the second embodiment, by providing prescribed slits to the metal plate (the main plate 33B) which has been cut into a substantially disk-like prescribed shape, one vane piece member is formed. The vane piece member is subjected to the first bending work in the direction perpendicular to the main plate 33B, and next, to the second bending work in the direction parallel to the plane of the main plate 33B at a prescribed position of the bent vane piece member. Thus, the first vane piece 21a and the second vane piece 21b of each vane

portion 22B are formed.

[0066] In Fig. 8, bending lines G (broken lines) represent the first bending work positions. At the bending lines G, bending is performed in the perpendicular direction relative to the main plate 33B. Further, bending lines H (broken lines) represent the second bending work positions. Each vane piece having bent at the corresponding bending line G is further bent at the bending line H. The bent portion R at the bending line H is structured with a curved plane, e.g., a radius of curvature of 25 mm (R25).

[0067] As described above, as to the heating device according to the second embodiment, the circulation fan 17B having the inlet angle IA, the outlet angle OA, and the bent portion R (radius of curvature: R25) which are identical to those of the circulation fan 17A of the heating device according to the first embodiment can be formed by bending work performed at two places, similarly to the circulation fan 17A according to the first embodiment.

[0068] As compared to the heating device according to the first embodiment, the heating device according to the second embodiment is advantageous in that, since each of the vane portions 22B is formed by one vane piece being bent, the circulation fan 17B according to the second embodiment can suppress a flow separation phenomenon which is prone to occur at the position where the inlet angle IA and the outlet angle OA intersect with each other (the bent portion R) than the circulation fan 17A according to the first embodiment.

[0069] Accordingly, the heating device according to the second embodiment is capable of improving the air blowing efficiency of the circulation fan 17B and reducing the turbulence noise generated by the vane portions 22B as compared to the heating device according to the first embodiment.

[0070] It is to be noted that, though the description has been given of the heating device according to the second embodiment having the vane portions 22B of the circulation fan 17B structured with eight vane pieces, as to the number of the vane pieces of the vane portions 22B, about six to sixteen pieces can achieve the similar effect. The greater the number of the vane pieces, the smaller the turbulence noise electric power generated per vane piece. Hence, the overall noise of the circulation fan can be reduced.

[0071] Further, though the description has been given of the circulation fan 17B of the heating device according to the second embodiment taking up the exemplary case in which the radius of curvature of the bent portion R between the first vane piece 21 a and the second vane piece 21b is set to 25 mm similarly to the heating device according to the first embodiment, However, the similar effect can be achieved by setting the radius of curvature to fall within the range of about 20 mm to 30 mm. Further, the similar effect can be achieved also in a case where the bent portions R are connected by an involute curve or the like.

(Third Embodiment)

[0072] In the following, a description will be given of a heating device according to a third embodiment of the present invention. Fig. 9 shows the structure of a circulation fan 17C installed in the heating device according to the third embodiment of the present invention. In Fig. 9, (a) is a plan view of the circulation fan 17C of the heating device according to the third embodiment, and (b) is a side view of the circulation fan 17C. It is to be noted that, as to the heating device according to the third embodiment, identical reference characters are allotted to the components having identical function and structure as those of the heating device according to each of the first and second embodiments, and the description thereof is omitted.

[0073] As shown in Fig. 9, the heating device according to the third embodiment is different in the structure from that according to the second embodiment in provision of a complementary plate 35 for complementing notches 34 created at a main plate 33C by vane pieces being bent to form vane portions 22C, and an auxiliary plate (shroud) 36 for clamping the vane pieces of the vane portion 22C with the main plate 33C.

[0074] The circulation fan 17C of the heating device according to the third embodiment is structured such that the circulation fan 17B of the heating device according to the second embodiment is provided with the complementary plate 35 and the auxiliary plate (shroud) 36. The complementary plate 35 is provided on the back side of the circulation fan 17C, so as to face the heat-source chamber backside wall of the heat-source chamber 15 (see Fig. 1). The complementary plate 35 is provided to close the notches 34 at the main plate 33C, and the air suctioned from the central region of the circulation fan 17C is efficiently shifted in the centrifugal direction.

[0075] On the other hand, the auxiliary plate (shroud) 36 is provided on the front side of the circulation fan 17C so as to face the partition plate 18 of the heat-source chamber 15 (see Fig. 1). The auxiliary plate 36 is provided to cover the vane portions 22C. It is to be noted that, the auxiliary plate 36 is annular-shaped and of which central region is hollow, and is structured to suction the air inside the heating chamber 12 from the central region.

[0076] With the circulation fan 17C of the heating device according to the third embodiment structured as above, provision of the complementary plate 35 makes it possible to prevent leakage of the air from the notches 34 of the main plate 33C toward the downstream side (back side), and provision of the auxiliary plate (shroud) 36 makes it possible to prevent leakage of the air suctioned into the vane portion 22C toward the upstream side (front side). Accordingly, the circulation fan 17C of the heating device according to the third embodiment exhibits drastically improved air blowing

efficiency.

[0077] Fig. 10 is a graph showing the pressure loss characteristic (dimensionless PQ characteristic) in which the rotation speeds are shown in a dimensionless expression, in which the vertical axis indicates the static pressure coefficient, and the horizontal axis indicates the flow rate coefficient. Fig. 10 is a graph in which the pressure loss characteristic (solid line) of a case where the circulation fan 17C of the heating device according to the third embodiment is used and the pressure loss characteristic (broken line) of the comparison example whose description has been given with reference to Fig. 6 are compared against each other. That is, the pressure loss characteristics shown in Fig. 10 each represent the relationship between the air volume (horizontal axis) and the static pressure (vertical axis) in a case where the air volume is varied using the circulation fan 17C according to the third embodiment and the circulation fan as the comparison example.

[0078] As can clearly be seen from the graph in Fig. 10, the circulation fan 17C of the heating device according to the third embodiment exhibits a drastically improved air volume characteristic than the circulation fan of the comparison example does. In particular, the air volume characteristic in a state where the pressure loss is great and the flow rate is limited is improved.

[0079] As described above, with the heating device according to the third embodiment, using the thin-type fan and the small-type motor, it becomes possible to realize excellent start-up performance and power-saving performance of the circulation fan, and to achieve miniaturization of the entire device.

(Fourth Embodiment)

[0080] In the following, a description will be given of a heating device according to a fourth embodiment of the present invention. Fig. 11 is a plan view showing the structure of a circulation fan 17D installed in the heating device according to the fourth embodiment of the present invention. Fig. 12 is a perspective view of the circulation fan 17D according to the fourth embodiment. It is to be noted that, as to the heating device according to the fourth embodiment, identical reference characters are allotted to the components having identical function and structure as those of the first to third embodiments, and the description thereof is omitted.

[0081] As shown in Figs. 11 and 12, the heating device according to the fourth embodiment is different in the structure from that according to the heating device according to the second embodiment in that an outer diameter a of a main plate 33D of the circulation fan 17D is smaller than an outer diameter A of the main plate 33D according to each of the first to third embodiments. Accordingly, in the heating device according to the fourth embodiment, part of the vane pieces of vane portions 22D of the circulation fan 17D projects from the outer circumference of the main plate 33D.

[0082] With the heating device according to the fourth embodiment, by providing prescribed slits to a metal plate (main plate 33D) having been cut in a prescribed shape, vane piece members are formed. Fig. 13 is a plan view showing the state of the main plate 33D before the vane portions 22D of the circulation fan 17D are formed, and shows a metal plate being cut out in order to form the circulation fan 17D. In Fig. 13, broken line portions (G, H) are the bending lines showing the bending places.

[0083] With the circulation fan 17D according to the fourth embodiment, similarly to the circulation fan 17B according to the second embodiment, each vane piece member is subjected to the first bending work (bending line G) in the direction perpendicular to the main plate 33D, and next, to the second bending work (bending line H) in the direction parallel to the plane of the main plate 33D at a prescribed position of the bent vane piece member. Thus, each vane portion 22D is formed. The bent portion R of the bending line H is formed with a curved plane, e.g., R 25.

[0084] With the heating device according to the fourth embodiment, the circulation fan 17D having the inlet angle IA, the outlet angle OA, and the bent portion R (radius of curvature: R25) which are identical to those of the circulation fan 17B of the heating device according to the second embodiment can be formed by bending work performed at two places, similarly to the circulation fan 17B according to the second embodiment.

[0085] With the heating device according to the fourth embodiment, similarly to the heating device according to the second embodiment, the flow separation phenomenon which is prone to occur at the position (bent portion R) where the inlet angle IA and the outlet angle OA in each vane portion 22D of the circulation fan 17D intersect each other is suppressed.

[0086] Accordingly, with the heating device according to the fourth embodiment, an improvement in the air blowing efficiency of the circulation fan 17D and a reduction in the turbulence noise generated by the vane portions 22D are achieved.

[0087] Further, as will be described below, the heating device according to the fourth embodiment achieves the special effect which cannot be achieved with the heating device according to each of the foregoing embodiments.

[0088] With the heating device according to the fourth embodiment, as the circulation fan 17D rotates, the air suctioned from the central region of the circulation fan 17D is caused to flow in the centrifugal direction by the vane portions 22D, to be discharged in the outer circumferential direction from the vane portions 22D. Here, as compared to the circulation fans 17A, 17B, and 17C respectively used in the first to third embodiments, the air volume sent from the vane portions

22D toward the rear side (back side) of the heat-source chamber 15 is increased.

[0089] That is, since the vane pieces of the vane portions 22D of the circulation fan 17D of the heating device according to the fourth embodiment project toward the outer circumference side than the main plate 33D, the air is sent from the vane portions 22D toward the rear side of the heat-source chamber 15.

