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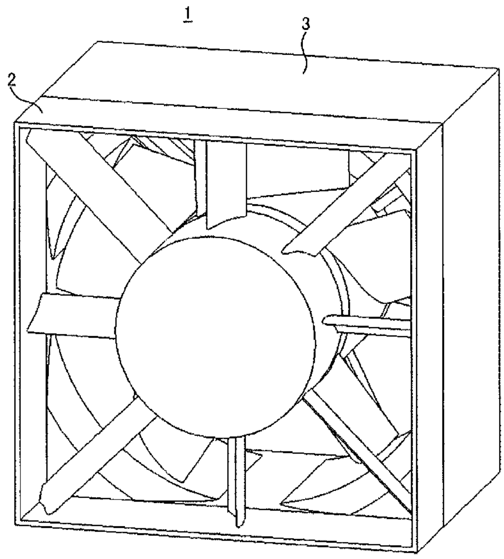
(54) Fan modules and server equipment

(57) A fan module (1) and server equipment (8) are provided that can achieve a balance between increased airflow and noise reduction when an axial flow fan (3) is mounted in the server equipment (8).

The fan module (1) for taking in and discharging air includes a stator (2) located on an upstream side with respect to airflow and an axial flow fan (3) located on the downstream side. When the fan module is viewed from the rotational-axial direction of the axial flow fan (3), if a leading edge of a rotor vane (32) constituting part of the axial flow fan (3) passes a trailing edge of a stator vane (22) constituting part of the stator (2), a skew is formed in which the leading edge of the rotor vane (32) constantly intersects the leading edge of the stator vane (22) at a single point.

FIG.1



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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates generally to fan modules and server equipment. The invention more particularly relates to a fan module formed by combining an axial flow fan with a stator, and server equipment which is an information instrument in which the fan module is mounted.

2. Description of the Related Art

[0002] Office automation equipment, IT devices and home electric appliances include therein a cooling fan for cooling electronic components from which heat is emitted. In recent years, these home electric appliances, office automation equipment and home electric appliances have increasingly been downsized and sophisticated in the market. Electronic components in the internal structure of the equipment or the like are increased in density along with the downsizing and sophistication. Thus, the amount of heat generation across the electronic components tends to increase.

[0003] To address the increase in the heat generation across the electronic components, an axial flow fan that is small-sized and can easily provide airflow is generally employed as a cooling fan. In many cases, designers use general-purpose axial flow fans available from fan's vendors to implement such small-sized axial flow fans in the equipment in a manner suitable for their respective applications.

[0004] Naturally, each of the general-purpose small-sized axial flow fans is not adjusted to match a corresponding one of devices. Therefore, many devices cannot bring out desired performance from the axial flow fans.

[0005] In particular, when boards and the like are mounted in high density in a device such as information instruments represented by server equipment used in a data center, airflow entering the axial flow fan is made turbulent and flow passages for such airflow are reduced in width. Thus, an amount of airflow generated by the axial flow fan is significantly lowered and noise is increased.

[0006] Accordingly, general-purpose small-sized axial flow fans to be mounted in information instruments emphasize technologies for enabling increased airflow and reduced noise.

[0007] For example, W02008/062835 describes the following. A first axial flow fan and a second axial flow fan, i.e., two axial flow fans in total, are arranged in series in the order from the upstream side of airflow with respect to a rotational-axial direction of the fan. A flow straightener is disposed between the first and second axial flow fans. The flow straightener changes the direction of airflow coming out from the first axial flow fan, thereby applying a swirl flow in a direction reverse to the rotational direction of the second axial flow fan to the second axial flow fan. There is an effect of improving the static pressure characteristics of the two axial flow fans to increase the amount of airflow.

SUMMARY OF THE INVENTION

[0008] The conventional technology as mentioned above produces the effect of improving the amount of airflow; however, it does not refer to noise reduction. Therefore, there is the necessity of achieving a balance between the increase in airflow and the noise reduction when the axial flow fans are mounted. In addition, since the conventional technology premises the series configuration of the two axial flow fans, there is a problem in that the conventional technology cannot be applied to information instruments that do not meet such a premise.

[0009] It is an object of the present invention to provide a fan module and server equipment that achieve increased airflow and reduced noise of an axial flow fan to be mounted on an information instrument or the like.

