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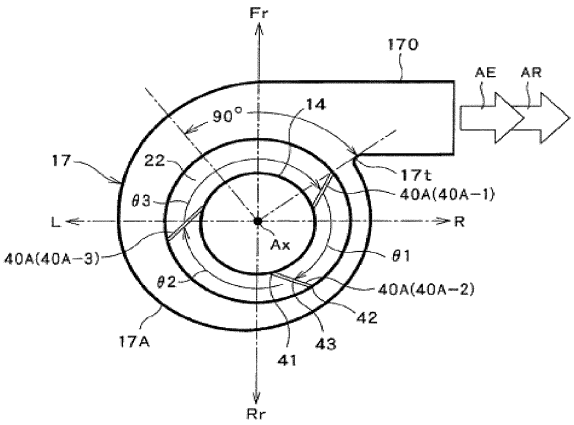
(57) [Problem] To provide a single-suction centrifugal blower for a vehicle that suppresses displacement of a separation cylinder relative to its peripheral components caused by vibrations and the like without impairing performance.

[Solving Means] Multiple ribs (40A, 40B, 40C) designed to bridge a gap between a separation cylinder (14) and a scroll housing (17) are arranged in a suction port (22). Each of the ribs has an inner end (41), an outer end (42), a front edge (43), and a rear edge (44). The inner end is connected to the separation cylinder, the outer end is connected to the scroll housing, the rear edge extends toward an inside space of the scroll housing in a region between the separation cylinder and the scroll housing, and the front edge extends to a side opposite to the rear edge in the region between the separation cylinder and the scroll housing. Each of the ribs is inclined with respect to a meridional section of a centrifugal blower in such a way as to satisfy at least one of: a condition where the inner end is located at an angular position ahead of the outer end in a rotation direction of an impeller; and a condition where the rear edge is located at an angular position ahead of the front edge in the rotation direction of the impeller.

Figure 2A

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## Description

### Technical Field

**[0001]** The present invention relates to a centrifugal blower designed for a two-layer flow air conditioning system for a vehicle.

### Background Art

**[0002]** A two-layer flow air conditioning system for a vehicle is known in the field of air conditioning systems for a vehicle. This type of air conditioning system includes: two air blowing passages, i.e. a first air blowing passage and a second air blowing passage, that are separated from each other; and a single centrifugal blower that flows the air into these two air blowing passages. The centrifugal blower has: a scroll housing; and an air intake housing for taking in the air to be sent to the scroll housing.

**[0003]** The centrifugal blower has a separation cylinder that is inserted into a suction port of the scroll housing and a radially inside space of blade rows of an impeller (see PTLs 1 and 2, for example). A space between the radially outside of the blade rows of the impeller and the scroll housing is divided vertically by a separation wall, which forms a first airflow channel that communicates with the first air blowing passage and a second airflow channel that communicates with the second air blowing passage. The separation cylinder is installed in such a way that a first airflow which flows through a first passage located outside the separation cylinder flows through the first airflow channel after being introduced into an upper half part of the blade rows and a second airflow which flows through a second passage located inside the separation cylinder flows through the second airflow channel after being introduced into a lower half part of the blade rows.

**[0004]** In the centrifugal blower of PTLs 1 and 2, the separation cylinder is constrained by the air intake housing only at its inlet end portion and no other portion is constrained in any way. Due to vibrations during traveling of a vehicle, or due to a mass of air flowing around the separation cylinder, the separation cylinder vibrates, so that the separation cylinder and the impeller might come into contact with each other due to displacement of an outlet end of the separation cylinder relative to the blade rows of the impeller. For this reason, it is difficult to reduce the gap between the outlet end of the separation cylinder and the blade rows of the impeller (this influences performance in separation of the first airflow and the second airflow from each other).

### Citation List

### Patent Literature

**[0005]**

PTL 1: Japanese Patent Application Publication No. 2004-132342

PTL 2: International Publication WO No. 2015/082436 pamphlet

### Summary of Invention

### Technical Problem

**[0006]** The present invention aims to provide a single-suction centrifugal blower for a vehicle that has a configuration capable of suppressing displacement of a separation cylinder relative to its peripheral components caused by vibrations and the like without impairing the performance of the centrifugal blower.

### Solution to Problem

**[0007]** According to an embodiment of the present invention, provided is a single-suction centrifugal blower for a vehicle including: a motor; an impeller that has multiple blades which form circumferential blade rows and that is driven to rotate about a rotational axis line by the motor to blow air, sucked inside a radially inside space of the blade rows from one end side in an axial direction thereof, out toward radially outside; a scroll housing that has an internal space which houses the impeller therein, a suction port which opens on the one end side in the axial direction, and a discharge port which opens in a circumferential direction thereof; a partition wall that divides a region of the inside space of the scroll housing, located between an inner circumferential face of the scroll housing and an outer circumferential face of the impeller, and an internal space of the discharge port in the axial direction to form a first airflow channel and a second airflow channel; a separation cylinder that passes through a space of the suction port on radially inside thereof and a space of the blade rows of the impeller on the radially inside thereof and extends in the axial direction, that is provided to divide a flow of air sucked into the scroll housing through the suction port into a first airflow to pass through outside of the separation cylinder and a second airflow to pass through inside of the separation cylinder, and that has an outlet side end part which guides the first airflow to the first airflow channel while changing a direction of the first airflow radially outward and guides the second airflow to the second airflow channel while changing a direction of the second airflow radially outward; an air intake housing that has at least one external air introduction port for taking in external air of the vehicle and at least one internal air introduction port for taking in internal air of the vehicle, and that is configured so as to be capable of letting the external air, taken through the external air introduction port, flow toward the outside of the separation cylinder and letting the internal air, taken through the internal air introduction port, flow toward the inside of the separation cylinder; and multiple ribs that are arranged in the suction port and designed to bridge

a gap between the scroll housing and the separation cylinder.

**[0008]** Each of the ribs has an inner end, an outer end, a front edge, and a rear edge, the inner end is connected to the separation cylinder, the outer end is connected to the scroll housing, the rear edge extends toward the inside space of the scroll housing in a region between the separation cylinder and the scroll housing, and the front edge extends to a side opposite to the rear edge in the region between the separation cylinder and the scroll housing. Each of the ribs is inclined with respect to a meridional section of the centrifugal blower in such a way as to satisfy at least one of: a condition where the inner end is located at an angular position ahead of the outer end in a rotation direction of the impeller; and a condition where the rear edge is located at an angular position ahead of the front edge in the rotation direction of the impeller.