[0090] With the heating device according to the fourth embodiment, the sheathed heater 16 being a heat source is provided at the position on the outer side of the vane portions 22D of the circulation fan 17D and at the position being displaced toward back side, similarly to the heating device according to the first embodiment. Thus, with the heating device according to the fourth embodiment, since the sheathed heater 16 is disposed at the position toward the back side than the circulation fan 17D in the heat-source chamber 15, the air discharged from the circulation fan 17D surely flows in the direction toward the sheathed heater 16 being the heat source. As a result, with the structure of the heating device according to the fourth embodiment, the air is sent to the heat source from the circulation fan 17D at high air blowing efficiency, and is highly efficiently heated by the sheathed heater 16 being the heat source. Accordingly, highly efficient use of the heat source is achieved, and hence an excellent effect is exhibited in saving energy.

[0091] It is to be noted that, though the description has been given of the circulation fan 17D according to the fourth embodiment having no complementary plate and auxiliary plate, which are provided to the circulation fan 17C according to the third embodiment, the complementary plate and the auxiliary plate may also be provided to the circulation fan 17D. In such a case where the complementary plate is provided to the circulation fan 17D, it is preferable to employ the same outer shape dimension as the outer diameter a of the main plate 33D. The complementary plate is provided on the back side of the circulation fan 17D, so as to face the heat-source chamber backside wall of the heat-source chamber 15. The complementary plate is provided to close the notches at the main plate 33D. Thus, provision of the complementary plate makes it possible to prevent the leakage of the air from the notches of the main plate 33D toward the downstream side (back side).

[0092] Further, in a case where the auxiliary plate is provided to the circulation fan 17D, it is preferable to employ an outer shape dimension greater than the outer diameter a of the main plate 33D such that it covers the vane portions 22D. It is to be noted that, the auxiliary plate may be provided to cover part of the vane portions 22D (i.e., the central side portion). It is to be noted that, the auxiliary plate is annular-shaped and of which central region is hollow, and is structured to suction the air inside the heating chamber 12 from the central region. Thus, provision of the auxiliary plate makes it possible to prevent leakage of the air suctioned into the vane portions 22D toward the upstream side (front side). With the heating device structured in this manner, similarly to the third embodiment, a further improvement in the air blowing efficiency of the circulation fan 17D can be achieved.

[0093] As described above, with the heating device of the present invention, it becomes possible to implement a highly efficient circulation fan possessing high readiness using the motor whose driving torque is small. Therefore, it becomes possible to use the thin-type fan and the small-type motor, whereby a reduction in the dimension in the depth direction of the entire device can be achieved. That is, according to the present invention, it becomes possible to provide a compact heating device whose door or the like will not project from a kitchen cupboard, and which possesses an excellent cooking performance.

Industrial Applicability

[0094] The present invention, which uses a highly efficient thin circulation fan for a heating device is applicable to household and industrial ovens having a convection function, and to a heating device in the industrial fields such as a thawing device, a drying device or the like, and still further, to a heating device for ceramics, sintering, biochemical reaction or the like.

Reference Signs List

[0095]

1	heating device
8	casing
10	magnetron
11	antenna
12	heating chamber
15	heat-source chamber
16	sheathed heater
17A, 17B, 17C, 17D	circulation fan
18	partition plate
19	air intake port

20	air outlet port
21a, 21b	vane piece
22A, 22B, 22C, 22D	vane portion
33A, 33B, 33C, 33D	main plate
34	notch
35	complementary plate
36	auxiliary plate

Claims

1. A heating device, comprising:

a heating chamber that accommodates an object to be heated;
a heat-source chamber that is adjacent to the heating chamber, and that supplies hot air into the heating chamber; and
a partition plate that has air intake ports and air outlet ports, and that partitions the heating chamber and the heat-source chamber, wherein
the heat-source chamber is provided with a circulation fan attached to a rotary shaft of a motor, and a heat source that heats air moved by the circulation fan,
the circulation fan has a main plate and a plurality of vane portions provided to the main plate,
each of the vane portions is structured with a plurality of vane pieces forming a right angle with a plane of the main plate, and
in a plurality of the vane pieces, a plane of a vane piece closest to a rotation central axis of the circulation fan fixing an inlet angle and a plane of a vane piece farthest from the rotation central axis of the circulation fan fixing an outlet angle are structured with planes different from each other.

2. The heating device according to claim 1, wherein
the inlet angle is an angle formed between a straight line connecting between a point closest to the rotation central axis of the circulation fan on a first intersection line and the rotation central point and the first intersection line, the first intersection line being a line where the plane of the vane piece closest to the rotation central axis of the circulation fan and the plane of the main plate intersect with each other,
the outlet angle OA is an angle formed between a tangent in a rotary direction at a point farthest from the rotation central axis of the circulation fan on a second intersection line and the second intersection line, the second intersection line being a line where the plane of the vane piece farthest from the rotation central axis of the circulation fan and the plane of the main plate intersect with each other, and
the inlet angle is set to fall within a range from 50 degrees to 60 degrees, and the outlet angle is set to fall within a range from 40 degrees to 50 degrees.

3. The heating device according to claim 1, wherein
a plurality of the vane pieces of each of the vane portions of the circulation fan are each formed by a part of a cut out main plate material being bent at a right angle, and the vane pieces are formed by part of the main plate material being separately bent.

4. The heating device according to claim 1, wherein
a plurality of the vane pieces of each of the vane portions of the circulation fan are each formed by a part of a cut out main plate material being bent, and a plurality of the vane pieces of each of the vane portions are formed by a single plate material being bent.

5. The heating device according to one of claims 3 and 4, wherein
the circulation fan has a complementary plate that closes notches produced by the part of the main plate being bent, and an auxiliary plate that clamps a plurality of the vane pieces with the main plate.

6. The heating device according to claim 1, wherein
a part of the vane pieces of the circulation fan projects from the main plate in a centrifugal direction.

7. The heating device according to claim 1, wherein
a part of the vane pieces of the circulation fan projects from the main plate in a centrifugal direction, and

the heat source is disposed at a position outer than the vane pieces of the circulation fan, and displaced rearward than the circulation fan.

8. The heating device according to claim 1, wherein
the inlet angle of each of the vane pieces of the circulation fan is set to 55 degrees, and the outlet angle of each of the vane pieces of the circulation fan is set to 45 degrees.

9. The heating device according to claim 1, wherein
the vane pieces of the circulation fan each have a width in an axial direction of the rotary shaft of the motor set to fall within a range from 6 mm to 15 mm.

10. The heating device according to claim 1, wherein
the circulation fan has the vane portions of six to sixteen in number.

11. The heating device according to claim 1, wherein
a length of a first intersection line where the plane of the vane piece closest to the rotation central axis of the circulation fan and the plane of the main plate intersect with each other is set to fall within a range from 2.5 times to 3.0 times as long as a length of a second intersection line where the plane of the vane piece farthest from the rotation central axis of the circulation fan and the plane of the main plate intersect with each other.

12. The heating device according to claim 1, wherein
a ratio of a distance from a point closest to the rotation central axis on a first intersection line where the plane of the vane piece closest to the rotation central axis of the circulation fan and the plane of the main plate intersect with each other to a distance from a point farthest from the rotation central axis on a second intersection line where the plane of the vane piece farthest from the rotation central axis of the circulation fan and the plane of the main plate intersect with each other to the rotation central axis is set to fall within a range from 0.5 to 0.7.

13. The heating device according to claim 1, wherein
the vane pieces of the vane portions of the circulation fan are each structured with two pieces including a vane piece structuring the inlet angle and a vane piece structuring the outlet angle, and a radius of curvature of a boundary portion between the two vane pieces is set to fall within a range from 20 mm to 30 mm.

Fig.1

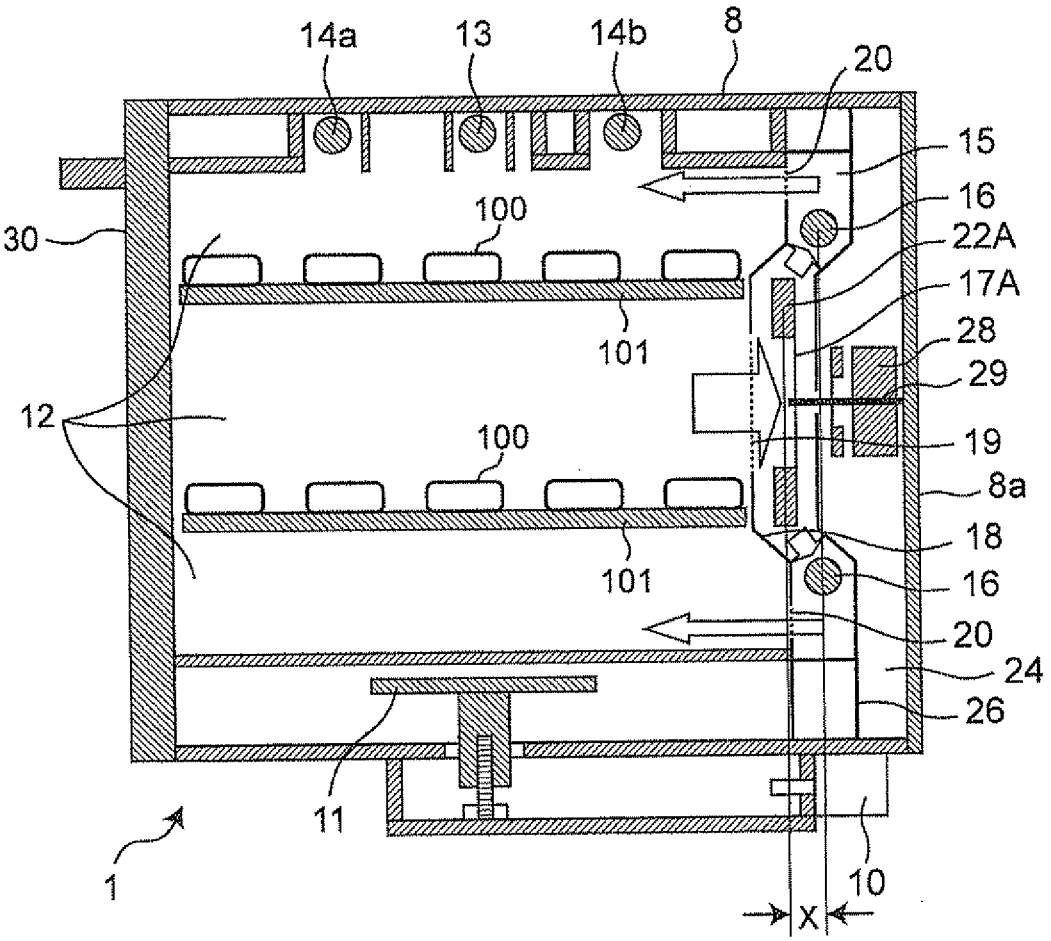

14a
13
14b
8
20
15
16
22A
17A
28
29
19
8a
18
16
20
24
26
10
X
30
100
101
12
100
101
11
1