[0010] According to an aspect of the present invention, there is provided a fan module for taking in and discharging air, including: a stator located on an upstream side with respect to airflow; and an axial flow fan located on a downstream side with respect to the airflow. When the fan module is viewed from a rotational-axial direction of the axial flow fan, the stator includes a stator vane trailing edge and the axial flow fan includes a rotor vane leading edge, the trailing edge and the leading edge each having two points of intersection with two concentric circles having different diameters. A straight line connecting the two points of intersection on the trailing edge and a straight line connecting the two points of intersection on the leading edge are configured such that if, on one of the two concentric circles, one point of intersection on the trailing edge is superimposed on the point of intersection on the leading edge, on the other of the two concentric circles, the other point of intersection on the trailing edge is not coincident with the other point of intersection on the leading edge.

[0011] Preferably, the rotor vane has a tilt direction opposite to that of the stator vane.

[0012] Preferably, the stator vane applies a reverse pre-swirl to the rotor vane.

[0013] Preferably, the stator vane constituting part of the stator is configured to be warped like a U-shape.

[0014] Preferably, a second stator is disposed on the downstream side of the axial flow fan.

[0015] Preferably, a trailing edge of a stator vane constituting part of the second stator disposed on the downstream side of the axial flow fan is located at a positive position with respect to a position of a leading edge of the stator vane in a rotational direction of the axial flow fan.

[0016] Preferably, an interval between adjacent stator vanes constituting part of the stator is smaller than a width of a finger.

[0017] Preferably, the axial flow fan and the stator constituting the fan module are integrated with each other.

[0018] Preferably, a plurality of the fan modules are combined in series or in parallel.

[0019] According to another aspect of the present invention, there is provided server equipment in which the fan module described above is mounted.

[0020] The present invention can provide a fan module that can achieve a balance between increased airflow and noise reduction in an axial flow fan mounted in server equipment.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021]

Fig. 1 is a perspective view of a fan module according to a first embodiment of the present invention.
Fig. 2 is a perspective view of a stator constituting part of the fan module shown in Fig. 1.
Fig. 3 is a perspective view of an axial flow fan constituting part of the fan module shown in Fig. 1.
Fig. 4 is an explanatory view showing a state of airflow entering the axial flow fan exposed to the atmosphere.
Fig. 5 is an explanatory view showing a state of airflow entering the axial flow fan mounted in an information instrument.
Fig. 6 is a graph showing a comparison of velocity distribution of airflow entering the axial flow fan between when the axial flow fan is exposed to the atmosphere and when it is mounted in the information instrument.
Fig. 7 is a diagram partially showing the fan module shown in Fig. 1 as viewed from a direction of a rotational axis.
Fig. 8 is a graph showing an effect of a second embodiment of the present invention.
Fig. 9 is a schematic cross-sectional view of a fan module according to a third embodiment of the present invention.
Fig. 10 is a perspective view of a fan module according to a fourth embodiment of the present invention.
Fig. 11 is a perspective view of a stator constituting part of the fan module shown in Fig. 10.
Fig. 12 is a schematic cross-sectional view of the fan module according to the fourth embodiment of the present invention.
Fig. 13 is a perspective view of a fan module according to a fifth embodiment of the present invention.
Fig. 14 is a perspective view of a stator constituting part of the fan module shown in Fig. 13.
Fig. 15 is a configurational schematic of a PC server according to a sixth embodiment of the present invention.
Fig. 16 is a perspective view of a fan module according to a seventh embodiment of the present invention.
Fig. 17 is a graph showing an effect of the seventh embodiment of the present invention.
Fig. 18 is a perspective view of a fan module according to an eighth embodiment of the present invention.
Fig. 19 is a perspective view of a fan module according to a ninth embodiment of the present invention.
Fig. 20 is a configurational schematic of a blade server according to a tenth embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0022] Preferred embodiments of the present embodiment will hereinafter be described with reference to the drawings. A schematic configuration of a fan module is first described with reference to Figs. 1 to 3. Members denoted with the same reference numerals in the figures have the same function; therefore, their explanations may be omitted in other figures. Fig. 1 is a perspective view of a fan module. The fan module 1 is configured such that a stator 2 and an axial flow fan 3 are arranged in series in this order from the upstream side of airflow.

[0023] Fig. 2 is a perspective view of the stator 2. The stator 2 includes a boss 21, stator vanes 22 extending from the boss 21, and an outer frame 23 supporting the stator vanes.

