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(71) Applicant: **MITSUBISHI ELECTRIC CORPORATION**
Chiyoda-ku
Tokyo 100-8310 (JP)

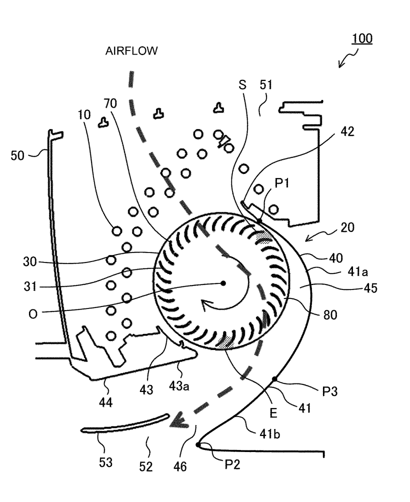
(72) Inventors:
- **ADACHI, Naho**
Tokyo 100-8310 (JP)
- **TERAMOTO, Takuya**
Tokyo 100-8310 (JP)

(74) Representative: **Pfenning, Meinig & Partner mbB**
Patent- und Rechtsanwälte
An der Frauenkirche 20
01067 Dresden (DE)

(54) SCROLL CASING, AND AIR-BLOWING DEVICE AND AIR-CONDITIONING DEVICE PROVIDED WITH SAID SCROLL CASING

(57) A scroll casing accommodates a cross-flow fan, thereby forming an airflow passage, and includes a scroll section having, as an upstream end, an approach point at which the scroll section most closely approaches the fan in the scroll casing, and forms an upstream side of the airflow passage. A region between the upstream end of the scroll section and a downstream end of the scroll section is divided into three regions in the flow direction of airflow in the airflow passage. In the three regions, the distance between the center of rotation of the fan and the scroll section increases at different change rates from the upstream end to the downstream end as the scroll section is viewed at a section perpendicular to an axis of rotation of the fan. Where the three regions are a first region, a second region, and a third region in this order from an upstream side in the flow direction of the airflow, the change rate of the second region is the smallest.

FIG. 1



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Description

Technical Field

[0001] The present disclosure relates to a scroll casing that accommodates a fan, and to an air-sending device and an air-conditioning apparatus which include the scroll casing.

Background Art

[0002] An air-sending device includes a cross-flow fan provided with a plurality of blades arranged annularly. Also, the air-sending device includes an air-sending section provided with a scroll casing that accommodates the cross-flow fan. In the air-sending section, the scroll casing defines an airflow passage. In the airflow passage, air is sent when the cross-flow fan is rotated. A scroll casing of such a type of air-sending section includes a scroll section that spirally guides an airflow generated by the cross-flow fan, and is formed to have a logarithmic spiral shape from the start of the scroll of the scroll section to the end of the scroll thereof (see, for example, Patent Literature 1).

[0003] The logarithmic spiral shape of a scroll casing disclosed in Patent Literature 1 is the following shape as the scroll casing is viewed in a cross section perpendicular to the axis of rotation of a cross-flow fan. The logarithmic spiral shape is a shape in which the distance between the scroll casing and the center of rotation of the cross-flow fan continuously increases at a constant change rate from the start of the scroll to the end of the scroll. In Patent Literature 1, the scroll casing is formed to have the above shape, to thereby reduce noise.

Citation List

Patent Literature

[0004] Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2000-220592

Summary of Invention

Technical Problem

[0005] The technique of the scroll casing of Patent Literature 1 is intended to reduce noise, and thus still has room for improvement in reduction of a fan input.

[0006] The present disclosure is applied to solve the above problem, and relates to a scroll casing that can reduce a fan input, and an air-sending device and an air-conditioning apparatus that include the scroll casing.

Solution to Problem

[0007] A scroll casing according to an embodiment accommodates a cross-flow fan and thereby forms an airflow passage, and includes a scroll section having, as an upstream end, an approach point at which the scroll section most closely approaches the cross-flow fan in the scroll casing, the scroll section forming an upstream side of the airflow passage. A region between the upstream end of the scroll section and a downstream end of the scroll section is divided into three regions in a flow direction of airflow that passes through the airflow passage. The three regions are regions in which a distance between a center of rotation of the cross-flow fan and the scroll section increases at different change rates from the upstream end of the scroll section to the downstream end of the scroll section as the scroll section is viewed at a section perpendicular to an axis of rotation of the cross-flow fan, and where the three regions are a first region, a second region, and a third region in this order from an upstream side in the flow direction of the airflow, the change rate of the second region is the smallest.

[0008] An air-sending device according to another embodiment of the present disclosure includes: the above scroll casing; and the cross-flow fan accommodated in the scroll casing.

[0009] An air-conditioning apparatus according to still another embodiment of the present disclosure includes: the above air-sending device; a housing that houses accommodate the air-sending device; and a heat exchanger provided at a position where airflow generated by the air-sending device passes through.

Advantageous Effects of Invention

[0010] According to the embodiments of the present disclosure, it is possible to reduce the volume of air to be blown out from the blades in the second region, and as a result, reduce the torque applied to the blades in the second region and thus reduce the fan input.

Brief Description of Drawings

[0011]

[Fig. 1] Fig. 1 is a schematic sectional view of an air-conditioning apparatus including a scroll casing according to Embodiment 1.

[Fig. 2] Fig. 2 is a schematic sectional view of an air-sending device according to Embodiment 1.

[Fig. 3] Fig. 3 illustrates the shape of the scroll casing according to Embodiment 1 in comparison with an existing scroll casing.

[Fig. 4] Fig. 4 is a graph indicating, regarding in the scroll casing according to Embodiment 1, a relationship between the position of the casing and a distance L in the casing, in comparison with the existing scroll casing.

[Fig. 5] Fig. 5 is a diagraph indicating the distribution of an air volume in an outlet region of the cross-flow fan in the case where the existing scroll casing is applied to a wall-mounted air-conditioning indoor unit.

[Fig. 6] Fig. 6 is a diagram indicating the distribution of a fan input in an outlet region of the cross-flow fan in the case where the existing scroll casing is applied to the wall-mounted air-conditioning indoor unit.

[Fig. 7] Fig. 7 is a diagram indicating the distribution of the volume of air to be blown out from space between the blades in the outlet region of the cross-flow fan in the case where the scroll casing according to Embodiment 1 is applied to the wall-mounted air-conditioning indoor unit, in comparison with the existing scroll casing.

[Fig. 8] Fig. 8 is a diagram indicating the distribution of the fan input in the outlet region of the cross-flow fan in the case where the scroll casing according to Embodiment 1 is applied to the wall-mounted air-conditioning indoor unit, in comparison with the existing scroll casing.

[Fig. 9] Fig. 9 is a schematic diagram illustrating airflow in the case where the existing scroll casing is applied to the wall-mounted air-conditioning indoor unit and the volume of air is small.

Description of Embodiments

[0012] An air-conditioning apparatus including a scroll casing according to an embodiment of the present disclosure will be described with reference to the drawings, etc. It should be noted that in figures including Fig. 1 which will be referred to below, relative relationships in size between components, the shapes of the components, etc., may differ from those of actual ones. In addition, in each of the figures, components that are the same as or equivalent to those in a previous figure or previous figures are denoted by the same reference signs. The same is true of the entire text of the specification.

Embodiment 1

Air-conditioning Apparatus

[0013] Fig. 1 is a schematic sectional view of an air-conditioning apparatus including a scroll casing according to Embodiment 1.