Fig.2

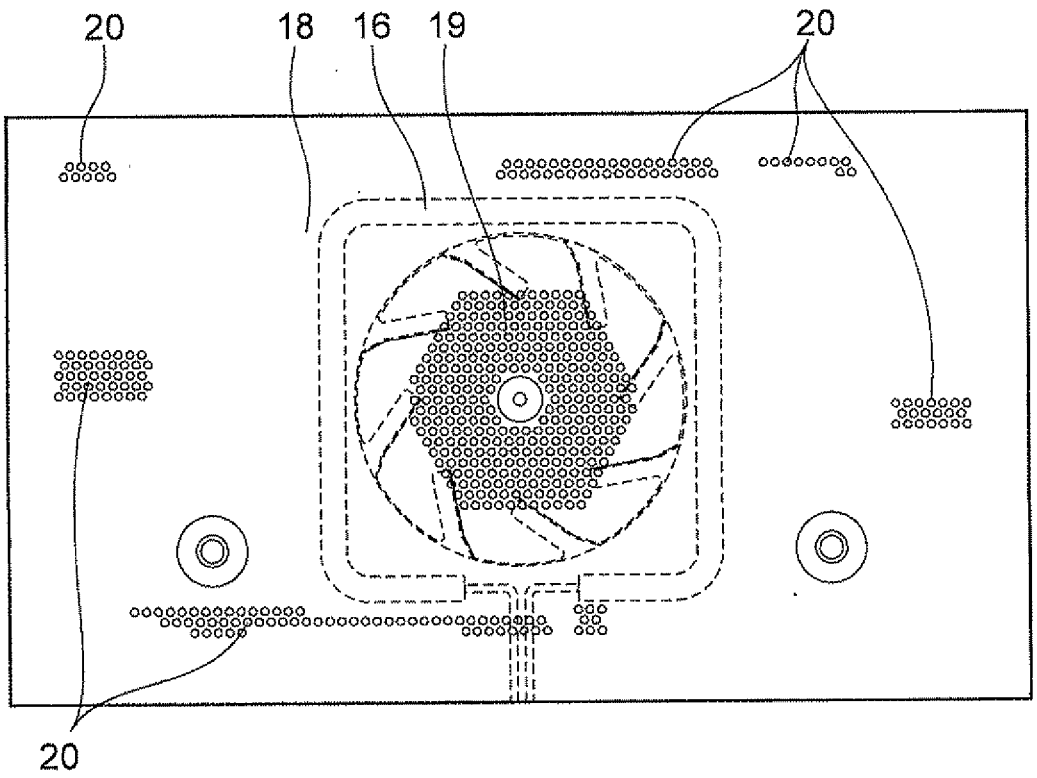


Fig.3

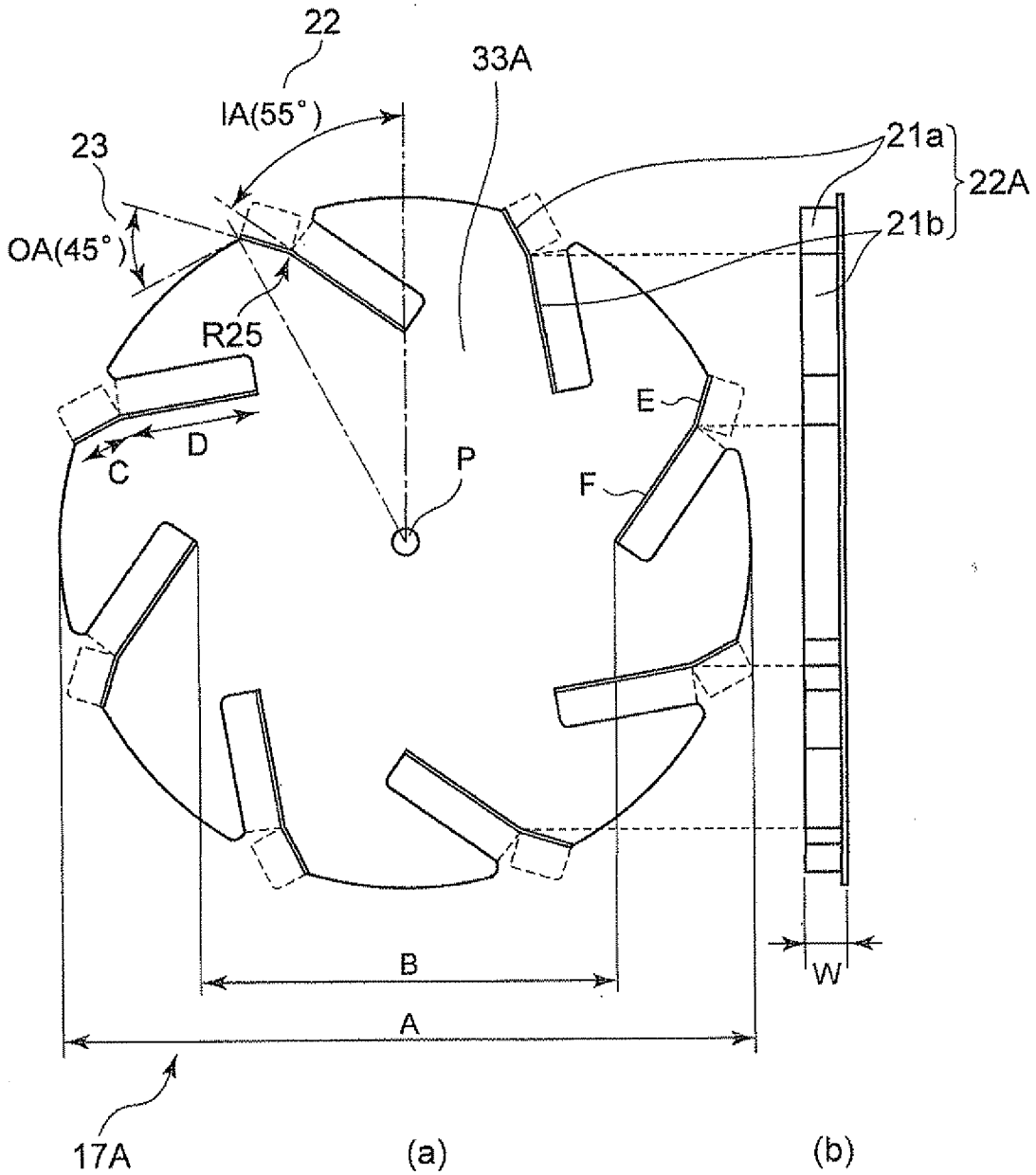


Fig.4

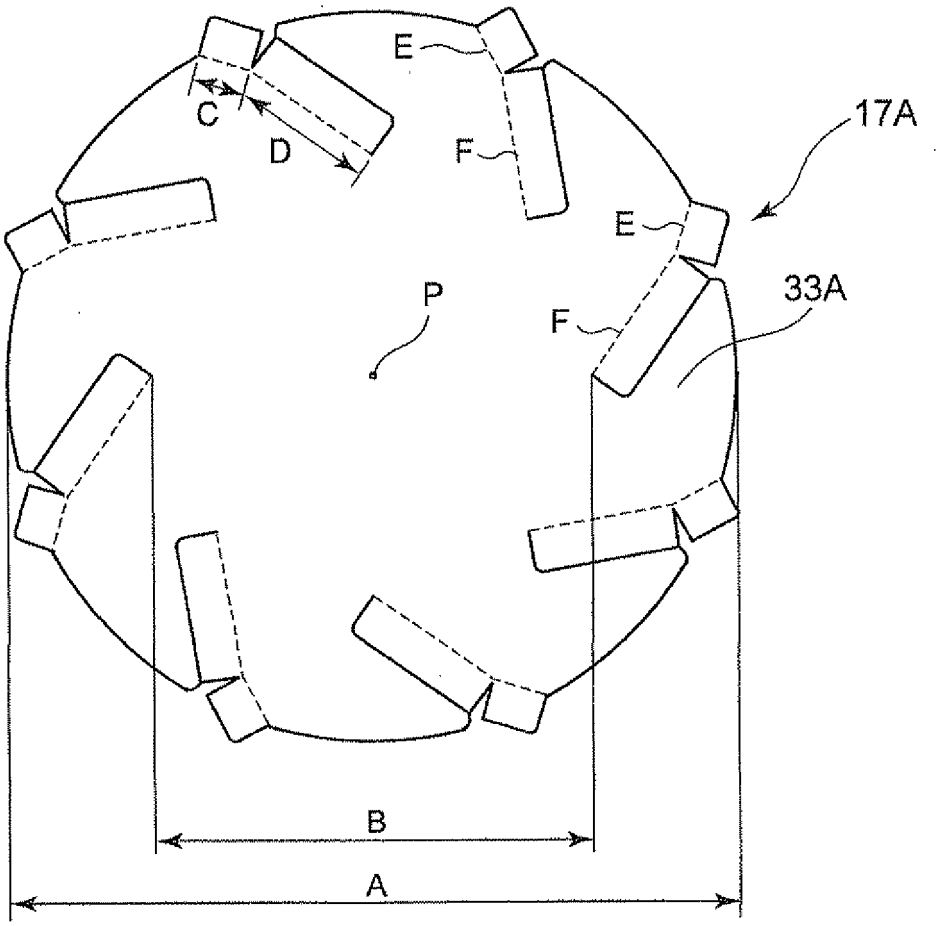


Fig.5

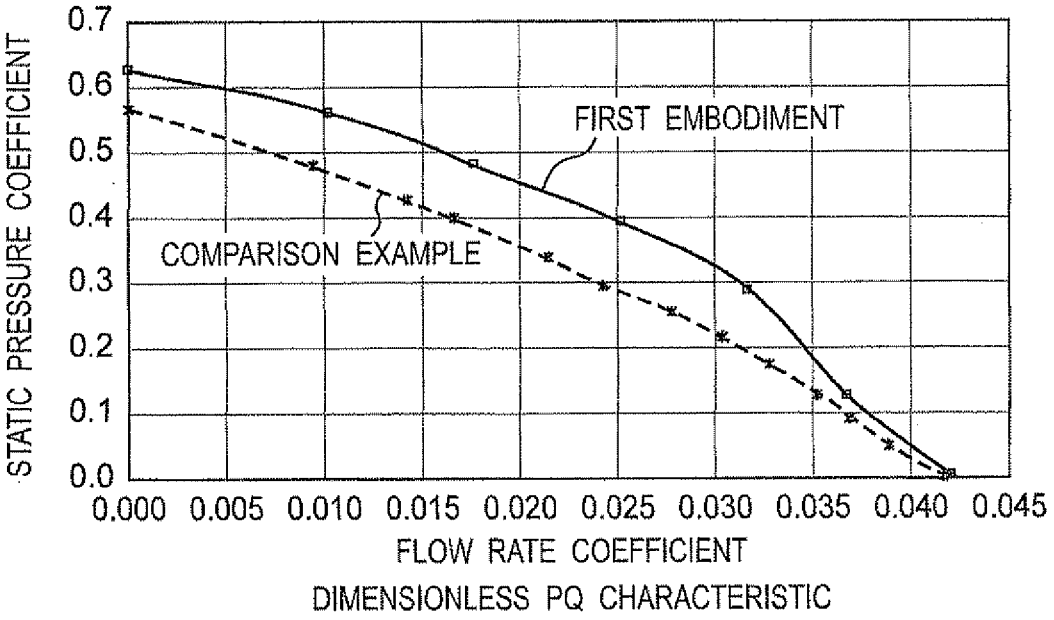

STATIC PRESSURE COEFFICIENT
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
FIRST EMBODIMENT
COMPARISON EXAMPLE
0.000 0.005 0.010 0.015 0.020 0.025 0.030 0.035 0.040 0.045
FLOW RATE COEFFICIENT
DIMENSIONLESS PQ CHARACTERISTIC