[0024] Fig. 3 is a perspective view of the axial flow fan. The axial flow fan 3 includes a rotating boss 31 to which a motor is mounted; rotor vanes 32 extending from the boss 31; a motor cup 33 supporting the motor mounted to the boss; braces 34 supporting the motor cup 33; and an outer frame 35 supporting the braces 34.

<First Embodiment>

[0025] A first embodiment is described with reference to Figs. 4, 5 and 6. Fig. 4 is an explanatory view showing a state of airflow entering the axial flow fan exposed to the atmosphere. Fig. 5 is an explanatory view showing a state of airflow entering the axial flow fan mounted in an information instrument. Fig. 6 is a graph showing a comparison in velocity distribution of airflow entering the axial flow fan between when the axial flow fan is exposed to the atmosphere and when it is mounted in the information instrument.

[0026] In cooling a variety of information instruments, resistor bodies such as boards which disturb airflow are generally located on the upstream side of a cooling fan. If the airflow thus disturbed by these resistor bodies enters the cooling fan mounted in an information instrument, noises are generated. As shown in Fig. 4, general-purpose small-sized axial flow fans are presupposed to be used under atmosphere-exposure conditions; therefore, they are designed under the assumption that airflow a1 enters the axial flow fan not only from a rotational-axial direction but from a direction perpendicular to the rotational-axial direction. On the other hand, the axial flow fan mounted in the information instrument has a restricted flow passage; therefore, airflow a2 enters the axial flow fan only from the rotational-axial direction as shown in e.g. Fig. 5. If distributions in airflow velocity in the rotational-axial direction are compared between the conditions of airflow into the axial flow fan as described above, the results are as shown in Fig. 6. In Fig. 6, an intersection between a vertical axis and a transverse axis corresponds to the position of radius 0 of the axial flow fan (i.e., the position of the center of the axial flow fan). As seen from Fig. 6, in the case of the axial flow fan mounted in the information instrument (the solid line in Fig. 6), the velocity of airflow in a rotational-axial direction is averagely increased because of the restricted flow passage. In other words, the average value of the velocity distribution of airflow entering the axial flow fan mounted in the information instrument is greater than that of the airflow entering the axial flow fan exposed to the atmosphere.

[0027] The axial flow fan mounted in the information instrument is used under the conditions different from originally assumed conditions. Therefore, an amount of airflow and static pressure are reduced.

[0028] If the fan module 1 shown in Fig. 1 is used to cool a variety of information instruments similarly to the conventionally used axial flow fan, airflow disturbed by the resistor bodies (specific examples are described later but they mean objects to be cooled in e.g. server equipment) located on the upstream side of the fan module is straightened by the stator 2. Thereafter, the airflow thus straightened enters the axial flow fan 3. In this way, disturbed airflow does not enter the axial flow fan 3. Thus, possible noise can be suppressed. Even in the state where the axial flow fan is mounted in the information instrument, the axial flow fan is improved to meet the inflow conditions assumed when designing the axial flow fan. Thus, the amount of airflow and static pressure of the axial flow fan mounted in the information instrument are increased compared with an axial flow fan not provided with a stator on the upstream side thereof.

<Second Embodiment>

[0029] As shown in Fig. 1, the fan module 1 has the stator 2 disposed immediately in front of the axial flow fan 3. The rotor vanes 32 are rotated along with the rotation of the boss 31 to which the motor of the axial flow fan 3 is attached. The rotation of the rotor vanes 32 causes interference with the stator vanes 22 of the stator. Thus, there is concern about increased noise of frequencies resulting from the number of the rotor vanes 32 or of the stator vanes 22.

[0030] To address the concern noise, a second embodiment focuses on a positional relationship between the stator vanes 22 and the rotor vanes 32. This suppresses increase in the noise of frequencies resulting from the number of the rotor vanes 32 or the stator vanes 22.

[0031] Fig. 7 partially shows the fan module 1 as viewed from the upstream side of airflow in the rotational-axial direction of the rotor vanes 32. As described earlier, the interference between the rotor vanes 32 and the stator vanes 22 occurs when the rotor vane 32 rotating in the direction of an arrow in Fig. 7 passes the stator vane 22 at rest.