## Advantageous Effects of Invention

**[0009]** According to the embodiment of the present invention described above, since the multiple ribs arranged in the suction port bridge the gap between the scroll housing and the separation cylinder, it is possible to suppress displacement of the separation cylinder relative to its peripheral components caused when the separation cylinder vibrates. In addition, since each of the ribs is inclined with respect to the meridional section of the centrifugal blower in such a way as to satisfy at least one of: the condition where the inner end is located at an angular position ahead of the outer end in the rotation direction of the impeller; and the condition where the rear edge is located at an angular position ahead of the front edge in the rotation direction of the impeller, it is possible to inhibit the ribs from hampering the flow of the air passing through the suction port of the scroll housing in a region outside the separation cylinder.

## Brief Description of Drawings

**[0010]**

[Fig. 1] Fig. 1 is a vertical sectional view of a centrifugal blower according to an embodiment of the present invention, including a meridional section thereof.

[Fig. 2A] Fig. 2A is a schematic sectional view taken along the line II-II of Fig. 1, and is a sectional view illustrating a first mode of ribs.

[Fig. 2B] Fig. 2B is a schematic sectional view in the same way as Fig. 2A illustrating a second mode of the ribs.

[Fig. 2C] Fig. 2C is a schematic sectional view in the same way as Fig. 2A illustrating a third mode of the ribs.

[Fig. 2D] Fig. 2D is a schematic view illustrating the flow of the air flowing into a scroll housing through a suction port of the scroll housing in a region outside a separation cylinder.

[Fig. 3A] Fig. 3A is a schematic side view illustrating the first mode of the ribs seen from radially outside.

[Fig. 3B] Fig. 3B is a schematic side view illustrating the second mode of the ribs seen from radially outside.

[Fig. 3C] Fig. 3C is a schematic side view illustrating the third mode of the ribs seen from radially outside.

[Fig. 4A] Fig. 4A is a schematic view illustrating a configuration in the case of dividing the separation cylinder into two or more portions.

[Fig. 4B] Fig. 4B is a schematic view illustrating another configuration in the case of dividing the separation cylinder into two or more portions.

## Description of Embodiments

**[0011]** Hereinbelow, an embodiment the present invention is described with reference to the accompanying drawings.

**[0012]** Fig. 1 and Figs. 2A to 2D are sectional views illustrating the structure of a region at and near an air intake part and a centrifugal blower of an air conditioning system for a vehicle.

**[0013]** A centrifugal blower 1 is a single-suction centrifugal blower. The centrifugal blower 1 has an impeller 2.

**[0014]** The impeller 2 has, in its outer circumferential portion, multiple blades 3 forming blade rows 3A arranged in its circumferential direction. The impeller 2 is driven to rotate about a rotational axis line Ax by a motor 13 to blow the air, sucked inside a radially inside space of the blade rows of the impeller 2 from an upper side in the axial direction thereof (one end side in the axial direction thereof), out toward the radially outside.

**[0015]** Note that, in this specification, for the sake of convenience of description, the direction of the rotational axis line Ax is referred to as an axial direction or an up-and-down direction, and upper and lower sides in Fig. 1 and Figs. 2A to 2D are respectively referred to as an "axially upper side" and an "axially lower side". However, the direction of the rotational axis line Ax at the time when an air conditioning system is actually mounted on a vehicle is not limited to the vertical direction by this. In addition, in this specification, unless otherwise noted, the direction of the radius of a circle which is drawn on a plane, orthogonal to the rotational axis line Ax, about any point on the rotational axis line Ax is referred to as a radial direction, and the circumferential direction of the circle is referred to as a circumferential direction. In addition, reference character "Fr" in Figs. 2A to 2D denotes the front side of the vehicle, reference character "Rr" denotes the rear side of the vehicle, reference character "R" denotes the right side of the vehicle, and reference character "L" denotes the left side of the vehicle for convenience. However, the flow of the air blown out through a discharge port 170 of the centrifugal blower is not limited to a rightward flow in a left-and-right direction of the vehicle by this.

**[0016]** The impeller 2 includes an internal deflection member 9 formed integrally with the impeller 2. The internal deflection member 9 is sometimes called a cone part. This internal deflection member 9 is a rotator in a geometrical sense, and has a side circumferential part 10 and a disk-shaped central part 11. In the central part 11, a rotating shaft 12 of the motor 13 is coupled to the impeller 2. In this example, the side circumferential part 10 curves in such a way that the profile line of the outer circumferential face of the side circumferential part 10 in a meridional section thereof inclines sharply toward the central part 11. In another example of the side circumferential part 10 (not illustrated), there is also a case where the profile line of the outer circumferential face of the side circumferential part 10 in the meridional section thereof does not curve from the central part 11 toward the blade rows 3A (has a linear cross section) .

**[0017]** The impeller 2 is housed in a substantially columnar internal space in a scroll housing 17. The scroll housing 17 has a suction port 22 that opens on the axially upper side and the discharge port 170 (see Figs. 2A to 2D). When the scroll housing 17 is seen in the axial direction, the discharge port 170 extends substantially in the direction of tangent to the outer circumferential face of the scroll housing 17. The discharge port 170 cannot be seen in Fig. 1.

**[0018]** The scroll housing 17 has a partition wall 20 that extends radially inward from an outer circumferential wall 17A of the scroll housing 17. The partition wall 20 divides a region of the inside space of the scroll housing 17, located between the inner circumferential face of the scroll housing 17 and the outer circumferential face of the impeller 2, in the axial direction (in the up-and-down direction) to form a first airflow channel 18 on the upper side and a second airflow channel 19 on the lower side that extend in the circumferential direction along the outer circumferential wall 17A of the scroll housing 17.

**[0019]** A separation cylinder 14 is inserted in the scroll housing 17 via the suction port 22. The cross section of an upper part of the separation cylinder 14 is substantially rectangular. The cross section of a region from a central part 15 to a lower part (outlet side end part) 16 of the separation cylinder 14 is circular or substantially circular. The shape of the cross section of the separation cylinder 14 shifts smoothly from rectangular to circular form as it extends from the upper part 24 closer to the central part 15. The lower part 16 of the separation cylinder 14 has a flare shape that increases in diameter toward its lower end.

**[0020]** The separation cylinder 14 passes through a space of the suction port 22 on the radially inside thereof and extends axially to a space 4 of the blade rows 3A of the impeller 2 on the radially inside thereof. The upper end opening of the separation cylinder 14 is located outside the scroll housing 17 (axially upward of the suction port 22). The lower end of the separation cylinder 14 is located in the space 4 of the blade rows 3A of the impeller 2 on the radially inside thereof.

**[0021]** The separation cylinder 14 divides the flow of the air, sucked inside the scroll housing 17, into a first airflow to pass through a first passage 14A located outside the separation cylinder 14 and a second airflow to pass through a second passage 14B located inside the separation cylinder 14. The first airflow passes through a ring-shaped region of the suction port 22 of the scroll housing 17 that is located outside the outer circumferential face of the separation cylinder 14, and flows into an upper half part 5 of the blade rows of the impeller 2 (a portion close to the suction port 22). The second airflow enters inside the separation cylinder 14 through the upper end of the separation cylinder 14 and flows into a lower half part 6 of the blade rows of the impeller 2 (a portion far from the suction port 22). Accordingly, the ring-shaped region of the suction port 22 of the scroll housing 17 that is located outside the outer circumferential face of the separation cylinder 14 can be deemed as a first suction port of the scroll housing 17, and the opening at the upper end of the separation cylinder 14 can be deemed as a second suction port of the scroll housing 17.