[0014] An air-conditioning apparatus 100 includes a heat exchanger 10, an air-sending device 20 that generates airflow and sends the airflow to the heat exchanger 10, and a housing 50 that houses the heat exchanger 10 and the air-sending device 20. In the top of the housing 50, an air inlet 51 is formed to allow air to be sucked into the housing 50. In a lower portion of a front side of the housing 50, an air outlet 52 is formed to allow air to be blown out from the housing 50. At the air outlet 52, an airflow direction louver 53 is provided to freely change the direction of the flow of air that is blown out from the air outlet 52. In the housing 50, the heat exchanger 10 is located on an upstream side of a flow passage that extends from the air inlet 51 to the air outlet 52, and the air-sending device 20 is located on a downstream side of the flow passage.

[0015] The air-conditioning apparatus 100 sucks airflow that is generated by driving the air-sending device 20, from the air inlet 51 into the housing 50, causes heat exchange to be performed between the sucked airflow and refrigerant in the heat exchanger 10, and thereafter blows out this airflow from the air outlet 52 into an indoor space, to thereby adjust the temperature of the indoor space. In the following, "upstream" means an upstream side in the flow direction of airflow in the air-conditioning apparatus 100, and "downstream" means a downstream side of the airflow in the air-conditioning apparatus 100. A dashed arrow in Fig. 1 indicates the airflow in the air-conditioning apparatus 100. It should be noted that Fig. 1 illustrates an example in which the air-conditioning apparatus is a wall-mounted air-conditioning indoor unit. However, the air-conditioning apparatus is not limited to the wall-mounted air-conditioning indoor unit, but may be, for example, a ceiling-suspended air-conditioning indoor unit.

Configuration of Air-sending Device 20

[0016] The air-sending device 20 includes a cross-flow fan 30 that generates airflow, and an air-sending section 40 that accommodates the cross-flow fan 30. The cross-flow fan 30 is configured such that impellers are stacked in a direction along the axis of rotation of the cross-flow fan. Each of the impellers includes a plurality of blades 31 that are annularly arranged with reference to the center O of rotation of the axis of rotation, and a support plate (not illustrated) on which the plurality of blades 31 are provided and which supports the plurality of blades 31 together. The cross-flow fan 30 is rotated in a direction indicated by a solid arrow in Fig. 1, and sucks airflow from space between blades 31 located close to the heat exchanger 10 and blow out airflow from space between blades 31 located close to a scroll casing 41 of the air-sending section 40. The scroll casing 41 will be described later.

[0017] The entire circumference of the cross-flow fan 30 is divided into two regions, that is, a region located close to the heat exchanger 10 (on the front side) and a region located close to the air-sending section 40 (on the back side). An inlet region 70 of the cross-flow fan 30, through which airflow is sucked, is the region located close to the heat exchanger 10 (on the front side), which is one of the above two regions. In contrast, an outlet region 80 of the cross-flow fan 30, through which airflow is blown out, is the above region located close to the air-sending section 40 (on the back side), which is the other of the two regions. A blowing start position S indicated by a dotted circle in Fig. 1 is the position of an upstream end portion of the outlet region 80 in a circumferential range thereof. A blowing end position E indicated by another dotted circle in Fig. 1 is the position of a downstream end portion of the outlet region 80 in the circumferential range.

[0018] The air-sending section 40 includes the scroll casing 41, a rear guide 42, a side wall 43, and a discharge portion 44. The scroll casing 41 accommodates the cross-flow fan 30 to thereby form an airflow passage 45. The scroll casing 41 adjusts the flow of air blown out from the cross-flow fan 30. An upstream end P1 of the scroll casing 41 is an approach point at which the scroll casing 41 mostly closely approaches the cross-flow fan 30. A downstream end P2 of the scroll casing 41 forms part of a circumferential wall of the air outlet 52 in the housing 50. The scroll casing 41 has a scroll portion 41a and a discharge portion 41b.

[0019] The scroll portion 41a is configured to spirally guide airflow generated by the cross-flow fan 30. The scroll portion 41a is a wall portion that is formed to extend from a height position located upstream of the height position of the center O of rotation of the cross-flow fan 30 to a position located downstream of the height position of the center O of rotation, through the back side of the cross-flow fan 30. An upstream end P1 of the scroll portion 41a coincides with the upstream end P1 of the scroll casing 41. A downstream end P3 of the scroll portion 41a is located downstream of the height position of the center O of rotation. The upstream end P1 of the scroll portion 41a is a scroll start portion of the scroll portion 41a. The downstream end P3 of the scroll portion 41a is a scroll end portion of the scroll portion 41a. The discharge portion 41b is located downstream of the scroll portion 41a. From the discharge portion 41b, airflow which passes through the scroll portion 41a is discharged. The discharge portion 41b is a wall portion that is formed to extend from the downstream end P3 of the scroll portion 41a toward the air outlet 52 of the housing 50.

[0020] The rear guide 42 is a wall portion that extends to a position located upstream of the upstream end P1 of the scroll casing 41. The side wall 43 is a wall portion that is located opposite to the scroll portion 41a, with the cross-flow fan 30 interposed between the side wall 43 and the scroll portion 41a, and is located at a height position which is located downstream of the height position of the center O of rotation. The side wall 43 is formed along an outer circumferential surface of the cross-flow fan 30. At a downstream end portion of the side wall 43, a tongue portion 43a is formed to serve as an airflow narrowing portion which narrows airflow. The discharge portion 44 is a wall portion that is formed to extend from the tongue portion 43a of the side wall 43 toward a discharge opening of the air-sending section 40. The discharge opening of the air-sending section 40 corresponds to a discharge opening of the air-sending device 20, and also to the air outlet 52 of the housing 50. It is not indispensable that the discharge opening of the air-sending section 40 corresponds to the air outlet 52 of the housing 50. A member that smoothly connects the discharge opening of the air-sending section 40 and the air outlet 52 of the housing 50 may be provided between the discharge opening of the air-sending section 40 and the air outlet 52 of the housing 50. The discharge portion 44 is formed opposite to the discharge portion 41b of the scroll casing 41.

[0021] The scroll portion 41a of the scroll casing 41 and the rear guide 42 form an upstream side of the airflow passage 45. The discharge portion 44 and the discharge portion 41b of the scroll casing 41 form a downstream side of the airflow passage 45. The downstream side of the airflow passage 45 serves as a discharge airflow passage 46 through which airflow blown out from the cross-flow fan 30 is guided to the outside. The discharge airflow passage 46 is an enlarged airflow passage whose cross-sectional area increases from the upstream side toward the downstream side.

Operation of Air-sending Device 20

[0022] In the air-sending device 20, as the cross-flow fan 30 rotates, air is sucked into the cross-flow fan 30 from the space between the blades 31 in the inlet region 70. The air sucked into the cross-flow fan 30 is outwardly blown out from the space between the blades 31 in the outlet region 80 in the radial direction of the cross-flow fan 30. The airflow outwardly blown out from the cross-flow fan 30 in the radial direction flows along the scroll portion 41a of the scroll casing 41. Thereafter, this airflow is discharged to the discharge airflow passage 46 and blown out from the discharge airflow passage 46 into the indoor space through the discharge opening of the air-sending section 40 (the air outlet 52 of the housing 50).

Fan Input Reduction Effect

[0023] The air-sending device 20 including the scroll casing 41 according to Embodiment 1 has a fan input reduction effect. It will be described how the air-sending device 20 is configured to obtain the above effect.

[0024] Fig. 2 is a schematic sectional view of the air-sending device according to Embodiment 1. The shape of the scroll casing 41 will be described with reference to Fig. 2.