[0032] In Fig. 7, circles 41, 42 have different radii and are concentric with the boss 21 of the stator 2. A point of intersection between the circle 41 and the stator vane 22 is assumed as a point 43. A point of intersection between the circle 42 and the stator vane 22 is assumed as a point 44. A point of intersection between the circle 41 and the rotor vane 32 is assumed as a point 45. A point of intersection between the circle 42 and the rotor vane 32 is assumed as a point 46. A line segment connecting the point 43 with the point 44 is assumed as a line 47, and a line segment connecting the point 45 with the point 46 is assume as a line 48. The fan module in the second embodiment is configured such that if the point 43 and the point 45 are superimposed on each other on the circle 41 or the point 44 and the point 46 are superimposed on each other on the circle 42, the line 47 is not coincident with the line 48. This non-coincident configuration means a state where as shown in e.g. Fig. 7, if the point 46 on the rotor vane 32 shifts to a position superimposed on the point 44 on the stator vane, another point 45' on the rotor vane 32 is not superimposed on the point 43 on the stator vane.

[0033] More specifically, the fan module taking in and discharging air is characteristically configured as below. The fan module includes the stator located on the upstream side with respect to airflow and the axial flow fan located on the downstream side. When the fan module is viewed from the rotational-axial direction of the axial flow fan, if two virtual concentric circles having different radii are assumed, a trailing edge of a stator vane constituting part of the stator and a leading edge of a rotor vane constituting part of the axial flow fan each have two points of intersections with the two concentric circles. A straight line connecting the two points of intersection on the trailing edge of the stator vane and a straight line connecting the two points of intersection on the leading edge of the rotor vane are configured as below. If, on one of the two concentric circles, one point of intersection on the trailing edge of the stator vane is superimposed on the point of intersection on the leading edge of the rotor vane, on the other of the two concentric circles, the other point of intersection on the trailing edge of the stator vane is not coincident with the other point of intersection on the leading edge of the rotor vane.

[0034] Further, when the leading edge of the rotor vane passes the trailing edge of the stator vane, a skew is formed in which the leading edge of the rotor vane constantly intersects the leading edge of the rotor vane at a single point.

[0035] With this configuration, the rotor vane 32 constantly passes the stator vane 22 only at a single point. Therefore, an area where the interference between the rotor vane and the stator vane occurs simultaneously can be minimized. This can produce an effect of suppressing an increase in the sound pressure level of each frequency component of noises resulting from the number of the rotor vanes 32 or the stator vanes 22. Fig. 8 is a graph showing the effect of the second embodiment. Fig. 8 can confirm the fact that the fan module of the second embodiment shown in Fig. 7 can reduce the noise of vane passing frequency (the sound pressure level) resulting from the number of the rotor vanes or the stator vanes. If the second embodiment is implemented, the sound pressure level is lowered as a whole compared with the case that the second embodiment is not implemented. Incidentally, if "order of vane passing frequency" of the horizontal axis in Fig. 8 is n-order, a relationship is such that "noise frequency" / ("the rotation number of the axial flow fan" × "the number of vanes") = n.

<Third Embodiment>

[0036] In a third embodiment, a configuration in which the direction of airflow is changed by stator vanes is added to that of the first or second embodiment to thereby increase the amount of airflow in a fan module mounted in server equipment such as an information instrument. Fig. 9 is a schematic cross-sectional view of a fan module of the third embodiment, showing a positional relationship between a stator vane 22 and a rotor vane 32. The stator vane 22 of a stator and the rotor vane 32 of an axial flow fan are arranged from the upstream side of airflow. The rotor vane 32 is rotated in a rotational direction R. The stator vane 22 is warped in a U-shape in cross-section relative to the rotational direction R.

[0037] A velocity component 51 of airflow entering the fan module is changed in direction by the stator vane 22 and turned to a velocity component 52 of the airflow, which enters the rotor vane 32. In other words, because of the presence of the stator vane 22, the airflow having a velocity component 54 which is a circumferential velocity in a direction reverse to the rotational direction R enters the rotor vane 32. In short, the stator vane applies a reverse pre-swirl to the rotor vane. In general, an axial flow fan is designed under the assumption that the airflow entering the rotor vane has no circumferential velocity component. However, if the axial flow fan is mounted in a variety of information instruments or the like for use, airflow is disturbed; therefore, the airflow having a circumferential velocity component which has the same direction as the rotational direction of the axial flow fan enters the axial flow fan. Incidentally, a velocity component 53 of the airflow has the same direction and magnitude as those of the velocity component 51 of airflow entering the fan module.