**[0022]** The air intake part of the air conditioning system has a housing 21. This housing 21 shall be referred to as an "air intake housing" for the purpose of distinguishing it from the scroll housing 17. The scroll housing 17 and the air intake housing 21 may be molded integrally, or may be manufactured separately and coupled together by a method such as screwing, bonding, or fitting. The scroll housing 17 and the air intake housing 21 constitute a part of an air conditioning system casing.

**[0023]** The air intake housing 21 has a first opening 25, a second opening 26, a third opening 27, and a fourth opening 28. Through the first opening 25 and the third opening 27, the internal air (in-vehicle air) can be introduced into an internal space 23 of the air intake housing 21 from an in-vehicle space 29 (which is not illustrated in detail). Meanwhile, through the second opening 26 and the fourth opening 28, the external air (the air taken from outside the vehicle) can be introduced into the internal space 23 of the air intake housing 21 from an outlet 30 (which is not illustrated in detail) of an external air inlet passage equipped in the vehicle.

**[0024]** By rotating a door 31 about a rotational axis 31A, it is possible to allow or shut down the flow of the air (internal air) into the air intake housing 21 through the first opening 25. By rotating a door 32 about a rotational axis 32A, it is possible to allow or shut down the flow of the air (external air) into the air intake housing 21 through the second opening 26. By rotating a switching door 33 about a rotational axis 33A and switching its position, it is possible to let the air (internal air or external air) flow into the air intake housing 21 through any one of the third opening 27 and the fourth opening 28.

**[0025]** The air intake housing 21 and the separation cylinder 14 are formed in such a way that almost all the air introduced into the air intake housing 21 through the first opening 25 and/or the second opening 26 passes through the first passage 14A and almost all the air in-

troduced into the air intake housing 21 through the third opening 27 and/or the fourth opening 28 passes through the second passage 14B.

**[0026]** A filter 35 for removing contaminants, such as dust and particles contained in the air is provided in the air intake housing 21 at a position between the region where the first opening 25, the second opening 26, the third opening 27, and the fourth opening 28 are arranged and the upper end of the separation cylinder 14. The filter 35 is preferably constituted of a single filter element.

**[0027]** Although not clearly illustrated in Fig. 1, an upper end part of the separation cylinder 14 extends in a direction vertical to the paper of Fig. 1, and is substantially rectangular in the plan view as described previously. The upper end part of the separation cylinder 14 is constrained by the air intake housing 21 in such a way that two short sides of this rectangle are coupled (coupled by integral molding or bonding) to a wall body of the air intake housing 21 opposed to these sides. The point that the upper end part of the separation cylinder 14 is constrained by the air intake housing 21 is as in the case of PTLs 1 and 2 described in Citation List.

**[0028]** Multiple (three in the illustrated example) ribs 40A-1, 40A-2, and 40A-3 for bridging a gap between the scroll housing 17 and the separation cylinder 14 are arranged in the suction port 22 of the scroll housing 17, more specifically, in a region in the axial direction of the scroll housing 17 having the shape of a bell mouth (see Figs. 2A to 2D). Here, these ribs are hereinafter also referred to as "ribs 40A" for simplifying the description unless these ribs need to be distinguished from each other.

**[0029]** By providing these ribs 40A, it is possible to prevent, or significantly suppress, displacement of a region ranging from the central part 15 to the lower part 16 of the separation cylinder 14 relative to components located at its periphery (such as the scroll housing 17 and the impeller 2). Thereby, even in the case of reducing the gap between the tip of the lower part 16 of the separation cylinder 14 and the blades 3 of the impeller 2, for example, it is possible to prevent the separation cylinder 14 and the blades 3 from colliding with each other when the entire centrifugal blower 1 or the separation cylinder 14 vibrates. By reducing the above gap, it is possible to inhibit mix of the internal air with the external air which might induce failure in a two-layer flow mode to be described later. In addition, by providing the ribs 40A, the clearance between the outer circumferential face of the separation cylinder 14 and the circumferential edge of the suction port 22 of the scroll housing 17 can be kept at its designed value, thus making it possible to achieve the performance of the centrifugal blower as designed.

**[0030]** When the ribs 40A are arranged, the upper end part of the separation cylinder 14 does not necessarily have to be constrained by the air intake housing 21 as long as mix of the internal air with the external air near the upper end part of the separation cylinder 14 can be avoided.

**[0031]** It is also preferable that a part of the separation cylinder 14 (a lower portion of the separation cylinder 14, for example), the ribs 40A, and a part of the scroll housing 17 (an upper part of the scroll housing 17, for example) are integrally molded by the resin injection molding technique. In this case, for example, the separation cylinder 14 can be made in such a way that an upper portion of the separation cylinder 14 is made separately from the lower portion of the separation cylinder 14 and is joined to the lower part of the separation cylinder 14 by a method such as bonding or fitting. The separation cylinder 14 is a thin tubular component which is long in the axial direction thereof, and is thus likely to warp at the time of resin injection molding. By making the upper portion and the lower portion of the separation cylinder 14 separately as described above, each component constituting the separation cylinder 14 becomes smaller in size and less likely to warp, thus making it possible to secure the performance of the centrifugal blower as designed.

**[0032]** However, the separation cylinder 14, the ribs 40A, and the scroll housing 17 may be alternatively molded separately and then joined to each other by joining means such as bonding or fitting.

**[0033]** Each rib 40A has an inner end 41, an outer end 42, a front edge 43, and a rear edge 44. The inner end 41 is connected to the separation cylinder 14, and the outer end 42 is connected to the scroll housing 17. The rear edge 44 extends toward the inside space of the scroll housing 17 in a region between the separation cylinder 14 and the scroll housing 17, whereas the front edge 43 extends to the side opposite to the rear edge 44 in the region between the separation cylinder 14 and the scroll housing 17.

**[0034]** The term "front edge" denotes the upstream edge of each rib 40A relative to the flow direction of the air passing through the vicinity of each rib, whereas the term "rear edge" denotes the downstream edge of each rib 40A relative to the flow direction of the air passing through the vicinity of each rib. Note that the vectors of the flow of the air (see Fig. 2D) flowing into the suction port 22 of the scroll housing 17 located outside the separation cylinder 14 have a rotational component of the same direction as the rotation direction of the impeller 2 and a component of a direction perpendicular to the sheet of Fig. 2D.