[0025] The scroll portion 41a is divided into three regions in the flow direction of air that flows through the airflow passage 45. The three regions are regions in which the distance L between the center O of rotation and the scroll portion 41a increases at different change rates α from the upstream end P1 of the scroll portion 41a to the downstream end P3 of the scroll portion 41a as the scroll portion 41a is viewed at a section perpendicular to the axis of rotation. That is, the scroll portion 41a includes the three regions having the above different change rates α. These three regions will hereinafter be referred to as a first region A, a second region B, and a third region C in this order from the upstream side in the flow direction of airflow. The first region A, the second region B, and the third region C continuously extend in this order.

[0026] Furthermore, blades 31 of the cross-flow fan 30 that are associated with the first region A will be referred to as "blades 31 in the first region A." In this case, the blades 31 of the cross-flow fan 30 that are associated with the first region A mean blades 31 located within a region which has a fan-shaped section and is defined by a line connecting an upstream end of the first region A and the center O of rotation, a line connecting a downstream end of the first region A and the center O of rotation, and the first region A, as the scroll portion 41a is viewed at the section perpendicular to the axis of rotation. Similarly, blades 31 of the cross-flow fan 30 that are associated with the second region B will hereinafter be referred to as "blades 31 in the second region B"; and blades 31 of the cross-flow fan 30 that are associated with the third region C will hereinafter be referred to as "blades 31 in the third region C."

[0027] The upstream end of the first region A is the upstream end P1 of the scroll portion 41a at which part of the scroll portion 41a most closely approaches the cross-flow fan 30 as described above. The downstream end of the first region A coincides with the upstream end of the second region B. The upstream end of the second region B is located upstream of the height position of the center O of rotation. The downstream end of the second region B is located downstream of the height position of the center O of rotation. The downstream end of the second region B coincides with the upstream end of the third region C. The upstream end of the third region C is located upstream of the height position of the tongue portion 43a of the side wall 43. The downstream end of the third region C is located downstream of the height position of the tongue portion 43a of the side wall 43.

[0028] Where regarding the scroll portion 41a, $\alpha 1$ is the change rate α of the first region A, $\alpha 2$ is the change rate α of the second region B, and $\alpha 3$ is the change rate α of the third region C, in the scroll casing 41, the change rate $\alpha 2$ of the second region B is set lower than the change rate α of the first region A and the change rate $\alpha 3$ of the third region C. That is, the change rate $\alpha 2$ of the second region B is the lowest in the scroll portion 41a; and the change rate $\alpha 3$ of the third region C is higher than the change rate $\alpha 1$ of the first region A. To sum up, the scroll casing 41 satisfies the relationship "$\alpha 2 < \alpha 1 < \alpha 3$".

[0029] Fig. 3 illustrates the shape of the scroll casing according to Embodiment 1 in comparison with an existing scroll casing. In Fig. 3, a curved dotted line on the back side of the scroll casing 41 (on the right side in Fig. 3) indicates the existing scroll casing. The existing scroll casing has a constant change rate in the scroll section. Fig. 4 is a graph indicating, regarding the scroll casing according to Embodiment 1, a relationship between the position of the casing and the distance L in the casing, in comparison with the existing scroll casing. In the graph of Fig. 4, the slope of each of lines indicates the change rate α. Figs. 3 and 4 are diagrams obtained in the case where the change rate of the first region A is equal to that of the first region A in the existing scroll casing.

[0030] In the scroll portion 41a in Embodiment 1, since the change rate $\alpha 2$ of the second region B is the lowest, as indicated in the graph of Fig. 4, the slope of part of the line that is associated with the second region B is gentler than the slopes of parts of the line that are associated with the first region A and the third region C. Also, in the graph, the slope of the part of the line that is associated with the second region B is gentler than that in the second region B of the existing scroll casing. That is, the change rate $\alpha 2$ of the second region B is less than that of the second region B of the existing scroll casing in the case where the change rate $\alpha 1$ of the first region A is equal to that of the first region A of the existing scroll casing. The change rate $\alpha 2$ of the second region B is lower than that of the second region B of the existing scroll casing, whereby the position of the second region B as indicated in Fig. 3 is closer to the cross-flow fan 30 than that of the existing scroll casing which is indicated by the dotted line.

[0031] The position of the second region B in the scroll portion 41a is set such that it is effective to reduce the fan input. This point will be described next with reference to Figs. 5 and 6.

[0032] Fig. 5 is a diagram indicating the distribution of an air volume in the outlet region of the cross-flow fan in the case where the existing scroll casing is applied to a wall-mounted air-conditioning indoor unit. In Fig. 5, the horizontal axis represents the position in the outlet region, and the vertical axis represents the air volume [m^3/min]. Fig. 6 is a diagram indicating the distribution of a fan input in the outlet region of the cross-flow fan in the case where the existing scroll casing is applied to the wall-mounted air-conditioning indoor unit. In Fig. 6, the horizontal axis represents the position in the outlet region, and the vertical axis represents the fan input [W]. The fan input [W] is the amount of input power that is calculated by multiplying by an angular velocity, a torque applied to the blades at each of position between the start position of blowing and the end position thereof in the outlet region of the cross-flow fan.

[0033] An intermediate region as indicated in each of Figs. 5 and 6 is an intermediate portion of the existing scroll section in the airflow direction. In this intermediate region, the air volume in the airflow passage between the cross-flow fan and the scroll section is relatively large, and a high pressure loss occurs when airflows blown out from the blades mix with each other. Since the pressure loss is relatively high, the fan input in the intermediate region is relatively high as indicated in Fig. 6. In Embodiment 1, the change rate α of the intermediate region, where the pressure loss increases, is set to a small value as described above, to thereby reduce the fan input as described below. That is, in Embodiment 1, the intermediate region where the pressure loss increases is set as the second region B.

[0034] In the wall-mounted air-conditioning indoor unit as illustrated in Fig. 3, the air outlet 52 of the housing 50 is provided in the lower portion of the front side of the housing 50, and the air-sending device 20 is used, with the discharge opening of the air-sending section 40 located to face downward. In the case where the air-sending device 20 is used in such a manner, the scroll portion 41a is formed to extend in an up-down direction. Specifically, the scroll portion 41a is formed to extend from a height position located upstream of the height position of the center O of rotation of the cross-flow fan 30 to a height position located downstream of the height position of the center O of rotation, through the back side of the cross-flow fan 30. In the case where the scroll portion 41a is formed in such a manner, the region where the pressure loss increases is located in the vicinity of the height position of the center O of rotation. Accordingly, the second region B is provided in the vicinity of the height position of the center O of rotation as illustrated in Fig. 2, specifically, in such a manner as to extend across the height position of the center O of rotation of the cross-flow fan 30.

Advantages of Scroll Casing 41

[0035] Next, the Advantages of the scroll casing 41 according to Embodiment 1 will be described.

[0036] As illustrated in Fig. 3, as is clear from the comparison between the solid line indicating the second region B in Embodiment 1 and the dotted line indicating the second region B of the existing scroll casing, the second region B of Embodiment 1 is closer to the outer circumference of the cross-flow fan 30 than that of the existing scroll casing and the space between the cross-flow fan 30 and the second region B is thus reduced. As the space between the cross-flow fan 30 and the second region B is reduced, a static pressure in this space increases, and the volume of air to be blown out from the blades 31 (which will hereinafter be referred to as "inter-blade blowing air volume") in the second region B decreases. Since the inter-blade blowing air volume in the second region B decreases, it is possible that the torque applied to the blades 31 in the second region B is reduced, thus decreasing a resistance against rotation of the cross-flow fan 30. It is therefore possible to reduce the fan input required to drive the cross-flow fan 30.