[Expression 1]

$$P_{th} = \rho(C_{u2}u_2 - C_{u1}u_1) \quad \ldots \text{ expression 1}$$

P_{th}: Theoretical total pressure
ρ : Density
C_{u1} : Swirl velocity at rotor vane inlet
C_{u2} : Swirl velocity at rotor vane outlet
u_1 : Circumferential velocity at rotor vane inlet u_2 : Circumferential velocity at rotor vane outlet

[0038] Expression 1 is an expression representing the theoretical total pressure of the axial flow fan. According to this expression, the theoretical total pressure of the axial flow fan is obtained by multiplying a value by the air density p, such a value being obtained by reducing the product of the swirl velocity C_{u1} which is the circumferential velocity component at the axial flow fan inlet and the rotating velocity u_1 from the product of the swirl velocity C_{u2} which is the circumferential velocity component at the axial flow fan outlet and the rotating velocity u_2. This expression shows that if the airflow entering the axial flow fan has a circumferential velocity component in the same direction as the rotational direction of the axial flow fan, the total pressure of the axial flow fan is lowered. On the other hand, the stator vane 22 of the third embodiment allows the airflow having the circumferential velocity component in a direction reverse to the rotational direction R of the rotor vane 32 to enter the rotor vane 32. According to expression 1, such airflow increases the theoretical total pressure of the axial flow fan, which leads to increased static pressure and also to the increased amount of airflow.

<Fourth Embodiment>

[0039] Fig. 10 is a perspective view of a fan module 11 according to a fourth embodiment. The fan module 11 is configured such that a first stator 2, an axial flow fan 3 and a second stator 6 are arranged in this order from the upstream side of airflow. The first stator 2 and the axial flow fan 3 are the same as those in the first to third embodiments.

[0040] Fig. 11 is a perspective view of a configuration of the second stator 6. The second stator 6 includes a boss 61, a plurality of stator vanes 62 extending from the boss 61, and an outer frame 63 supporting the stator vanes 62.

[0041] Fig. 12 is a schematic cross-sectional view of the fan module, showing a positional relationship among the stator vane 22, the rotor vane 32 and the stator vane 62 according to the fourth embodiment. The stator vane 22 of the first stator, the rotor vane 32 of the axial flow fan and the stator vane 62 of the second stator are arranged from the upstream side of airflow. The rotor vane 32 is rotated in a rotational direction R. The stator vane 62 has a trailing edge located at a positive position with respect to the position of the leading edge in the rotational direction R. Incidentally, the airflow entering the stator vane 22 and reaching the rotor vane 32 is the same as that in Fig. 9. Further, the airflow coming out from the rotor vane 32 enters the stator vane 62 at a velocity component 55. The airflow having passed the stator vane 62 is straightened and runs out at a velocity component 56.

[Expression 2]

$$P_s = \rho\eta_s \times (V_2^2 - V_3^2)/2 \qquad \ldots \text{ expression 2}$$

P_s : Static pressure rise
ρ : Density
η_s : Static pressure efficiency
V_2 : Absolute value of velocity at stator vane inlet V_3 : Absolute value of velocity at stator vane outlet Expression 2 is an expression representing a static pressure rise due to the second stator. According to this expression, the static pressure rise due to the second stator is obtained by multiplying a value by the density ρ of air and static pressure efficiency η_s, such a value being obtained by subtracting the square of an absolute value V_3 of the velocity at the stator vane outlet from the square of an absolute value V_2 of the velocity at the stator vane inlet. If the effect of the second stator is correlated with Fig. 12, the velocity component 55 is reduced by the stator vane 62 and changed into velocity 56. That is to say, the static pressure is raised according to the reduced velocity to increase the amount of airflow.

<Fifth Embodiment>

[0042] Fig. 13 is a perspective view of a fan module 12 according to a fifth embodiment. The fan module 12 is configured such that a stator 7 and an axial flow fan 3 are arranged in series in this order from the upstream side of airflow.

[0043] Fig. 14 is a perspective view of a detailed configuration of the stator 7 in Fig. 13. The stator 7 includes a boss 71, a plurality of stator vanes 72 extending from the boss 71, one or more guide rings 73, and an outer frame 74 supporting the stator vanes. The number of the stator vanes 72 is set so that the interval between the stator vanes 72 adjacent to each other may be smaller than the size of a finger of an operator handling server equipment. The guide ring or guide rings are further installed to completely prevent the entering of the operator’s finger.