**[0035]** The flow velocity of the air passing through the inside of the suction port 22 located outside the separation cylinder 14 is large (fast). Hence, the arrangement of the ribs 40A might hamper the flow of the air passing through the suction port 22 located outside the separation cylinder 14 in such a degree as to cause a reduction in the flow velocity thereof which is problematic in terms of the air sending performance of the centrifugal blower.

**[0036]** In order to inhibit the ribs 40A from hampering the flow of the air, in this embodiment, as illustrated in Fig. 2A and Fig. 3A, each rib 40A is inclined with respect to the meridional section of the centrifugal blower in such a way that the inner end 41 of the rib 40A is located at an angular position ahead of the outer end 42 of the rib

in the rotation direction of the impeller 2. By inclining each rib 40A in this manner, each rib 40A becomes less likely to hamper the flow of the air passing through the inside of the suction port 22 located outside the separation cylinder 14.

**[0037]** (The first) rib 40A-1 is located at a position corresponding to a tongue part 17t of the scroll housing 17. (The second) rib 40A-2 is located at a position ahead of the rib 40A-1 by an angle $\theta 1$ in the rotation direction of the impeller 2. (The third (the last in this example)) rib 40A-3 is located at a position ahead of the rib 40A-2 by an angle $\theta 2$ in the rotation direction of the impeller 2. The rib 40A-1 is located at a position ahead of the rib 40A-3 by an angle $\theta 3$ in the rotation direction of the impeller 2.

**[0038]** The scroll housing 17 of the centrifugal blower 1 is designed in such a way that the flow rate of the air passing through the inside of the suction port 22 located outside the separation cylinder 14 is the smallest at the position of the tongue part 17t and becomes larger as the air advances in the rotation direction of the impeller 2. Accordingly, it is preferable to decrease the density in the arrangement of the ribs 40 in the section where the flow rate of the air is large. For this reason, the first rib 40A-1 is provided at the position of the tongue part 17t where the flow rate of the air is the smallest, and the ribs 40A-1, 40A-2, and 40A-3 are arranged so that the angles $\theta 1$, $\theta 2$, and $\theta 3$ may satisfy the relationship of $\theta 1 < \theta 2 < \theta 3$.

**[0039]** It is preferable that no rib 40A exists in an angular range from the angular position of the tongue part 17t to an angular position ahead of the angular position of the tongue part 17t by 90 degrees in the direction opposite to the rotation direction of the impeller 2 since the flow rate of the air passing through the inside of the suction port 22 located outside the separation cylinder 14 is particularly large in this range. For this reason, in the illustrated example, (the third (the last in this example)) rib 40A-3 is disposed so that $\theta 3 > 90$ degrees may be satisfied.

**[0040]** Although the foregoing description has been given of the case where the three ribs 40A are arranged, preferable arrangement of ribs 40A in the case of arranging three or more ribs 40A can be generalized as follows.

(1) The first to Nth (N is a positive integer equal to or larger than three) ribs 40A are sequentially arranged at angular intervals in the rotation direction of the impeller 2, the first rib 40A-1 is located at a position corresponding to the tongue part 17t of the scroll housing 17, and the angular interval between the i-th (note that i is a positive integer equal to or larger than one and equal to or smaller than N) rib 40A-i out of the N ribs 40A and the rib 40A-(i+1), which is adjacent to the i-th rib 40A-i and located at a position ahead of the i-th rib 40A in the rotation direction of the impeller (2), becomes larger as i becomes larger.

(2) No rib 40A is provided in the angular range from the angular position of the tongue part 17t to the angular position ahead of the angular position of the tongue part 17t by 90 degrees in the direction opposite to the rotation direction of the impeller 2.

**[0041]** Note that, although any number of ribs 40A may be arranged, it is not preferable to arrange so many ribs 40A because they are obstacles for the flow of the air passing through the inside of the suction port 22 located outside the separation cylinder 14. In addition, if the number of ribs 40A increases, the manufacturing cost of the centrifugal blower 1 also increases. On the other hand, if the number of ribs 40A is too small, the capacity of the ribs 40A in constraining the separation cylinder 14 is deteriorated. In consideration of the above, it is preferable that the number of ribs 40A is set at about two to four.

**[0042]** The inclination state of the ribs is not limited to the above. Specifically, ribs 40B (40B-1, 40B-2, 40B-3) illustrated in Fig. 2B and Fig. 3B may be arranged instead of the ribs 40A illustrated in Fig. 2A and Fig. 3A. Each rib 40B is inclined with respect to the meridional section of the centrifugal blower in such a way that the rear edge 44 of the rib 40B is located at an angular position ahead of the front edge 43 of the rib in the rotation direction of the impeller 2. In this case, also, each rib 40B becomes less likely to hamper the flow of the air passing through the inside of the suction port 22 located outside the separation cylinder 14.

**[0043]** Alternatively, ribs 40C (40C-1, 40C-2, 40C-3) as illustrated in Fig. 2C and Fig. 3C may be arranged. Each rib 40C is inclined with respect to the meridional section of the centrifugal blower in such a way that the inner end 41 of the rib 40C is located at an angular position ahead of the outer end 42 of the rib in the rotation direction of the impeller 2 and the rear edge 44 of the rib 40C is located at an angular position ahead of the front edge 43 of the rib in the rotation direction of the impeller 2. In this case, also, each rib 40C becomes less likely to hamper the flow of the air passing through the inside of the suction port 22 located outside the separation cylinder 14.

**[0044]** In the embodiment illustrated in Fig. 2B and Fig. 3B and the embodiment illustrated in Fig. 2C and Fig. 3C, the angular positions where the ribs are arranged may also be set the same as the embodiment illustrated in Fig. 2A and Fig. 3A.

**[0045]** Note that, when the embodiment of Fig. 2A and Fig. 3A, the embodiment of Fig. 2B and Fig. 3B, and the embodiment of Fig. 2C and Fig. 3C are compared, the embodiment of Fig. 2A and Fig. 3A is the easiest to manufacture in terms of the resin injection molding technique, and the embodiment of Fig. 2C and Fig. 3C exhibits the best performance.

**[0046]** Each rib (40A, 40B, 40C) does not necessarily have to be flat and may curve.

**[0047]** Next, an operation of the air conditioning system for a vehicle illustrated in Figs. 1 and 2 is described.

**[0048]** In a first operation mode of the air conditioning

system for a vehicle, the second opening 26 and the fourth opening 28 are opened, and the first opening 25 and the third opening 27 are closed. This state is not illustrated. In this case, the external air introduced through the second opening 26 passes through the first passage 14A located outside the separation cylinder 14 to form a first airflow to flow into the upper half part 5 of the blade rows 3A of the impeller 2. Meanwhile, the external air introduced through the fourth opening 28 passes through the second passage 14B located inside the separation cylinder 14 to form a second airflow to flow into the lower half part 6 of the blade rows of the impeller 2. The first operation mode is sometimes referred to as an external air mode.