[0037] Fig. 7 is a diagram indicating the distribution of the volume of air to be blown out from the space between the blades in the outlet region of the cross-flow fan in the case where the scroll casing according to Embodiment 1 is applied to a wall-mounted air-conditioning indoor unit, in comparison with the existing scroll casing. In Fig. 7, the horizontal axis represents the position in the outlet region, and the vertical axis represents the air volume [m^3/min]. Fig. 8 is a diagram indicating the distribution of the fan input in the outlet region of the cross-flow fan in the case where the scroll casing according to Embodiment 1 is applied to a wall-mounted air-conditioning indoor unit, in comparison with to the existing scroll casing. In Fig. 8, the horizontal axis represents the position in the outlet region, and the vertical axis represents the fan input [W]. The fan input [W] is the amount of input power that is calculated by multiplying by an angular velocity, a torque applied to the blades 31 at each of positions between the start position of blowing and the end position thereof in the outlet region 80.

[0038] In the scroll casing 41 according to Embodiment 1, as indicated by a downward arrow in Fig. 7, it is possible to reduce the inter-blade blowing air volume in the second region B, that is, the inter-blade blowing air volume in the intermediate region, whereas the air volume in the intermediate region in the existing scroll casing is large. As a result, as indicated in Fig. 8, the fan input based on the torque applied to the blades 31 in the second region B can be reduced, as compared with the existing scroll casing.

[0039] It should be noted that the inter-blade blowing air volume in the second region B is reduced, and accordingly the inter-blade blowing air volume in the third region C increases as indicated by an upward arrow in Fig. 7. This raises a concern that the pressure loss in the third region C may increase. However, since the space between the cross-flow fan 30 and the third region C is larger than the space between the cross-flow fan 30 and the second region B, the pressure loss in the third region C is lower than the pressure loss in the second region B. Accordingly, the amount of an increase in the fan input that is caused by the increase in the inter-blade blowing air volume in the third region C is not large, and the fan input in the third region C is substantially the same as that of the existing scroll casing as indicated in Fig. 8. Therefore, the fan input reduction effect in the second region B is high, and the fan input in the entire fan is thus reduced. In such a manner, the change rate $\alpha2$ of the second region B is the smallest in the scroll portion 41a, whereby the fan input in the entire fan can be reduced.

[0040] It is described above that the inter-blade blowing air volume in the second region B is reduced, and accordingly the inter-blade blowing air volume in the third region C increases. However, further for the following reason, the inter-blade blowing air volume in the third region C increases. Specifically, since the change rate $\alpha3$ of the third region C is higher than the change rate $\alpha1$ of the first region A, the inter-blade blowing air volume in the third region C increases.

[0041] The change rate $\alpha3$ of the third region C is higher than the change rate $\alpha1$ of the first region A, whereby a large space is secured between the third region C and the cross-flow fan 30, and the static pressure is low. Accordingly, the inter-blade blowing air volume in the third region C increases. The upstream end of the third region C (the downstream end of the second region B) is provided upstream of the height position of the tongue portion 43a of the side wall 43, and it is ensured that the length of the third region C in the airflow direction is greater than in the case where the upstream end of the third region C is provided downstream of the height position of the tongue portion 43a of the side wall 43. It is therefore possible to ensure that a region in which the inter-blade blowing air volume increases is large.

[0042] It is possible to obtain the following advantages (A) and (B) by increasing the inter-blade blowing air volume in the third region C.

(A) As the inter-blade blowing air volume in the third region C increases, the volume of airflow from the third region C toward the air outlet 52 of the housing 50 increases. The volume of airflow from the third region C toward the air outlet 52 of the housing 50 increases, as a result of which after the airflow is blown out from the outlet region 80 of the cross-flow fan 30, the volume of circulating flow that passes through the space between the tongue portion 43a and the cross-flow fan 30 and then re-flows toward the inlet region 70 decreases. It should be noted that the circulating flow causes a decrease in the volume of airflow to be blown out from the air outlet 52. Thus, since the volume of circulating flow can be decreased, the fan input can be reduced.

(B) Since the third region C is close to the air outlet 52 of the housing 50, as the inter-blade blowing air volume in the third region C increases, a dynamic pressure increases at an opening of the discharge airflow passage 46 that defines the air outlet 52 of the housing 50. When the dynamic pressure increases at the opening of the discharge airflow passage 46, a static pressure recovery amount increases which is the amount of a dynamic pressure to be recovered as a static pressure in the discharge airflow passage 46, thereby enabling the cross-flow fan 30 to achieve high performance.

[0043] The change rate $\alpha 1$ of the first region A and the change rate $\alpha 3$ of the third region C are individually set depending on the shape of the cross-flow fan 30 to be installed. For example, the change rate $\alpha 1$ of the first region A and the change rate $\alpha 3$ of the third region C are individually set depending on the installation angle or other factors of the blades 31 of the cross-flow fan 30. The installation angle of the blades 31 is defined as an angle formed between a center line in the blade thickness of a trailing edge-side end portion of the blade 31 (which is a downstream end portion in the flow direction) and a circumferential arc that connects trailing edge ends of the plurality of blades 31. This installation angle affects an outflow angle of airflow to be blown out from the space between the blades 31. The installation angle of each of the blades 31 may be also defined as an angle between the center line in the blade thickness of the trailing edge-side end portion of the blade 31 and a line extending in the radial direction of the impeller. It is conceivable that optimum values of the change rate $\alpha 1$ of the first region A and the change rate $\alpha 3$ of the third region C are present as values at which the fan input can be minimized at a set air volume, and which vary depending on the shape of the cross-flow fan 30. Therefore, by setting the change rate $\alpha 1$ of the first region A and the change rate $\alpha 3$ of the third region C to respective optimum values, it is possible to form the scroll casing in such an optimum shape as to minimize the fan input at a set air volume.

Advantages of Scroll Casing 41 at Small Air Volume

[0044] In the air-conditioning apparatus 100, the air volume of airflow that passes through the inside of the housing 50 may be decreased to a small air volume, because, for example, dust is deposited at the air inlet 51 of the housing 50 or for other reasons. The advantages of the scroll casing 41 at a small air volume will be described below.

[0045] In the scroll casing 41 according to Embodiment 1, the change rate $\alpha 1$ of the first region A is higher than the change rate $\alpha 2$ of the second region B, thereby reducing the probability that the outlet region of the cross-flow fan 30 will move in the opposite direction to the rotation direction. As a result, the fan input reduction effect can be obtained. This point will be described in comparison with the existing scroll casing in which the change rate is constant.

[0046] Fig. 9 is a schematic diagram illustrating airflow in the case where the existing scroll casing is applied to a wall-mounted air-conditioning indoor unit and the volume of air is small.

[0047] When the air volume of airflow that passes through the inside of a housing 500 is reduced to a small air volume, the airflow in an existing scroll casing 410 cannot overcome a pressure loss in the discharge airflow passage 46, and thus moves closer to the scroll casing 410 (the back side). As a result, an outlet region 800 of a cross-flow fan 300 moves in the opposite direction to the rotation direction. That is, as is clear from the comparison of Fig. 9 with Fig. 1, the blowing start position S and the blowing end position E as indicated in Fig. 9 shift in the opposite direction to the rotation direction of the axis of rotation relative to the blowing start position S and the blowing end position E as indicated in Fig. 1.