Fig.6

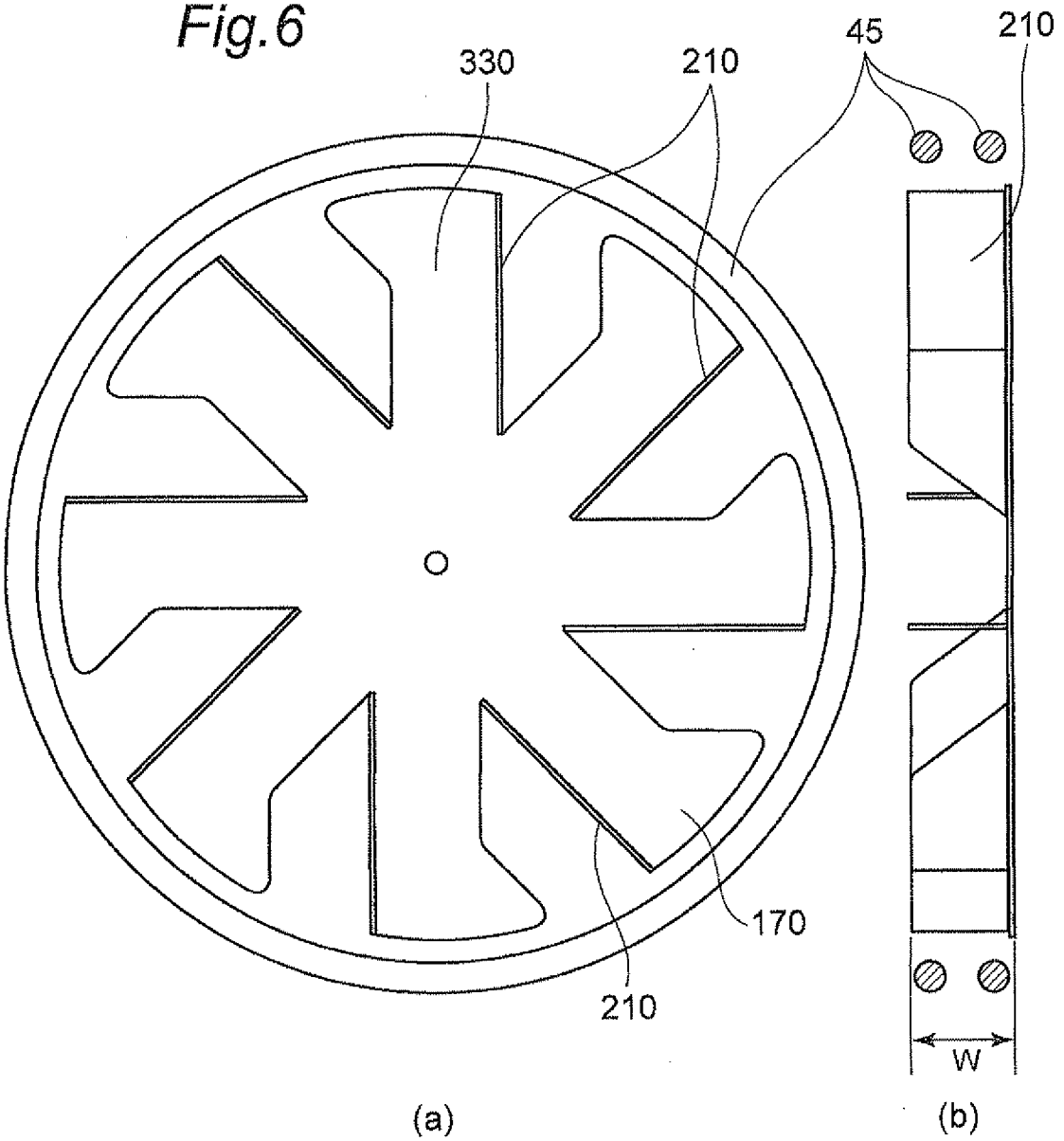


Fig.7

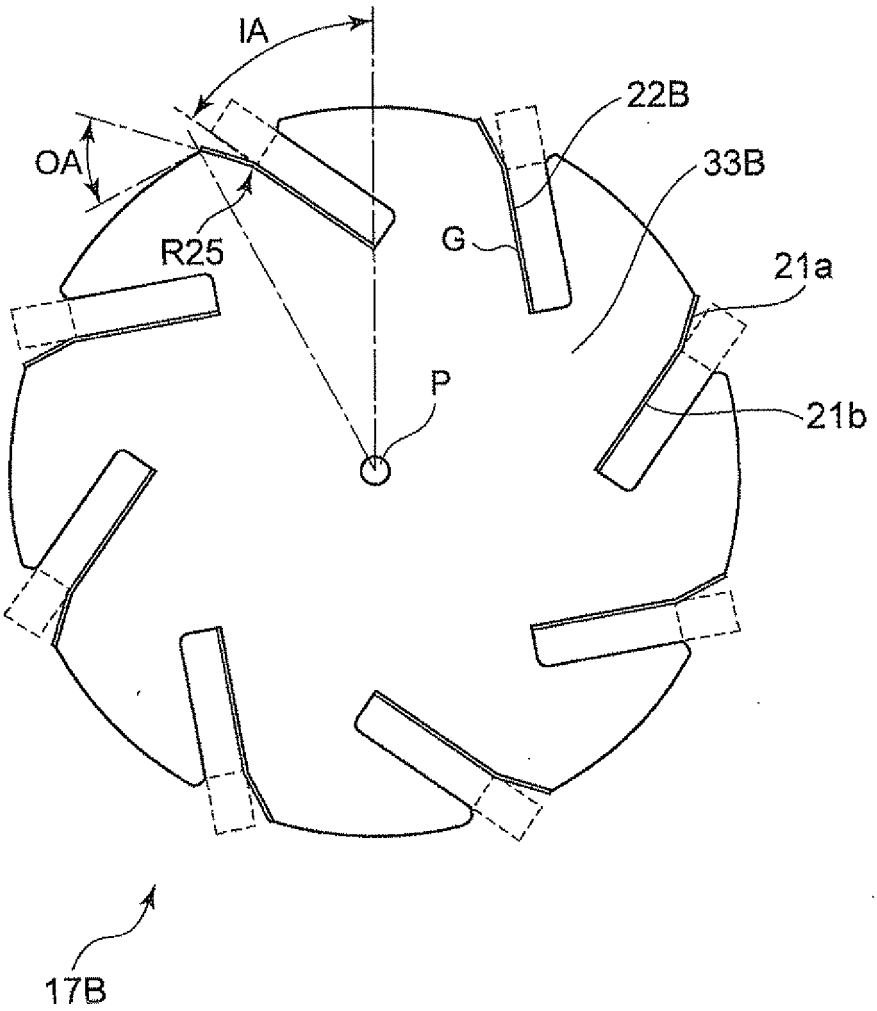


Fig.8

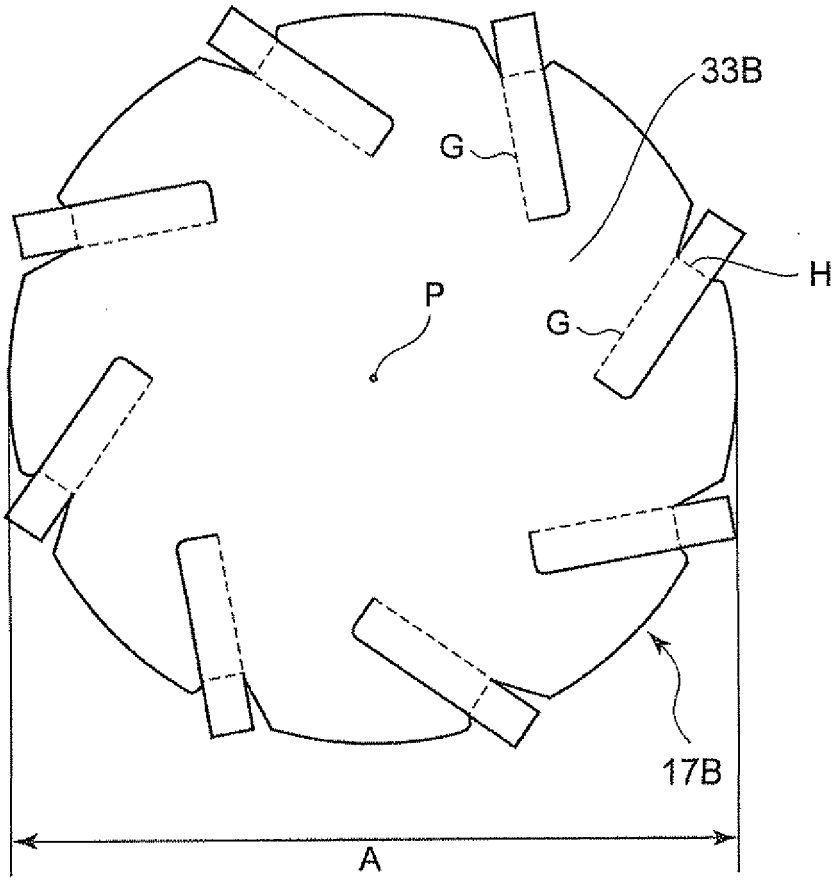


Fig.9

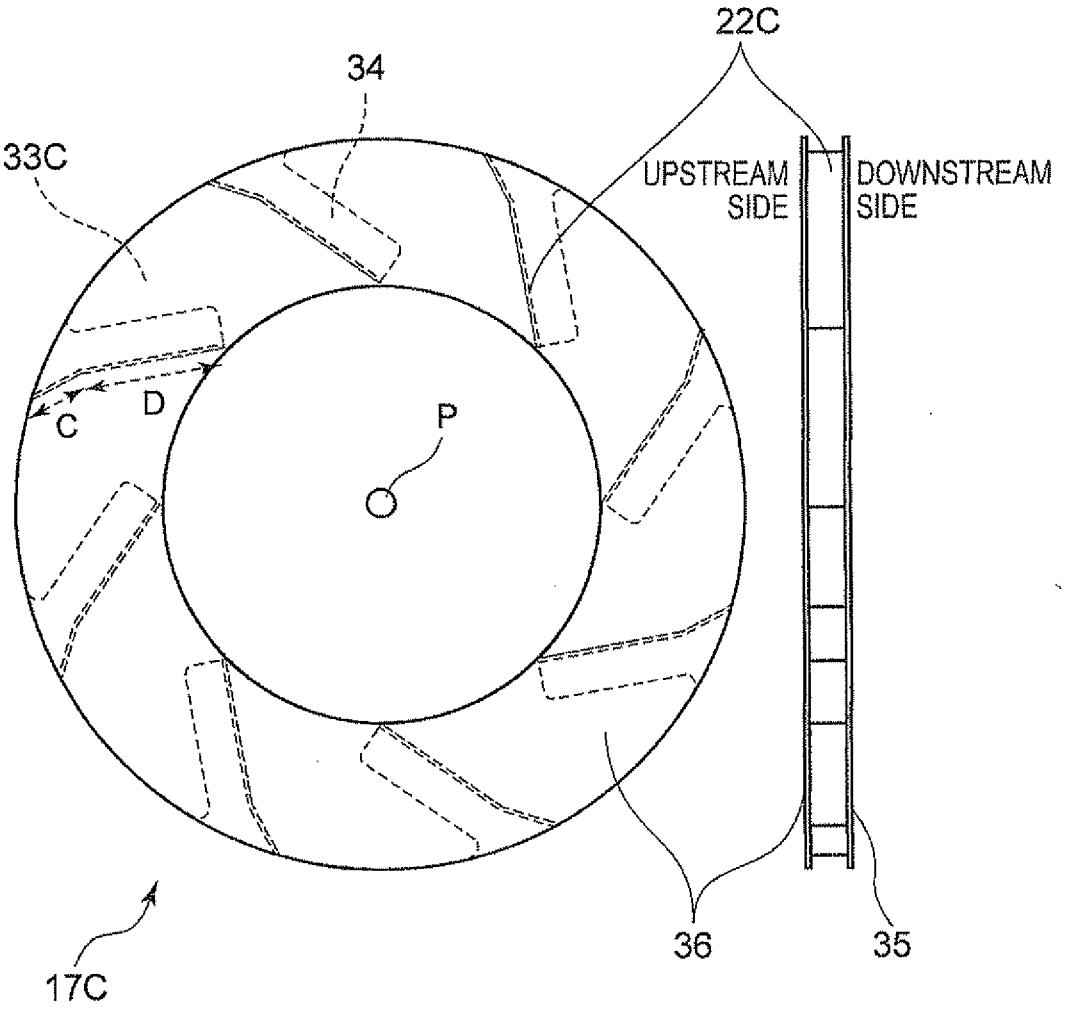


Fig.10

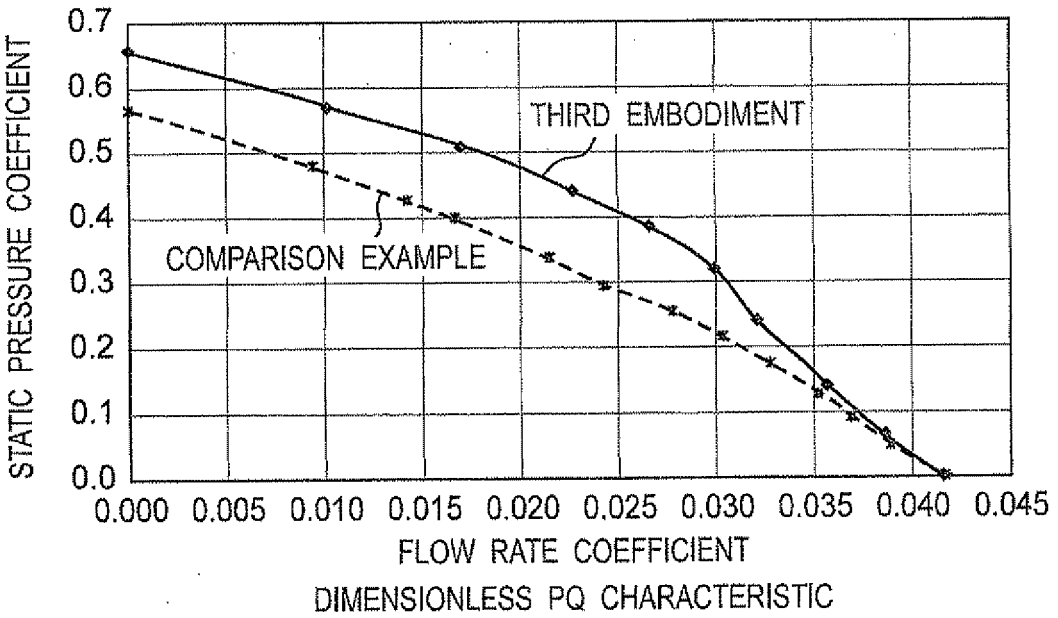

STATIC PRESSURE COEFFICIENT
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
THIRD EMBODIMENT
COMPARISON EXAMPLE
0.000 0.005 0.010 0.015 0.020 0.025 0.030 0.035 0.040 0.045
FLOW RATE COEFFICIENT
DIMENSIONLESS PQ CHARACTERISTIC