**[0049]** In a second operation mode, the second opening 26 and the third opening 27 are opened, and the first opening 25 and the fourth opening 28 are closed. This state is illustrated in Figs. 1 and 2. In this case, external air AE introduced through the second opening 26 passes through the first passage 14A located outside the separation cylinder 14 to form a first airflow to flow into the upper half part 5 of the blade rows 3A of the impeller 2. Meanwhile, internal air AR introduced through the third opening 27 passes through the second passage 14B located inside the separation cylinder 14 to form a second airflow to flow into the lower half part 6 of the blade rows 3A of the impeller 2. The second operation mode is sometimes referred to as an internal/external air two-layer flow mode.

**[0050]** In a third operation mode, the first opening 25 and the third opening 27 are opened, and the second opening 26 and the fourth opening 28 are closed. This state is not illustrated. In this case, the internal air introduced through the first opening 25 passes through the first passage 14A located outside the separation cylinder 14 to form a first airflow to flow into the upper half part 5 of the blade rows 3A of the impeller 2. Meanwhile, the internal air introduced through the third opening 27 passes through the second passage 14B located inside the separation cylinder 14 to form a second airflow to flow into the lower half part 6 of the blade rows 3A of the impeller 2. The third operation mode is sometimes referred to as an internal air mode.

**[0051]** The second operation mode (internal/external air two-layer flow mode) is used at the time of performing the heater operation for quickly warming up the vehicle compartment from a state where the vehicle compartment is cold while preventing fog on a windshield especially during winter season or during a relatively low temperature period. When this heater operation is performed by automatic control, for a while after the start of the heating, the external air AE blows on the windshield (not illustrated) through a defroster blowout port (not illustrated) of the vehicle compartment, and the internal air AR blows toward the feet of a passenger through a foot blowout port (not illustrated) of the vehicle compartment.

**[0052]** When the second operation mode (internal/external air two-layer flow mode) is executed, the external air AE having flowed into the upper half part 5 of the blade rows 3A of the impeller 2 is fed to the defroster blowout port via the first airflow channel 18, and the internal air AR having flowed into the lower half part 6 of the blade rows 3A of the impeller 2 is fed to the foot blowout port via the second airflow channel 19. In this event, if the highly humid internal air AR is mixed with the external air AE which is to be fed to the defroster blowout port, this might cause fog on the windshield that is a problematic phenomenon in terms of safety. In addition, if the low-temperature external air AE is mixed with the internal air AR which is to be fed to the foot blowout port, this might cause a passenger to feel a sense of discomfort. Accordingly, when the second operation mode is executed, it is preferable that all the external air AE flows into the first airflow channel 18 and all the internal air AR flows into the second airflow channel 19.

**[0053]** Note that, when the first and third operation modes are executed, only the internal air or only the external air is used, and hence avoiding mix of the internal air with the external air is not requested so strictly as when the second operation mode is executed. To make it possible to reduce the gap between the lower end of the separation cylinder 14 and the blades 3 of the impeller 2 by the ribs 40 contributes to improvement in performance in separation of the internal air from the external air especially during the second operation mode.

**[0054]** Figs. 4A and 4B schematically illustrate a joint structure of joining the upper portion of the separation cylinder 14, made separately from the lower portion of the separation cylinder 14, to the lower portion of the separation cylinder 14 in the case of integrally molding the lower portion of the separation cylinder 14, the ribs 40A, and the upper part of the scroll housing 17 by the resin injection molding technique.

**[0055]** In Fig. 4A, an upper portion 14D of the separation cylinder 14 is fitted into a lower portion 14C of the separation cylinder 14. By doing so, at the joint part, there is a chance where the external air flowing outside the separation cylinder 14 can mix with the internal air flowing inside the separation cylinder 14, but there is no chance where the internal air flowing inside the separation cylinder 14 can mix with the external air flowing outside the separation cylinder 14.

**[0056]** In Fig. 4B, a ring-shaped reception part 14F is provided in an upper portion 14E of the separation cylinder 14, and an upper end of the lower portion 14C of the separation cylinder 14 is inserted in the reception part 14F. By doing so, it is possible to prevent the external air flowing outside the separation cylinder 14 from mixing with the internal air flowing inside the separation cylinder 14 at the joint part. Reference Signs List

**[0057]** 1: centrifugal blower, 2: impeller, Ax: rotational axis line, 3: blade, 3A: circumferential blade row, 13: motor, 14: separation cylinder, 16: outlet side end part (lower part) of separation cylinder, 17: scroll housing, 17t: tongue part of scroll housing, 18: first airflow channel, 19: second airflow channel, 20: partition wall, 21: air in-

take housing, 22: suction port of scroll housing, 26, 28: external air introduction port (opening), 25, 27: internal air introduction port (opening), 40A, 40B, 40C: rib, 41: inner end of rib, 42: outer end of rib, 43: front edge of rib, 44: rear edge of rib, AE: external air, AR: internal air.

## Claims

**1.** A single-suction centrifugal blower (1) for a vehicle comprising:

a motor (13);
an impeller (2) that has a plurality of blades (3) which form circumferential blade rows (3A) and that is driven to rotate about a rotational axis line (Ax) by the motor to blow air, sucked inside a radially inside space of the blade rows (3A) from one end side in an axial direction thereof, out toward radially outside;
a scroll housing (17) that has an internal space which houses the impeller therein, a suction port (22) which opens on the one end side in the axial direction, and a discharge port (170) which opens in a circumferential direction thereof;
a partition wall (20) that divides a region of the inside space of the scroll housing (17), located between an inner circumferential face of the scroll housing (17) and an outer circumferential face of the impeller (2), and an internal space of the discharge port (170) in the axial direction to form a first airflow channel (18) and a second airflow channel (19);
a separation cylinder (14) that passes through a space of the suction port on radially inside thereof and a space of the blade rows of the impeller (2) on the radially inside thereof and extends in the axial direction, that is provided to divide a flow of air sucked into the scroll housing (17) through the suction port (22) into a first airflow to pass through outside of the separation cylinder and a second airflow to pass through inside of the separation cylinder, and that has an outlet side end part (16) which guides the first airflow to the first airflow channel (18) while changing a direction of the first airflow radially outward and guides the second airflow to the second airflow channel (19) while changing a direction of the second airflow radially outward;
an air intake housing (21) that has at least one external air introduction port (26, 28) for taking in external air of the vehicle and at least one internal air introduction port (25, 27) for taking in internal air of the vehicle, and that is configured so as to be capable of letting the external air, taken through the external air introduction port (26, 28), flow toward the outside of the separation cylinder (14) and letting the internal air, taken through the internal air introduction port (25, 27), flow toward the inside of the separation cylinder (14); and
a plurality of ribs (40A, 40B, 40C) that are arranged in the suction port (22) and designed to bridge a gap between the scroll housing (17) and the separation cylinder (14), wherein
each of the ribs (40A, 40B, 40C) has an inner end (41), an outer end (42), a front edge (43), and a rear edge (44), the inner end is connected to the separation cylinder (14), the outer end is connected to the scroll housing (17), the rear edge extends toward the inside space of the scroll housing (17) in a region between the separation cylinder (14) and the scroll housing (17), and the front edge extends to a side opposite to the rear edge in the region between the separation cylinder (14) and the scroll housing (17), and
each of the ribs (40A, 40B, 40C) is inclined with respect to a meridional section of the centrifugal blower in such a way as to satisfy at least one of:

a condition where the inner end (41) is located at an angular position ahead of the outer end (42) in a rotation direction of the impeller (2); and
a condition where the rear edge (44) is located at an angular position ahead of the front edge (43) in the rotation direction of the impeller (2).