[0044] The fan module 12 has an effect of completely preventing the operator’s finger from entering the stator 7. That is to say, safety measures are taken for fan module replacing work.

[0045] Incidentally, the fifth embodiment does not always need the guide ring 73. If the interval between the stator vanes 72 adjacent to each other is smaller than the size of the operator’s finger, the same effect as that of the guide ring can be produced.

<Sixth Embodiment>

[0046] Fig. 15 is a configurational schematic of a PC server in which fan modules are mounted according to a sixth embodiment. The PC server 8, which is a type of server equipment, includes a chassis 81, units 82 each having an inside board on which a CPU is mounted, and fan modules 13.

[0047] The fan module described in any one of the first to fifth embodiment can be used as the fan module 13. The fan module 13 is of an integral structure in which a stator and an axial flow fan are joined to each other. Therefore, time required for mounting work and replacing work for the fan module 13 can be reduced.

<Seventh Embodiment>

[0048] Fig. 16 is a perspective view of a fan module according to a seventh embodiment. A fan module 111 is configured such that a first fan module 14 and a second fan module 15 are arranged in series. The fan module described in any one of the first to sixth embodiments can be used as the first and second fan modules 14, 15.

[0049] Among information instruments, particularly an information instrument having a high-density inside structure is increased in pressure loss. Such an information instrument uses two or more axial flow fans arranged in series in order to provide an amount of cooling air needed for a statistic pressure rise. The use of the axial flow fans arranged in series expects to increase the static pressure according to the increased number of the axial flow fans. However, such an expected effect is not generally obtained. For example, if two axial flow fans arranged in series are used, a double static pressure rise is expected. However, only an approximate one-and-a-half static pressure rise can be obtained in actuality.

[0050] As in the seventh embodiment, if the fan modules described in any one of the first to sixth embodiments are arranged in series for use, the single axial flow fan is fan-modularized to increase static pressure and also airflow is straightened. Thus, as shown in Fig. 17, a static pressure rise two times or more of that in the case where the single axial flow fans are arranged in series can be obtained.

[0051] Incidentally, the fan module 111 described in the seventh embodiment is configured such that the two fan modules are arranged in series. However, the effect of the seventh embodiment can be produced without limiting the number of the fan modules arranged in series. Additionally, it is not always necessary to use the same fan modules arranged in series.

<Eighth Embodiment>

[0052] Fig. 18 is a perspective view of a fan module according to an eighth embodiment. A fan module 112 is configured such that a first axial flow fan 3, a first stator 6, a second stator 2 and a second axial flow fan 3 are arranged in series in this order from the upstream side of airflow.

[0053] When the fan module is viewed from the rotational-axial direction of the second axial flow fan, if two virtual concentric circles having different radii are assumed, a trailing edge of a stator vane constituting part of the second stator and a leading edge of a rotor vane constituting part of the second axial flow fan each have two points of intersection with the two concentric circles. A straight line connecting the two points of intersection on the trailing edge of the stator vane and a straight line connecting the two points of intersection on the leading edge of the rotor vane are configured as below. If, on one of the two concentric circles, one point of intersection on the trailing edge of the stator vane is superimposed on the point of intersection on the leading edge of the rotor vane, on the other of the two concentric circles, the other point of intersection on the trailing edge of the stator vane is not coincident with the other point of intersection on the leading edge of the rotor vane.

[0054] Further, the second axial flow fan has the rotor vanes and the second stator has the stator vanes. It is preferred that the tilt direction of the rotor vane be opposite to that of the stator vane.

[0055] As with the seventh embodiment, the fan module 112 provides a static pressure rise greater than that in the case where the axial flow fan units are arranged in series for use. In particular, if a dimensional limitation is put on the fan module and the configuration of the seventh embodiment cannot be employed, the present embodiment produces an effect.

<Ninth Embodiment>

[0056] Fig. 19 is perspective view of a fan module according to a ninth embodiment. A fan module 113 is configured such that a first fan module 16 and a second fan module 17 are juxtaposed to each other.

[0057] To increase the amount of airflow of, particularly, an information instrument having a low-density inside structure among information instruments, axial flow fans are juxtaposed to each other for use to increase the amount of cooling airflow. The use of the fan modules juxtaposed to each other as in the present embodiment can increase the amount of airflow for cooling the axial flow fans juxtaposed to each other and mounted in an information instrument.