Fig.11

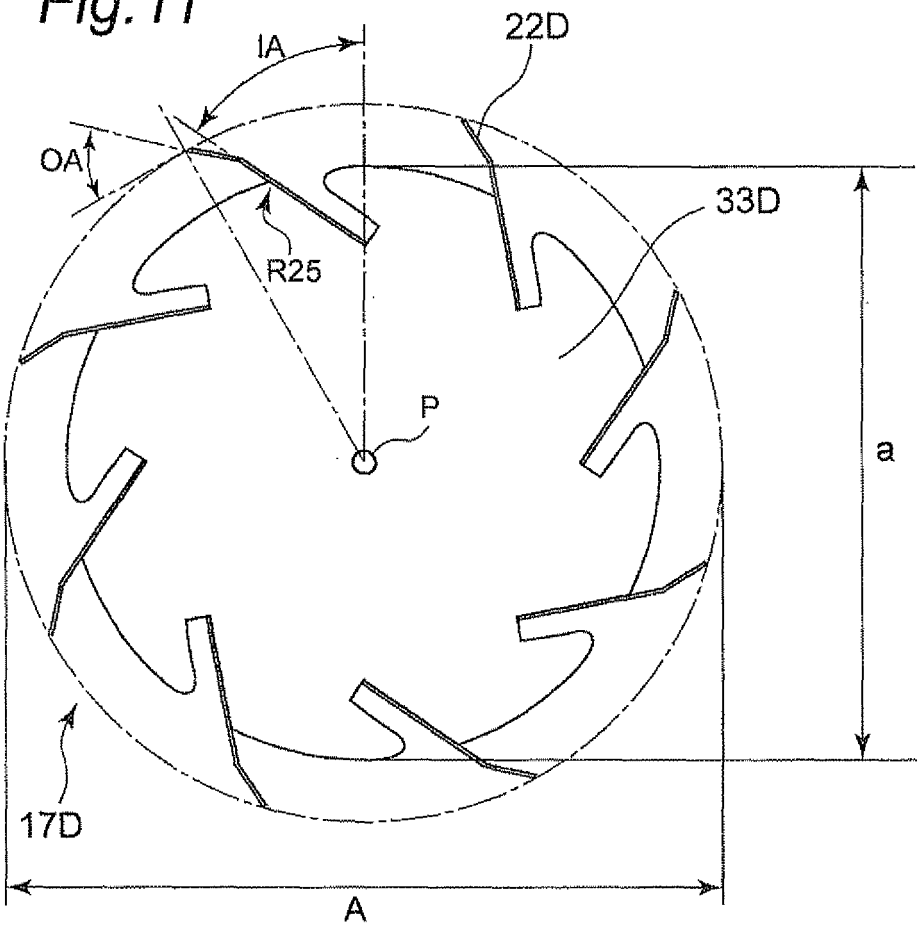


Fig.12

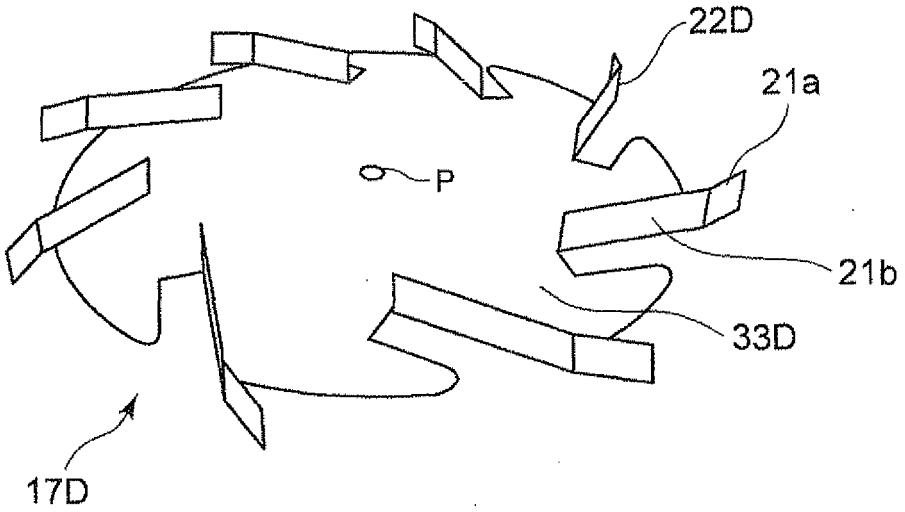


Fig.13

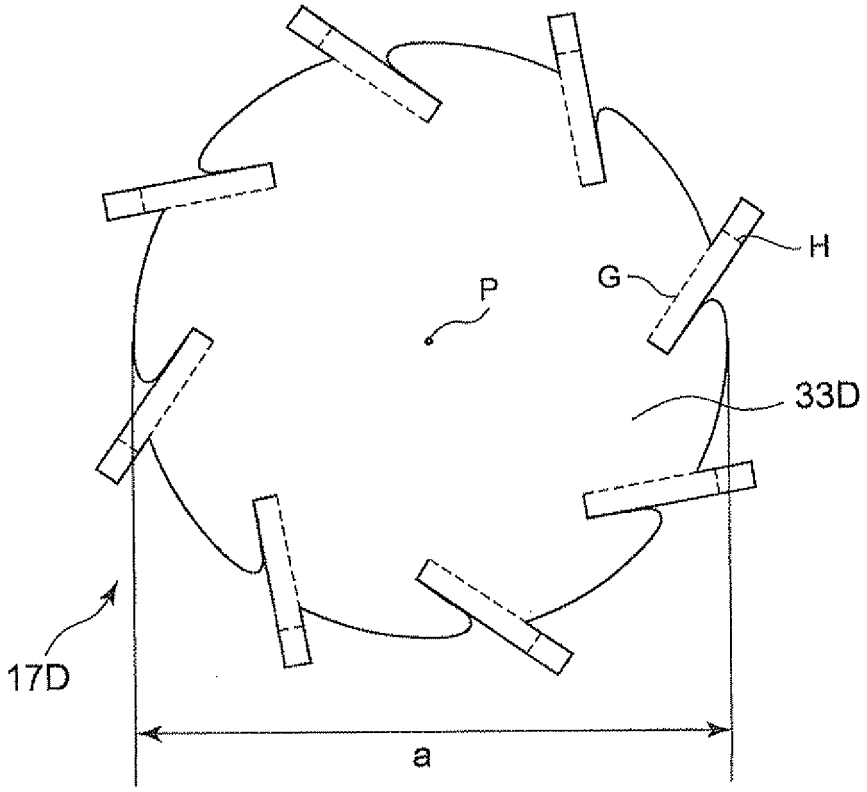
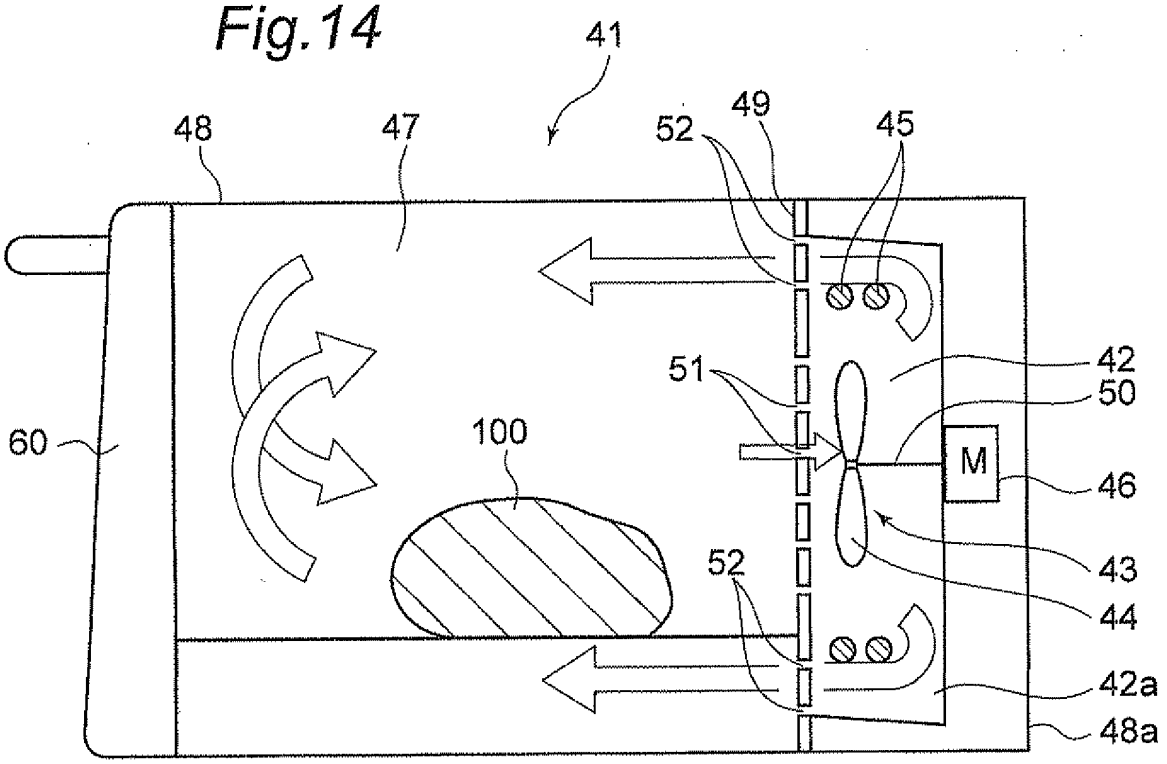


Fig.14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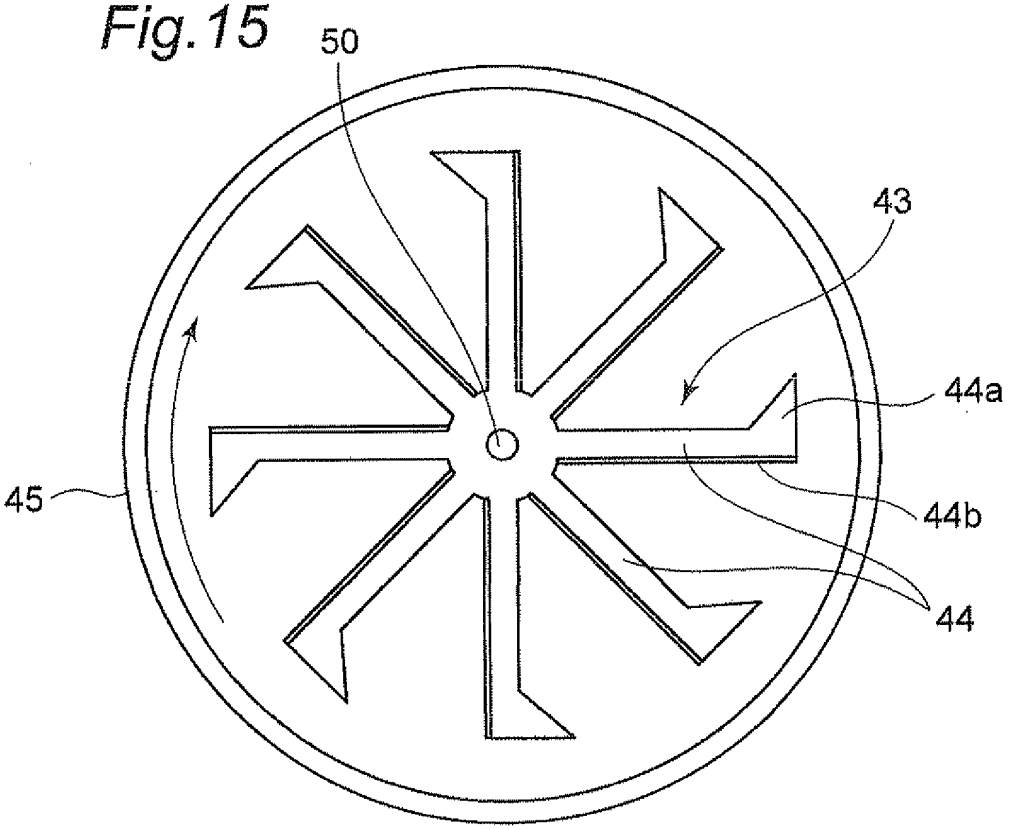
42a
48a