**2.** The centrifugal blower according to claim 1, wherein, in each of the ribs (40A, 40C), the inner end (41) is located at an angular position ahead of the outer end (42) in the rotation direction of the impeller (2).

**3.** The centrifugal blower according to claim 1, wherein, in each of the ribs (40B, 40C), the rear edge (44) is located at an angular position ahead of the front edge (43) in the rotation direction of the impeller (2).

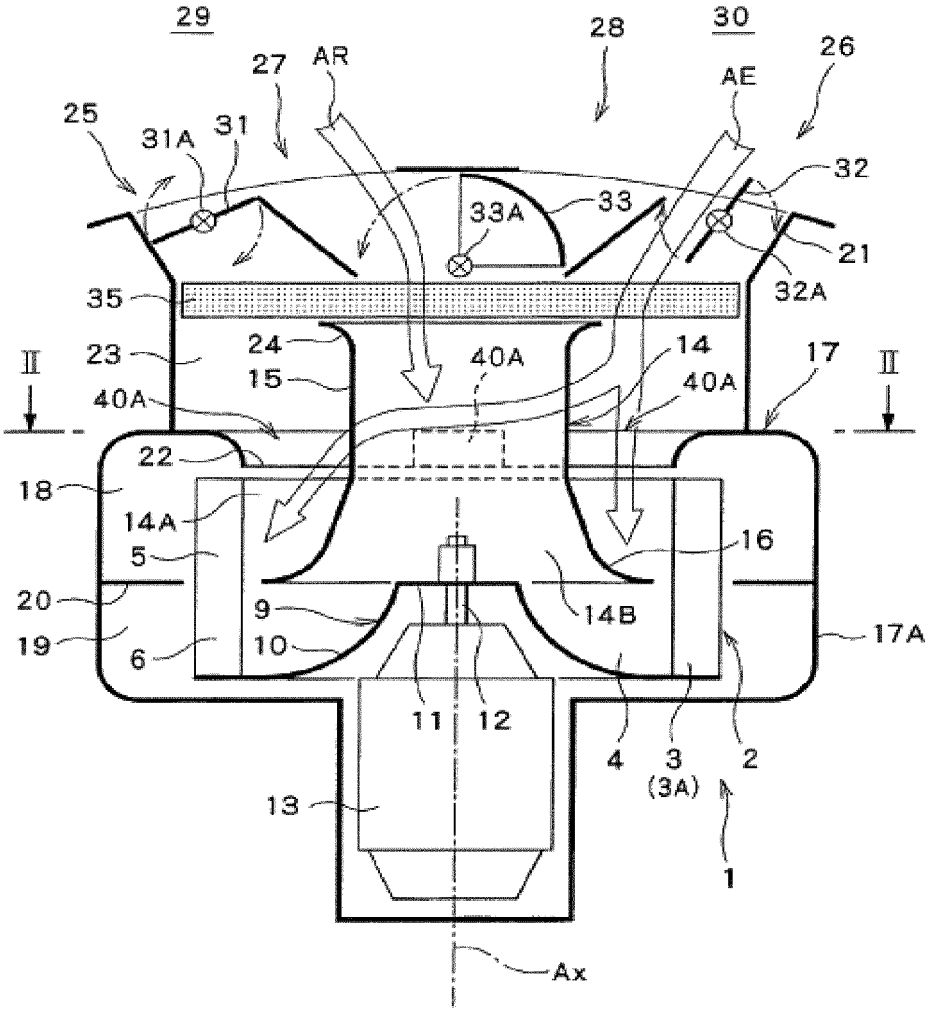
**4.** The centrifugal blower according to claim 1, wherein, in each of the ribs (40A, 40B, 40C), the inner end (41) is located at an angular position ahead of the outer end (42) in the rotation direction of the impeller (2), and the rear edge (44) is located at an angular position ahead of the front edge (43) in the rotation direction of the impeller (2).

**5.** The centrifugal blower according to any one of claims 1 to 4, wherein the centrifugal blower comprises, as the plurality of ribs (40A, 40B, 40C), the first to Nth (N is a positive integer equal to or larger than three) ribs that are sequentially arranged at angular intervals in the rotation direction of the impeller (2), the first rib is located at an angular position corresponding to a tongue part (17t) of the scroll housing (17),

and the angular interval between the i-th (note that i is a positive integer equal to or larger than one and equal to or smaller than N) rib out of the N ribs and a rib, which is adjacent to the i-th rib and located at an angular position ahead of the i-th rib in the rotation direction of the impeller (2), becomes larger as i becomes larger.

**6.** The centrifugal blower according to any one of claims 1 to 5, wherein no rib is provided in an angular range from the angular position of the tongue part (17t) to an angular position ahead of the angular position of the tongue part by 90 degrees in a direction opposite to the rotation direction of the impeller (2).