[0048] When the outlet region of the cross-flow fan 300 shifts in the opposite direction to the rotation direction, part of the airflow blown out from the outlet region of the cross-flow fan 300 flows toward a rear guide 420 (upward in Fig. 9), not toward a scroll section 410a (downward in Fig. 9). The air that flows toward the rear guide 420 collides with air that flows directly from a heat exchanger 110 located above the top of the fan toward the rear guide 420, thereby causing a loss. Furthermore, air that flows from the outlet region 800 of the cross-flow fan 300 toward the rear guide 420 becomes airflow that reenters the cross-flow fan 30 (an arrow 60 in Fig. 9), thereby causing a loss. When the loss is caused, the fan input required to ensure a set air volume increases.

[0049] In the existing scroll casing 410, at a small air volume, the outlet region 800 of the cross-flow fan 300 moves in the opposite direction to the rotation direction, thereby generating a circulating flow at the blowing end position E as described as follows. Airflow blown out from the space between blades 310 in the outlet region of the cross-flow fan 300 passes along with a reverse flow from an air outlet 520 toward a tongue portion 430a, through the space between the tongue portion 430a and the cross-flow fan 300, and then becomes a circulating flow that flows back toward an inlet region 700 of the cross-flow fan 30 (an arrow 61 in Fig. 9). Since such a circulating flow is generated, the fan input required to ensure a set air volume increases.

[0050] By contrast, in Embodiment 1, since the change rate α1 of the first region A is higher than the change rate α2 of the second region B, it is possible to ensure a certain inter-blade blowing air volume in the first region A (see Fig. 2), and reduce movement of the outlet region 800 of the cross-flow fan 300 in the opposite direction to the rotation direction at a small air volume. It is therefore possible to reduce the flow of air from the cross-flow fan 30 toward the rear guide 420, and thus also reduce a loss caused by generation of a flow of air from the cross-flow fan 30 toward the rear guide 420, and reduce an increase in the fan input.

[0051] Furthermore, in Embodiment 1, since the inter-blade blowing air volume in the third region C increases, it is possible to obtain the following advantage (C) at a small air volume.

(C) Because of an increase in the inter-blade blowing air volume in the third region C, the volume of airflow from the discharge airflow passage 46 toward the air outlet 52 increases. It is therefore possible to reduce backflow from the air outlet 52 toward the tongue portion 43a at a small air volume, and thus reduce the volume of circulating flow that flows back toward the inlet region 70 of the cross-flow fan 30. As a result, the fan input can be reduced.

[0052] It should be noted that the above description refers to by way of example the case where the scroll casing 41 is applied to the wall-mounted air-conditioning indoor unit; however, also in the case where the scroll casing 41 is applied to other types of indoor units, it is possible to obtain similar advantages to those in the above case.

Advantages

[0053] The scroll casing 41 according to Embodiment 1 accommodates the cross-flow fan 30 and thereby forms the airflow passage 45. The scroll casing 41 has the scroll portion 41a that has, as the upstream end P1, an approach point at which the scroll portion 41a most closely approaches the cross-flow fan 30 in the scroll casing 41, and forms an upstream side of the airflow passage. A region between the upstream end P1 of the scroll portion 41a and the downstream end P3 of the scroll portion 41a is divided into three regions in the flow direction of air that flows through the airflow passage 45. The three regions are regions in which the distance between the center of rotation of the cross-flow fan 30 and the scroll portion 41a increases at different change rates α from the upstream end P1 of the scroll portion 41a to the downstream end P3 of the scroll portion 41a as the scroll portion 41a is viewed at a section perpendicular to the axis of rotation of the cross-flow fan. In the scroll casing 41, the three regions are located as the first region A, the second region B, and the third region C in this order from the upstream side in the flow direction of airflow, and the change rate α2 of the second region B is the lowest.

[0054] Because the above configuration is provided, it is possible to reduce the volume of air to be blown out from the blades 31 in the second region B, and as a result, reduce the torque applied to the blades 31 in the second region B and thus also reduce the fan input. Particularly, in the second region B, a relatively high pressure loss occurs when airflows blown out from the blades 31 mix with each other. It is therefore possible to reduce the torque applied to the blades 31 in this second region B, thereby reducing the fan input in the entire fan.

[0055] The change rate α1 of the first region A and the change rate α3 of the third region C are individually set depending on the shape of the cross-flow fan 30, such that the fan input is minimized at a set air volume.

[0056] Therefore, the scroll casing can be formed to have such an optimum shape as to enable the fan input to be minimized at a set air volume.

[0057] The scroll casing 41 according to Embodiment 1 satisfies the relationship "α2<α1<α3", where α1 is the change rate of the first region A, α2 is the change rate of the second region B, and α3 is the change rate of the third region C.

[0058] In such a manner, since the change rate α2 of the second region B is set smallest in the scroll portion 41a, the air volume of air to be blown out from the blades 31 in the second region B can be reduced. The space between the second region B and the cross-flow fan 30 is a region where a pressure loss easily increases to a relatively high level. Thus, the volume of air in this region can be reduced, whereby the fan input reduction effect due to reduction of the torque applied to the blades 31 in the second region B is high. As a result, the fan input in the entire fan can be reduced.

[0059] Since the change rate α3 of the third region C is higher than the change rate α1 of the first region A, the inter-blade blowing air volume in the third region C increases. The above advantages (A), (B), and (C) are obtained because of an increase in the inter-blade blowing air volume in the third region C.

[0060] Furthermore, since the change rate α1 of the first region A is higher than the change rate α2 of the second region B, it is possible to ensure a certain inter-blade blowing air volume in the first region A (see Fig. 2), and reduce movement of the outlet region 80 of the cross-flow fan 30 in the opposite direction to the rotation direction at a small air volume. It is therefore possible to reduce the flow of air from the cross-flow fan 30 toward the rear guide 42. As a result, it is possible to reduce a loss caused by generation of a flow of air from the cross-flow fan 30 toward the rear guide 42, and reduce an increase in the fan input.

[0061] In the scroll casing 41 according to Embodiment 1, the scroll portion 41a is formed to extend from a height position located upstream of, in the air flow, the height position of the center O of rotation of the cross-flow fan 30, to a height position located downstream of, in the air flow, the height position of the center O of rotation. The second region B is provided to extend across the height position of the center O of rotation of the cross-flow fan 30.

[0062] By virtue of the above configuration, it is possible to reduce a torque applied to the blades 31 that passes through a region where a relatively high pressure loss occurs when airflows blown out from the space between the blades 31 mix with each other, and thus reduce the fan input.

[0063] The scroll casing 41 according to Embodiment 1 includes the side wall 43 which is located opposite to the scroll casing 41, with the cross-flow fan 30 interposed between the side wall 43 and the scroll casing 41, and the upstream end P1 of the third region C is located upstream of the height position of the tongue portion 43a of the side wall 43.

[0064] By virtue of the above configuration, the inter-blade blowing air volume in the third region C increases, and the above advantages (A), (B), and (C) can thus be obtained.

[0065] The air-sending device 20 in Embodiment 1 includes the scroll casing 41 described above and the cross-flow fan 30. The air-conditioning apparatus 100 in Embodiment 1 includes the above air-sending device 20, the housing 50 which houses the air-sending device 20, and the heat exchanger 10 which is provided at a position where airflow generated by the air-sending device 20 passes through.

[0066] By virtue of the above configuration, the air-sending device 20 and the air-conditioning apparatus 100 can reduce the fan input.