Fig.15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44a
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44b
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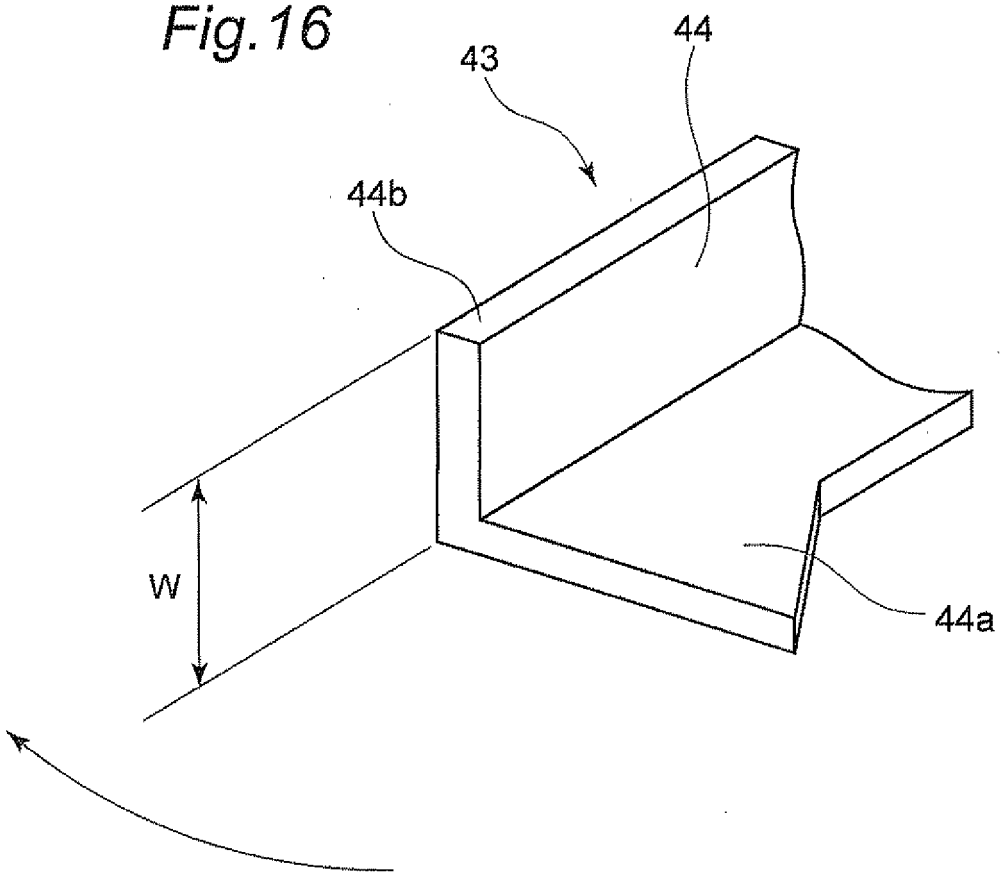
Fig.16



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/003484

A. CLASSIFICATION OF SUBJECT MATTER
F24C1/00(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)
F24C1/00

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 1996-2010
Kokai Jitsuyo Shinan Koho 1971-2010 Toroku Jitsuyo Shinan Koho 1994-2010

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 58-221335 A (Matsushita Electric Industrial Co., Ltd.), 23 December 1983 (23.12.1983), entire text; fig. 1, 8 (Family: none)	1,2
A	JP 2005-114226 A (Matsushita Electric Industrial Co., Ltd.), 28 April 2005 (28.04.2005), entire text; fig. 1 to 13 (Family: none)	1,2
A	JP 2007-3042 A (Hitachi Appliances, Inc.), 11 January 2007 (11.01.2007), entire text; fig. 1 to 5 (Family: none)	1,2

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"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)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"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
"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
"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
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
06 August, 2010 (06.08.10)	17 August, 2010 (17.08.10)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/003484

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2001-50538 A (Maruzen Co., Ltd.), 23 February 2001 (23.02.2001), entire text; fig. 1 to 5 (Family: none)	1,2

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PCT/JP2010/003484

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
(See extra sheet.)

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
Claims 1 and 2

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
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Continuation of Box No.III of continuation of first sheet(2)

The matter common to the inventions of claims 1-13 is "a heating apparatus comprising a heating chamber for accommodating objects to be heated, a heat source chamber adjacent to said heating chamber for feeding a hot wind to the inside of said heating chamber, and a partition having gas introducing holes and gas ejecting holes and partitioning said heating chamber and said heat source chamber, wherein said heat source chamber is provided with a circulating fan mounted on the rotation shaft of a motor, and a heat source for heating the air which has been moved by said circulating fan, wherein said circulating fan includes a main plate and a plurality of blades formed at said main plate, wherein each of said blades is composed of a plurality of blade portions perpendicular to the plane of said main plate, and wherein, the blade face of said blade portions, which forms an entrance angle and which is the closest to the rotation center axis of said circulating fan, and the blade face of said blade portions, which forms an exit angle and which is the remotest from the rotation center axis of said circulating fan, are made of different planes".

The international search, however, has revealed that this common matter is not novel since it is disclosed in document JP 58-221335 A (Matsushita Electric Industrial Co., Ltd.), 23 December 1983 (23.12.1983), entire text, fig. 1 and 8.

Consequently, that common matter is not a special technical feature within the meaning of PCT Rule 13.2, second sentence, since it makes no contribution over the prior art.

Therefore, there is no matter common to all the inventions of claims 1-13.

Since there is no other common matter which can be considered as a special technical feature within the meaning of PCT Rule 13.2, second sentence, no technical relationship within the meaning of PCT Rule 13 can be seen among those different inventions.

Consequently, it is obvious that the inventions of claims 1-13 do not satisfy the requirement of unity of invention.

This International Searching Authority has admitted that this application has the following inventions.

(Continued to next extra sheet)

Form PCT/ISA/210 (extra sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/003484

First invention: Invention of claims 1 and 2

A heating apparatus "comprising a heating chamber for accommodating objects to be heated, a heat source chamber adjacent to said heating chamber for feeding a hot wind to the inside of said heating chamber, and a partition having gas introducing holes and gas ejecting holes and partitioning said heating chamber and said heat source chamber, wherein said heat source chamber is provided with a circulating fan mounted on the rotation shaft of a motor, and a heat source for heating the air which has been moved by said circulating fan, wherein said circulating fan includes a main plate and a plurality of blades formed at said main plate, wherein each of said blades is composed of a plurality of blade portions perpendicular to the plane of said main plate, wherein, in the blade portions, the blade face, which forms an entrance angle and which is the closest to the rotation center axis of said circulating fan, and the blade face, which forms an exit angle and which is the remotest from the rotation center axis of said circulating fan, are made of different planes", "wherein the entrance angle is made between a first line of intersection, on which the blade face the closest to the rotation center axis of said circulating fan and the face of said main plate intersect each other, and the straight line which joins the point closest to the rotation center axis of said circulating fan and the rotation center point, wherein the exit angle OA is made between a second line of intersection, on which the blade face the remotest from the rotation center axis of said circulating fan and the face of said main plate intersect each other, and the tangential line in the rotating direction at the point the remotest from the center axis of said circulating fan, wherein said entrance angle is set within a range of 50 degrees to 60 degrees, and wherein said exit angle is set within a range of 40 degrees to 50 degrees".

Second invention: Invention of claims 1, 3 and 5

A heating apparatus "comprising a heating chamber for accommodating objects to be heated, a heat source chamber adjacent to said heating chamber for feeding a hot wind to the inside of said heating chamber, and a partition having gas introducing holes and gas ejecting holes and partitioning said heating chamber and said heat source chamber, wherein said heat source chamber is provided with a circulating fan mounted on the rotation shaft of a motor, and a heat source for heating the air which has been moved by said circulating fan, wherein said circulating fan includes a main plate and a plurality of blades formed at said main plate, wherein each of said blades is composed of a plurality of blade portions perpendicular to the plane of said main plate, wherein, in the blade portions, the blade face, which forms an entrance angle and which is the closest to the rotation center axis of said circulating fan, and the blade face, which forms an exit angle and which is the remotest from the rotation center axis of said circulating fan, are made of different planes", "wherein the blade portions of each blade in said circulating fan are formed by folding the main plate, as cut out, partially at right angles so that the individual blade portions are formed by folding the portions of said main plate separately", and "wherein said circulating fan further includes a complementary plate for clogging the notch which is formed by folding said main plate partially, and an auxiliary plate for clamping said blade portions together with said main plate".