Figure 1


29
28
30
26
27
AR
AE
25
31A
31
32
33A
33
21
32A
35
23
24
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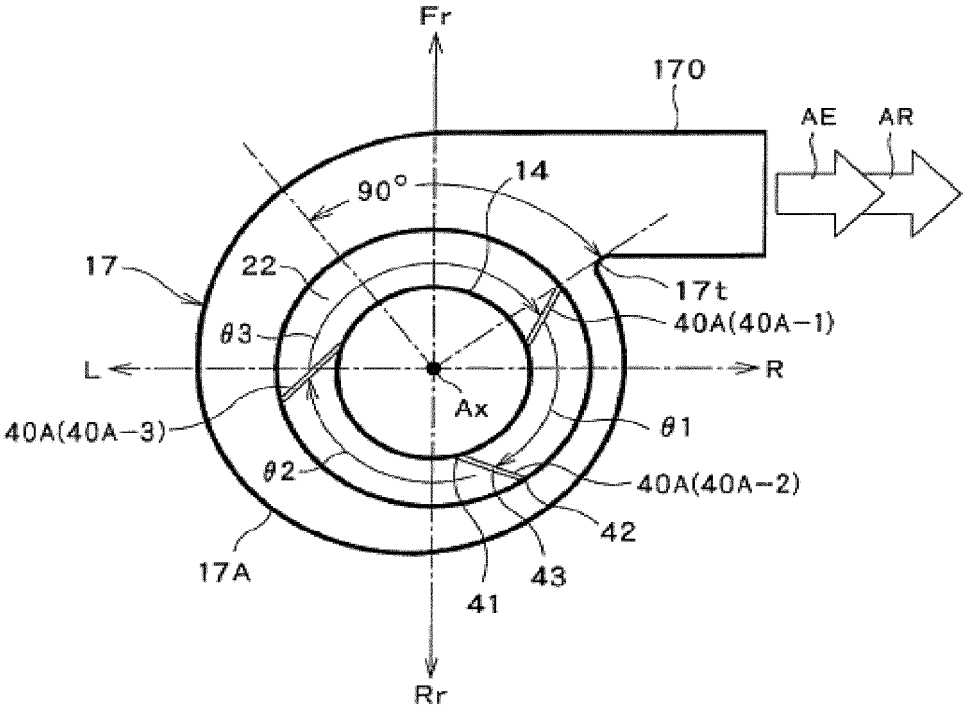
40A
14
40A
17
II
II
22
18
14A
5
16
20
9
14B
19
6
10
17A
11
12
4
3
(3A)
2
13
1
Ax

Figure 2A


Fr
170
AE
AR
90°
14
17
22
17t
40A(40A−1)
θ3
L
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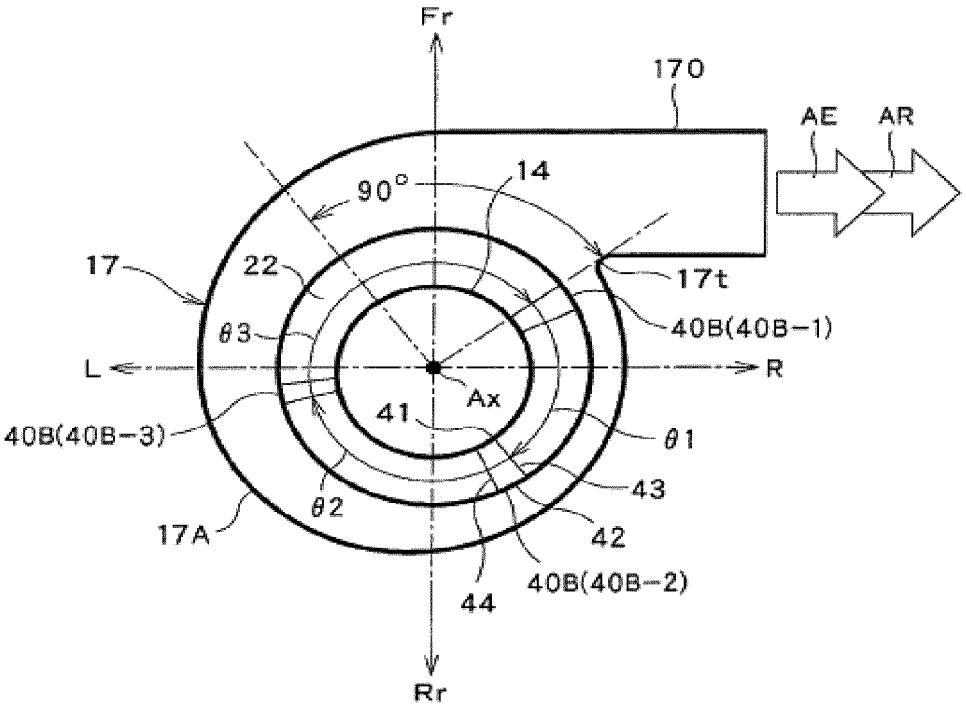
Ax
40A(40A−3)
θ1
θ2
40A(40A−2)
42
17A
43
41
Rr

Figure 2B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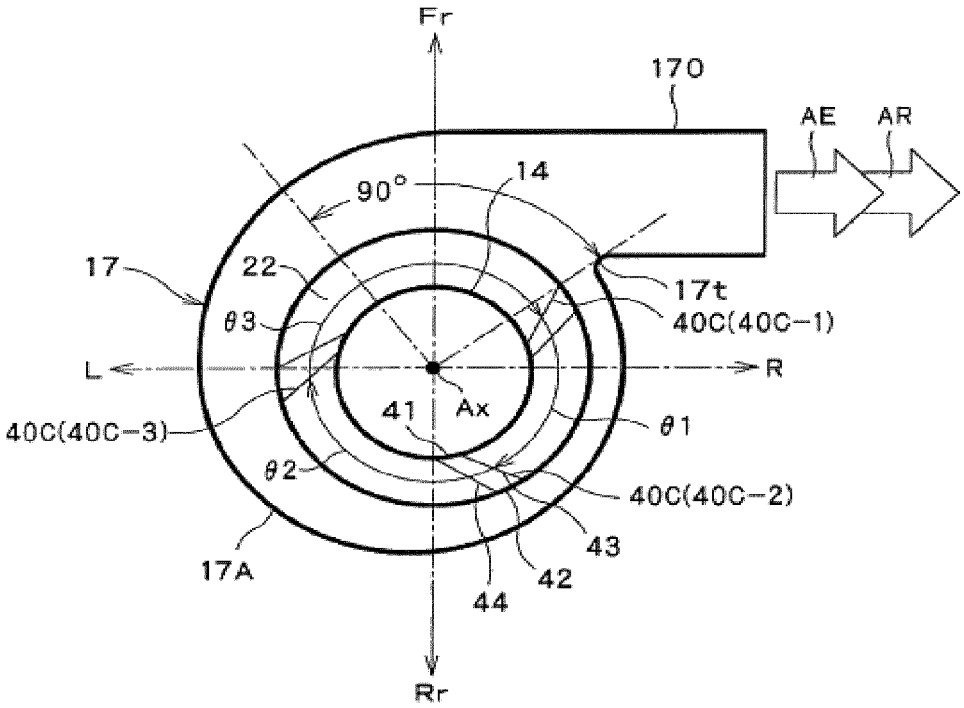
170
AE
AR
90°
14
17
22
17t
40B(40B-1)
θ3
L
R
Ax
41
40B(40B-3)
θ1
43
θ2
17A
42
40B(40B-2)
44
Rr

Figure 2C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170
AE
AR
90°
14
17
22
17t
θ3
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θ2
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43
17A
42
44
Rr