[0067] The configurations described above regarding the above embodiment are merely examples, and can be combined with other well-known techniques, and also be partially omitted and modified without departing from the gist of the embodiment.

Reference Signs List

[0068] 10: heat exchanger, 20: air-sending device, 30: cross-flow fan, 31: blade, 40: air-sending section, 41: scroll casing, 41a: scroll portion, 41b: discharge portion, 42: rear guide, 43: side wall, 43a: tongue portion, 44: discharge portion, 45: airflow passage, 46: discharge airflow passage, 50: housing, 51: air inlet, 52: air outlet, 53: airflow direction louver, 60: arrow, 61: arrow, 70: inlet region, 80: outlet region, 100: air-conditioning apparatus, 110: heat exchanger, 300: cross-flow fan, 310: blade, 410: scroll casing, 410a: scroll section, 420: rear guide, 430a: tongue portion, 500: housing, 520: air outlet, 700: inlet region, 800: outlet region, A: first region, B: second region, C: third region, E: blowing end position, L: distance, O: center of rotation, P1: upstream end, P2: downstream end, P3: downstream end, S: blowing start position

Claims

1. A scroll casing that accommodates a cross-flow fan and thereby forms an airflow passage, and comprises:

   a scroll section having, as an upstream end, an approach point at which the scroll section most closely approaches the cross-flow fan in the scroll casing, the scroll section forming an upstream side of the airflow passage,
   wherein a region between the upstream end of the scroll section and a downstream end of the scroll section is divided into three regions in a flow direction of airflow that passes through the airflow passage,
   the three regions are regions in which a distance between a center of rotation of the cross-flow fan and the scroll section increases at different change rates from the upstream end of the scroll section to the downstream end of the scroll section as the scroll section is viewed at a section perpendicular to an axis of rotation of the cross-flow fan, and where the three regions are a first region, a second region, and a third region in this order from an upstream side in the flow direction of the airflow, the change rate of the second region is the smallest.

2. The scroll casing of claim 1, wherein the change rate of the first region and the change rate of the third region are individually set depending on a shape of the cross-flow fan, such that a fan input is minimized at a set air volume.

3. The scroll casing of claim 1 or 2, wherein $\alpha 2<\alpha 1<\alpha 3$ is satisfied, where $\alpha 1$ is the change rate of the first region, $\alpha 2$ is the change rate of the second region, and $\alpha 3$ the change rate of the third region.

4. The scroll casing of any one of claims 1 to 3, wherein

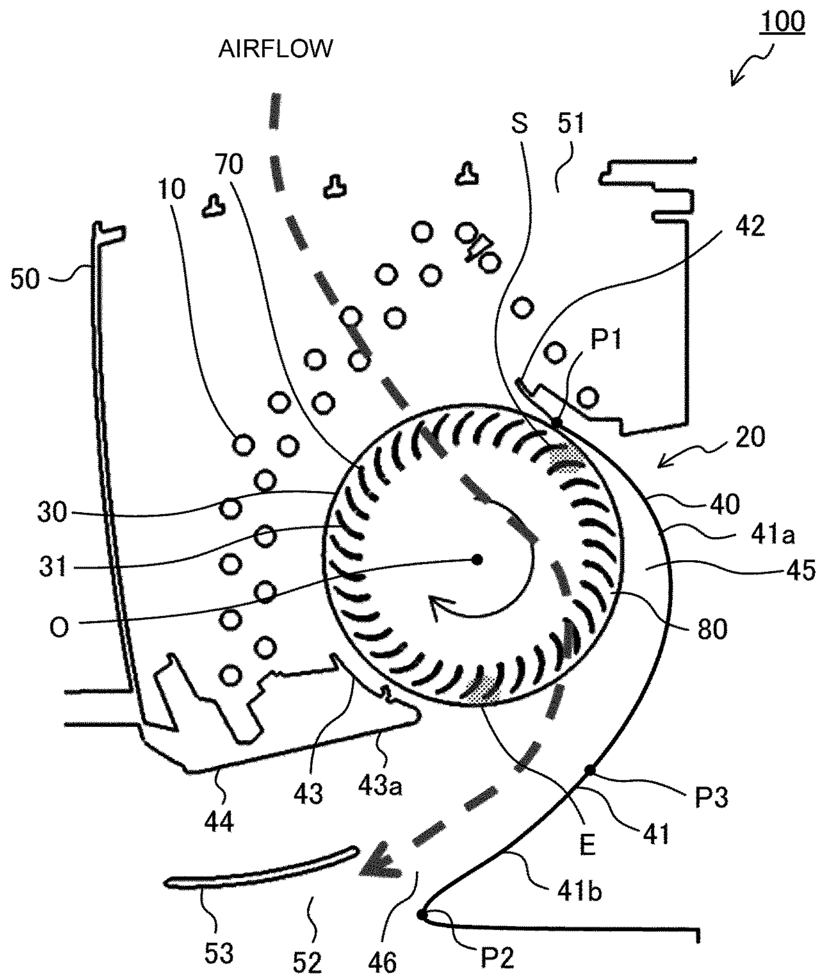
   the scroll section is formed to extend from a height position located upstream of, in the flow direction of the airflow, a height position of the center of rotation of the cross-flow fan to a position downstream of, in the flow direction of the airflow, the height position of the center of rotation, through a side of the cross-flow fan, and
   the second region is provided to extend across the height position of the center of rotation of the cross-flow fan.

5. The scroll casing of claim 4, including a side wall located opposite to the scroll casing, with the cross-flow fan interposed between the side wall and the scroll casing,
wherein an upstream end of the third region is located upstream of a height position of a tongue portion of the side wall.

6. An air-sending device comprising: the scroll casing of any one of claims 1 to 5; and the cross-flow fan.

7. An air-conditioning apparatus comprising: the air-sending device of claim 6; a housing that houses the air-sending device; and a heat exchanger provided at a position where airflow generated by the air-sending device passes through.

FIG. 1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S
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P1
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O
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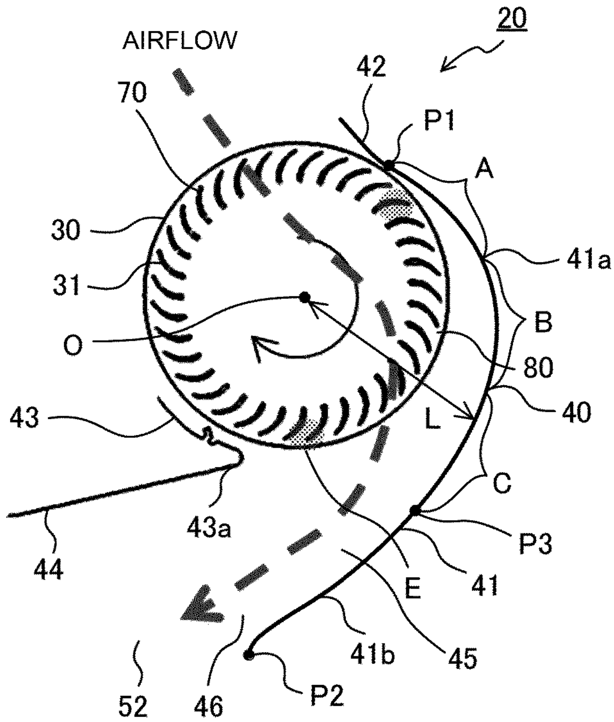
43
43a
P3
44
E
41
41b
53
52
46
P2