(Continued to next extra sheet)

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Third invention: Invention of claims 1, 4 and 5

A heating apparatus "comprising a heating chamber for accommodating objects to be heated, a heat source chamber adjacent to said heating chamber for feeding a hot wind to the inside of said heating chamber, and a partition having gas introducing holes and gas ejecting holes and partitioning said heating chamber and said heat source chamber, wherein said heat source chamber is provided with a circulating fan mounted on the rotation shaft of a motor, and a heat source for heating the air which has been moved by said circulating fan, wherein said circulating fan includes a main plate and a plurality of blades formed at said main plate, wherein each of said blades is composed of a plurality of blade portions perpendicular to the plane of said main plate, wherein, in the blade portions, the blade face, which forms an entrance angle and which is the closest to the rotation center axis of said circulating fan, and the blade face, which forms an exit angle and which is the remotest from the rotation center axis of said circulating fan, are made of different planes", "wherein the blade portions of each blade in said circulating fan are formed by folding the main plate, as cut out, partially so that the blade portions of each blade are formed by folding a sheet of plate material", and "wherein said circulating fan further includes a complementary plate for clogging the notch which is formed by folding said main plate partially, and an auxiliary plate for clamping said blade portions together with said main plate".

Fourth invention: Invention of claims 1 and 6

A heating apparatus "comprising a heating chamber for accommodating objects to be heated, a heat source chamber adjacent to said heating chamber for feeding a hot wind to the inside of said heating chamber, and a partition having gas introducing holes and gas ejecting holes and partitioning said heating chamber and said heat source chamber, wherein said heat source chamber is provided with a circulating fan mounted on the rotation shaft of a motor, and a heat source for heating the air which has been moved by said circulating fan, wherein said circulating fan includes a main plate and a plurality of blades formed at said main plate, wherein each of said blades is composed of a plurality of blade portions perpendicular to the plane of said main plate, wherein, in the blade portions, the blade face, which forms an entrance angle and which is the closest to the rotation center axis of said circulating fan, and the blade face, which forms an exit angle and which is the remotest from the rotation center axis of said circulating fan, are made of different planes", and "wherein said blade portions in said circulating fan are constituted such that they are partially protruded in the centrifugal directions from said main plate".

Fifth invention: Invention of claims 1 and 7

A heating apparatus "comprising a heating chamber for accommodating objects to be heated, a heat source chamber adjacent to said heating chamber for feeding a hot wind to the inside of said heating chamber, and a partition having gas introducing holes and gas ejecting holes and partitioning said heating chamber and said heat source chamber, wherein said heat source chamber is provided with a circulating fan mounted on the rotation shaft of a motor, and a heat source for heating the air which has been moved by said circulating fan, wherein said circulating fan includes a main plate and a plurality of blades formed at said main plate, wherein each of said blades is composed of a plurality of blade portions perpendicular to the plane of said main plate, wherein,

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in the blade portions, the blade face, which forms an entrance angle and which is the closest to the rotation center axis of said circulating fan, and the blade face, which forms an exit angle and which is the remotest from the rotation center axis of said circulating fan, are made of different planes", "wherein said blade portions in said circulating fan are constituted such that they are partially protruded in the centrifugal directions from said main plate, and wherein said heat source is positioned outside of the blade portions of said circulating fan and deviated to the back side said circulating fan.

Sixth invention: Invention of claims 1 and 8

A heating apparatus "comprising a heating chamber for accommodating objects to be heated, a heat source chamber adjacent to said heating chamber for feeding a hot wind to the inside of said heating chamber, and a partition having gas introducing holes and gas ejecting holes and partitioning said heating chamber and said heat source chamber, wherein said heat source chamber is provided with a circulating fan mounted on the rotation shaft of a motor, and a heat source for heating the air which has been moved by said circulating fan, wherein said circulating fan includes a main plate and a plurality of blades formed at said main plate, wherein each of said blades is composed of a plurality of blade portions perpendicular to the plane of said main plate, wherein, in the blade portions, the blade face, which forms an entrance angle and which is the closest to the rotation center axis of said circulating fan, and the blade face, which forms an exit angle and which is the remotest from the rotation center axis of said circulating fan, are made of different planes", "wherein the entrance angle of said blade portions in said circulating fan is set at 55 degrees, and wherein the exit angle of said blade portions in said circulating fan is set at 45 degrees".

Seventh invention: Invention of claims 1 and 9

A heating apparatus "comprising a heating chamber for accommodating objects to be heated, a heat source chamber adjacent to said heating chamber for feeding a hot wind to the inside of said heating chamber, and a partition having gas introducing holes and gas ejecting holes and partitioning said heating chamber and said heat source chamber, wherein said heat source chamber is provided with a circulating fan mounted on the rotation shaft of a motor, and a heat source for heating the air which has been moved by said circulating fan, wherein said circulating fan includes a main plate and a plurality of blades formed at said main plate, wherein each of said blades is composed of a plurality of blade portions perpendicular to the plane of said main plate, wherein, in the blade portions, the blade face, which forms an entrance angle and which is the closest to the rotation center axis of said circulating fan, and the blade face, which forms an exit angle and which is the remotest from the rotation center axis of said circulating fan, are made of different planes", and "wherein said blade portions in said circulating fan are set such that the axial width of the rotation shaft of said motor is set within a range of 6 mm to 15 mm".

Eighth invention: Invention of claims 1 and 10

A heating apparatus "comprising a heating chamber for accommodating objects to be heated, a heat source chamber adjacent to said heating chamber for feeding a hot wind to the inside of said heating chamber, and a partition having gas introducing holes and gas ejecting holes and partitioning said heating chamber and said heat source chamber,

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wherein said heat source chamber is provided with a circulating fan mounted on the rotation shaft of a motor, and a heat source for heating the air which has been moved by said circulating fan, wherein said circulating fan includes a main plate and a plurality of blades formed at said main plate, wherein each of said blades is composed of a plurality of blade portions perpendicular to the plane of said main plate, wherein, in the blade portions, the blade face, which forms an entrance angle and which is the closest to the rotation center axis of said circulating fan, and the blade face, which forms an exit angle and which is the remotest from the rotation center axis of said circulating fan, are made of different planes", and "wherein said circulating fan has six to sixteen blades".
Ninth invention: Invention of claims 1 and 11

A heating apparatus "comprising a heating chamber for accommodating objects to be heated, a heat source chamber adjacent to said heating chamber for feeding a hot wind to the inside of said heating chamber, and a partition having gas introducing holes and gas ejecting holes and partitioning said heating chamber and said heat source chamber, wherein said heat source chamber is provided with a circulating fan mounted on the rotation shaft of a motor, and a heat source for heating the air which has been moved by said circulating fan, wherein said circulating fan includes a main plate and a plurality of blades formed at said main plate, wherein each of said blades is composed of a plurality of blade portions perpendicular to the plane of said main plate, wherein, in the blade portions, the blade face, which forms an entrance angle and which is the closest to the rotation center axis of said circulating fan, and the blade face, which forms an exit angle and which is the remotest from the rotation center axis of said circulating fan, are made of different planes", and "wherein the length of the first intersection line, on which the blade face the closest to the rotation center axis of said circulating fan and the face of said main plate intersect each other, is set within a range of 2.5 times to 3.0 times as long as that of the second line of intersection, on which the blade face the remotest from the rotation center axis of said circulating fan and the face of said main plate intersect each other".

Tenth invention: Invention of claims 1 and 12

A heating apparatus "comprising a heating chamber for accommodating objects to be heated, a heat source chamber adjacent to said heating chamber for feeding a hot wind to the inside of said heating chamber, and a partition having gas introducing holes and gas ejecting holes and partitioning said heating chamber and said heat source chamber, wherein said heat source chamber is provided with a circulating fan mounted on the rotation shaft of a motor, and a heat source for heating the air which has been moved by said circulating fan, wherein said circulating fan includes a main plate and a plurality of blades formed at said main plate, wherein each of said blades is composed of a plurality of blade portions perpendicular to the plane of said main plate, wherein, in the blade portions, the blade face, which forms an entrance angle and which is the closest to the rotation center axis of said circulating fan, and the blade face, which forms an exit angle and which is the remotest from the rotation center axis of said circulating fan, are made of different planes", and "wherein the ratio of the distance to the rotation center axis of said circulating fan from the point the closest to the rotation center axis of the first intersection line, on which the blade face closest to the rotation center axis of said circulating fan

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and the face of the main plate intersect each other, to the distance to said rotation center axis from the point the remotest to said rotation center axis on the second line of intersection, on which the blade face the remotest from the rotation center axis of said circulating fan and the face of said main plate intersect each other, is set within a range of 0.5 to 0.7".

Eleventh invention: Invention of claims 1 and 13

A heating apparatus "comprising a heating chamber for accommodating objects to be heated, a heat source chamber adjacent to said heating chamber for feeding a hot wind to the inside of said heating chamber, and a partition having gas introducing holes and gas ejecting holes and partitioning said heating chamber and said heat source chamber, wherein said heat source chamber is provided with a circulating fan mounted on the rotation shaft of a motor, and a heat source for heating the air which has been moved by said circulating fan, wherein said circulating fan includes a main plate and a plurality of blades formed at said main plate, wherein each of said blades is composed of a plurality of blade portions perpendicular to the plane of said main plate, wherein, in the blade portions, the blade face, which forms an entrance angle and which is the closest to the rotation center axis of said circulating fan, and the blade face, which forms an exit angle and which is the remotest from the rotation center axis of said circulating fan, are made of different planes", "wherein the blade portions of the individual blades in said circulating fan are composed of two blade portions forming the entrance angle and the exit angle, and wherein the radius of curvature of the boundary portions of said two blade portions is set within a range of 20 mm to 30 mm".

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2008014619 A **[0008] [0009] [0010]**