Figure 2D

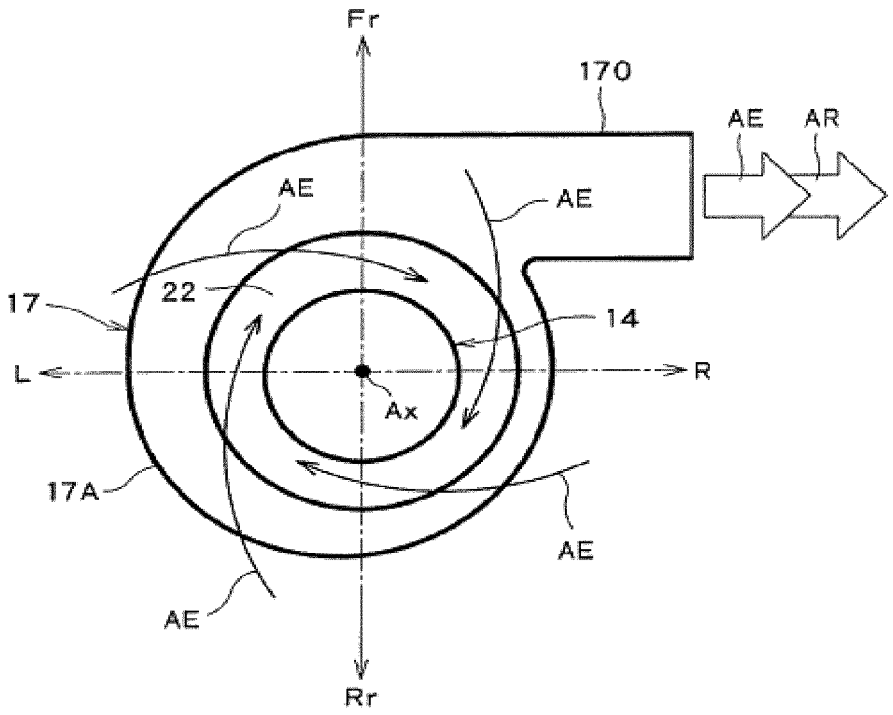


Figure 3A

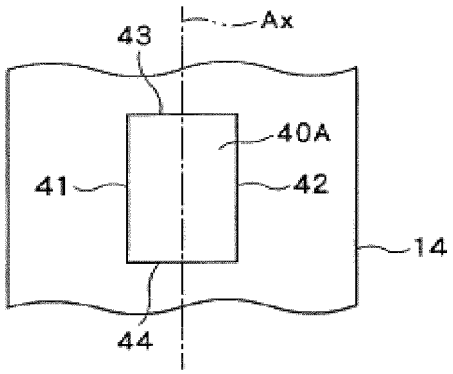



Figure 3B

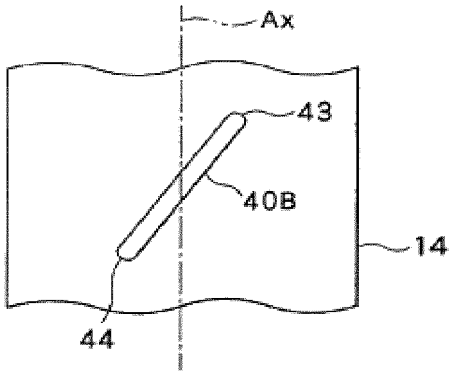


Figure 3C

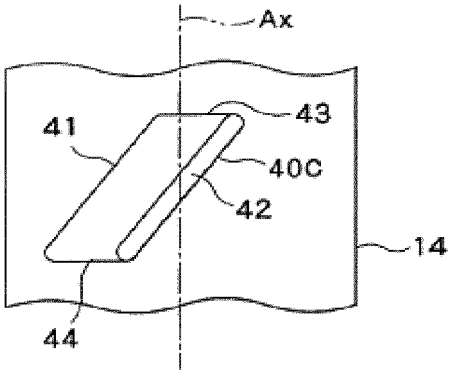


Figure 4A

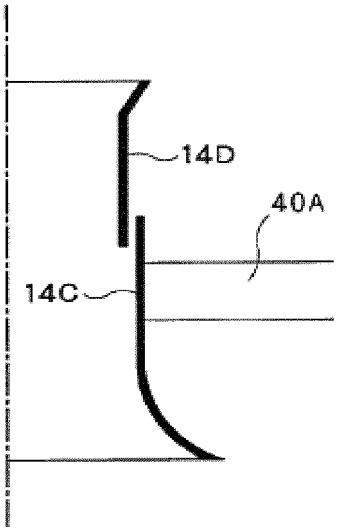
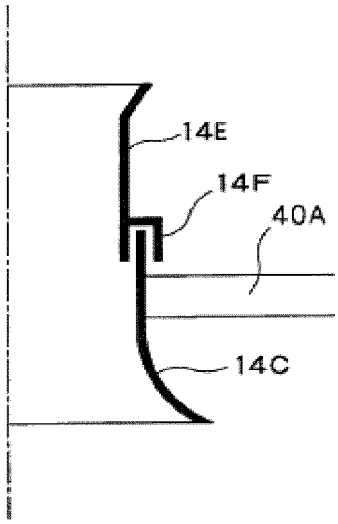



Figure 4B



## INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2017/046893

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl. F04D29/44(2006.01)i, F04D29/42(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)
Int.Cl. F04D29/44, F04D29/42

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 | 1971-2018 |
| Registered utility model specifications of Japan | 1996-2018 |
| Published registered utility model applications of Japan | 1994-2018 |

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| Y<br>A | US 2016/0355069 A1 (VINCENT, Philippe) 08 December 2016, paragraphs [0038], [0055], fig. 1-2 & JP 2017-505397 A | 1-4, 6<br>5 |
| Y<br>A | WO 2016/133014 A1 (NIPPON SOKEN, INC.) 25 August 2016, paragraph [0021], fig. 1-2 (Family: none) | 1-4, 6<br>5 |

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

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"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 28 March 2018 (28.03.2018) | 10 April 2018 (10.04.2018) |

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

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

**INTERNATIONAL SEARCH REPORT**

International application No.
PCT/JP2017/046893

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| Y<br>A | JP 2003-218568 A (TOSHIBA CORP.) 31 July 2003, paragraph [0014], fig. 4 (Family: none) | 1-4, 6<br>5 |
| Y<br>A | JP 59-128998 A (MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.) 25 July 1984, page 2, lower left column, lines 13-16, fig. 2-4 (Family: none) | 1-4, 6<br>5 |
| A | JP 2015-105575 A (DENSO CORP.) 08 June 2015, paragraphs [0041]-[0044], fig. 1 & WO 2015/079670 A1 | 5 |
| A | JP 2004-239148 A (NIPPON KEIKI WORKS LTD.) 26 August 2004, paragraph [0008], fig. 2 (Family: none) | 5 |
| A | US 2008/0152479 A1 (HORNG et al.) 26 January 2008, paragraph [0025], fig. 4 & TW 200827566 A | 5 |

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## REFERENCES CITED IN THE DESCRIPTION

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- JP 2004132342 A **[0005]**
- WO 2015082436 A **[0005]**