FIG. 2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70
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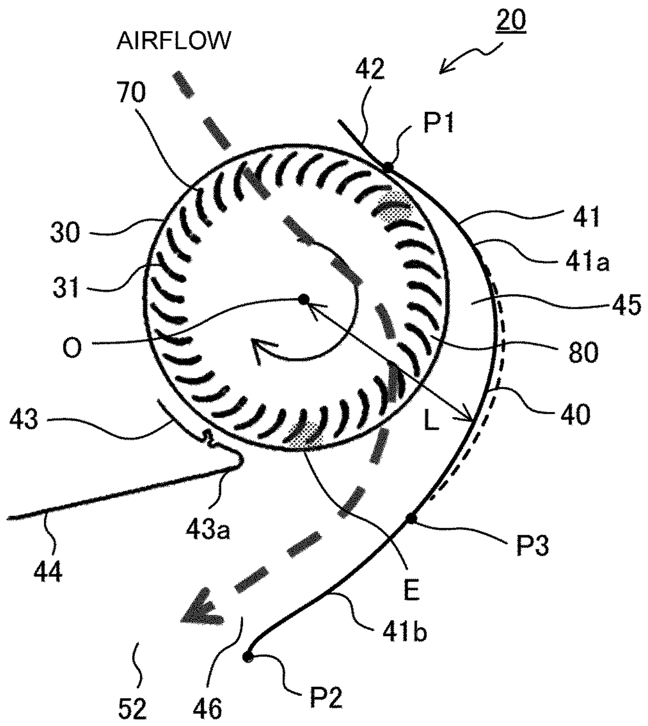
52
46
P2

FIG. 3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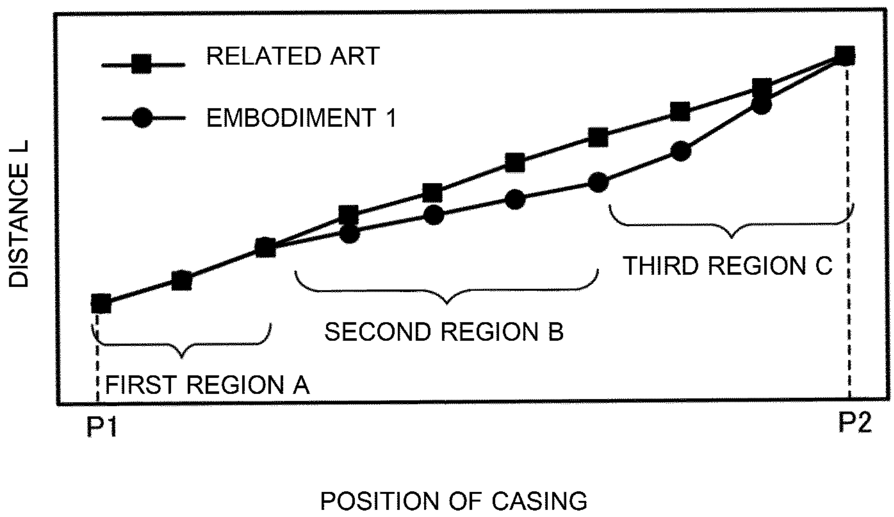
41b
52
46
P2

FIG. 4


RELATED ART
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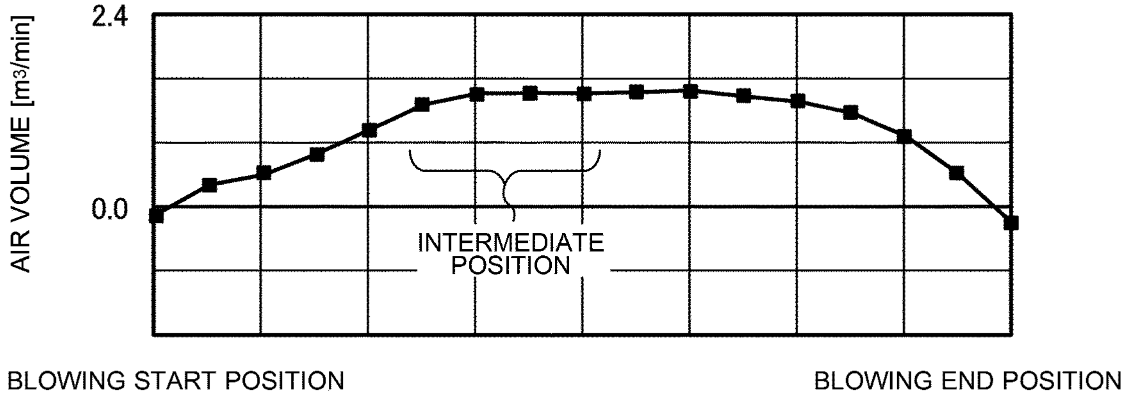
DISTANCE L
THIRD REGION C
SECOND REGION B
FIRST REGION A
P1
P2
POSITION OF CASING

FIG. 5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0.0
INTERMEDIATE POSITION
BLOWING START POSITION
BLOWING END POSITION

FIG. 6

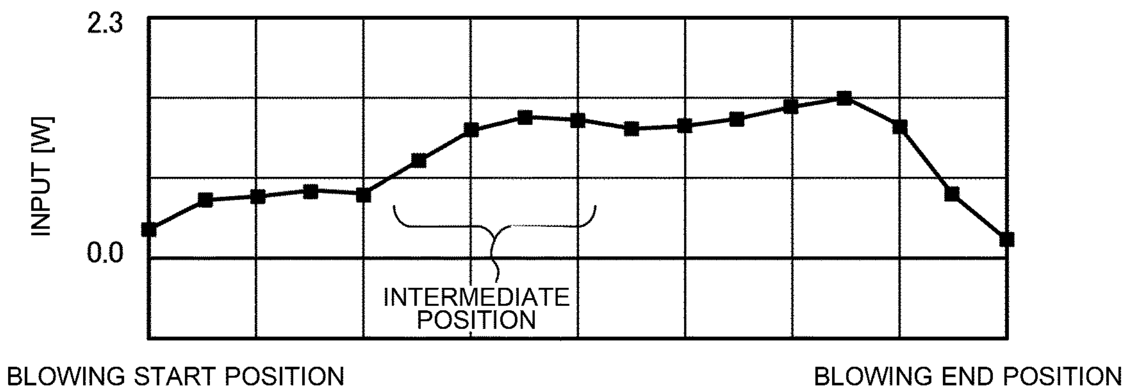

2.3
0.0
INPUT [W]
INTERMEDIATE
POSITION
BLOWING START POSITION
BLOWING END POSITION

FIG. 7

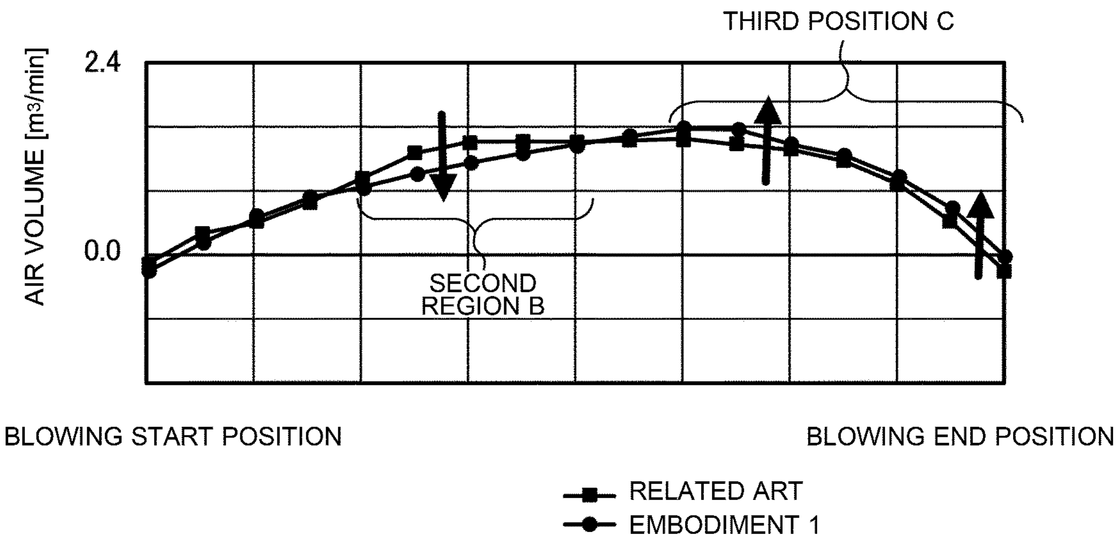
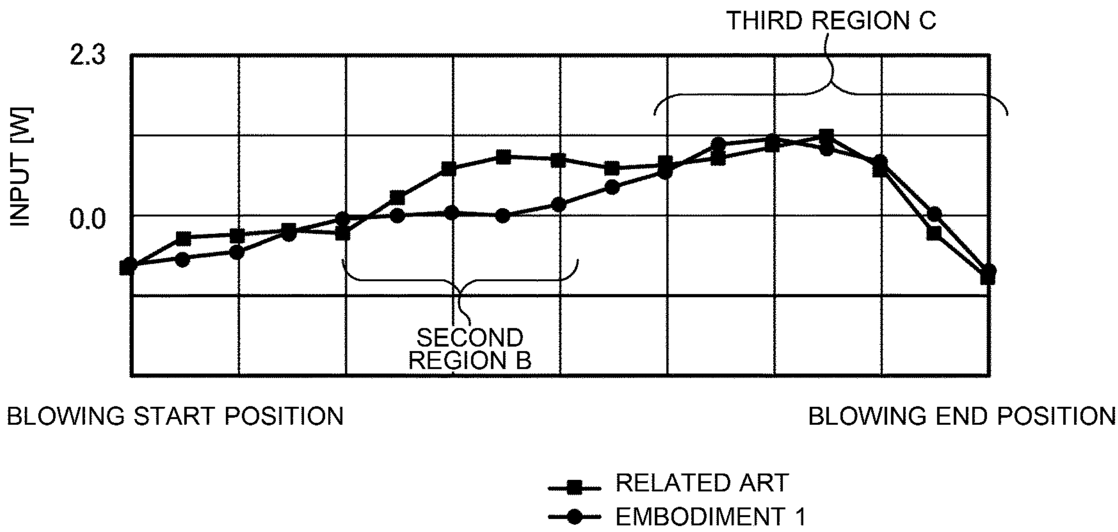

THIRD POSITION C
AIR VOLUME [m3/min]
2.4
0.0
SECOND REGION B
BLOWING START POSITION
BLOWING END POSITION
RELATED ART
EMBODIMENT 1

FIG. 8


THIRD REGION C
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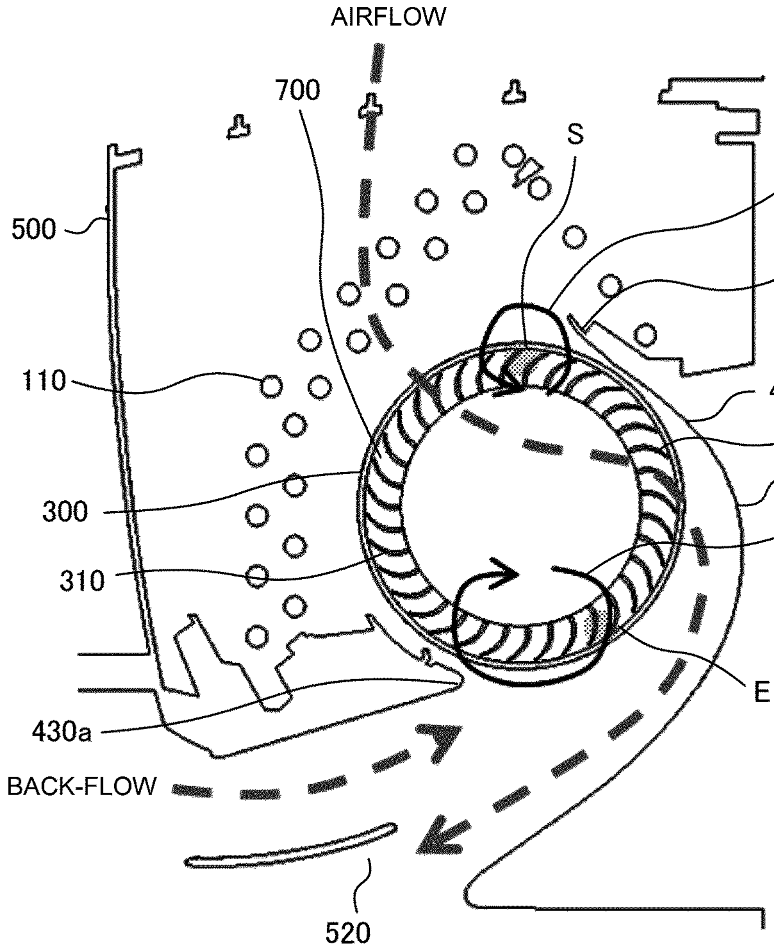
INPUT [W]
0.0
SECOND REGION B
BLOWING START POSITION
BLOWING END POSITION
RELATED ART
EMBODIMENT 1

FIG. 9


AIRFLOW
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S
60
500
420
110
410a
800
300
410
61
310
E
430a
BACK-FLOW
520

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2021/010593

A. CLASSIFICATION OF SUBJECT MATTER
F04D 29/42(2006.01)i
FI: F04D29/42 M
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)
F04D1/00-13/16; F04D17/00-19/02; F04D21/00-25/16; F04D29/00-35/00

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

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2021
Registered utility model specifications of Japan	1996-2021
Published registered utility model applications of Japan	1994-2021

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	CN 206035853 U (QINGDAO HAIER AIR CONDITIONER GENERAL CO., LTD.) 22 March 2017 (2017-03-22) paragraphs [0036]-[0039], [0049]-[0051], fig. 1-4	1-7
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 020797/1981 (Laid-open No. 134388/1982) (SHARP CORP.) 21 August 1982 (1982-08-21)	1-7
A	JP 61-118597 A (MITSUBISHI ELECTRIC CORP) 05 June 1986 (1986-06-05)	1-7
A	JP 7-305695 A (SANYO ELECTRIC CO LTD) 21 November 1995(1995-11-21)	1-7

☒ 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
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"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
19 April 2021 (19.04.2021)	18 May 2021 (18.05.2021)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2021/010593

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 152580/1988 (Laid-open No. 74599/1990) (MITSUBISHI HEAVY INDUSTRIES, LTD.) 07 June 1990 (1990-06-07)	1-7

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2021/010593

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN 206035853 U	22 Mar. 2017	(Family: none)	
JP 57-134388 U1	21 Aug. 1982	(Family: none)	
JP 61-118597 A	05 Jun. 1986	(Family: none)	
JP 7-305695 A	21 Nov. 1995	(Family: none)	
JP 2-74599 U1	07 Jun. 1990	(Family: none)	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2000220592 A **[0004]**