[0058] Incidentally, the fan module 113 described in the ninth embodiment is a fan module in which the two fan modules described in any one of the first to eighth embodiments are juxtaposed to each other. However, the fan modules of the present embodiment can produce the effect without limiting the number of the fan modules juxtaposed to one another and without the necessity of using the same fan modules.

<Tenth Embodiment>

[0059] Fig. 20 is a configurational schematic of a blade server, which is an example of server equipment, according to a tenth embodiment. A blade server 9 includes a casing 91, an electronic device section 92 including server blades, and a fan module 1111.

[0060] For example, the fan module 1111 is configured to combine a plurality of the fan modules described in any one of the first to ninth embodiments. Therefore, the fan module 1111 produces an effect of increasing the amount of airflow generated by the blade server 9 and of reducing noise thereof.

[0061] The application of the fan module in the present embodiment is not limited to the blade server but can be applied to general server equipment such as rack servers and PC servers.

[0062] It is to be noted that the present invention is not limited to the aforementioned embodiments, but covers various modifications. While, for illustrative purposes, those embodiments have been described specifically, the present invention is not necessarily limited to the specific forms disclosed. Thus, partial replacement is possible between the components of a certain embodiment and the components of another. Likewise, certain components can be added to or removed from the embodiments disclosed.

[0063] Note also that some or all of the aforementioned components, functions, processors, and the like can be implemented by hardware such as an integrated circuit or the like. Alternatively, those components, functions, and the like can be implemented by software as well. In the latter case, a processor can interpret and execute the programs designed to serve those functions. The programs, associated data tables, files, and the like can be stored on a stationary storage device such as a memory, a hard disk, and a solid state drive (SSD) or on a portable storage medium such as an integrated circuit card (ICC), an SD card, and a DVD.

[0064] Further note that the control lines and information lines shown above represent only those lines necessary to illustrate the present invention, not necessarily representing all the lines required as a product. Thus, it can be assumed that almost all the components are in fact interconnected.

Claims

1. A fan module (1) for taking in and discharging air, comprising:

   a stator (2) located on an upstream side with respect to airflow; and
   an axial flow fan (3) located on a downstream side with respect to the airflow;

   wherein, when the fan module (1) is viewed from a rotational-axial direction of the axial flow fan (3), the stator (2) includes a stator vane (22) trailing edge and the axial flow fan (3) includes a rotor vane (32) leading edge, the trailing edge (47) and the leading edge (48) each having two points of intersection (43, 44; 45, 46) with two concentric circles (41, 42) having different diameters, and
   wherein a straight line (47) connecting the two points of intersection (43, 44) on the trailing edge and a straight line (48) connecting the two points of intersection (45, 46) on the leading edge are configured such that if, on one of the two concentric circles (41, 42), one point of intersection (43, 44) on the trailing edge is superimposed on the point of intersection (45, 46) on the leading edge, on the other of the two concentric circles (42, 41), the other point of intersection (44, 43) on the trailing edge is not coincident with the other point of intersection (46, 45) on the leading edge.

2. The fan module (1) according to claim 1,
   wherein the rotor vane (32) has a tilt direction opposite to that of the stator vane (22).

3. The fan module (1) according to claim 1 or 2, wherein the stator vane (22) constituting part of the stator (2) is configured to be warped like a U-shape.

4. The fan module (1) according to claim 3, wherein the stator vane (22) applies a reverse pre-swirl to the rotor vane (32).

5. The fan module (1) according to any one of claims 1 to 4,
   wherein a second stator (6) is disposed on the downstream side of the axial flow fan (3).

6. The fan module (1) according to claim 5, wherein a trailing edge of a stator vane (62) constituting part of the second stator (6) disposed on the downstream side of the axial flow (3) fan is located at a positive position with respect to a position of a leading edge of the stator vane (62) in a rotational direction of the axial flow fan (3).

7. The fan module (1) according to any one of claims 1 to 6,
   wherein an interval between adjacent stator vanes (22; 62) constituting part of the stator (2; 6) is smaller than a

width of a finger.

8. The fan module (1) according to any one of claims 1 to 7,
wherein the axial flow fan (3) and the stator (2; 6) constituting the fan module (1) are integrated with each other.

9. The fan module (1) according to any one of claims 1 to 8,
wherein a plurality of the fan modules (1) are combined in series or in parallel.

10. Server equipment (8) in which the fan module (1) according to any one of claims 1 to 9 is mounted.

FIG.1

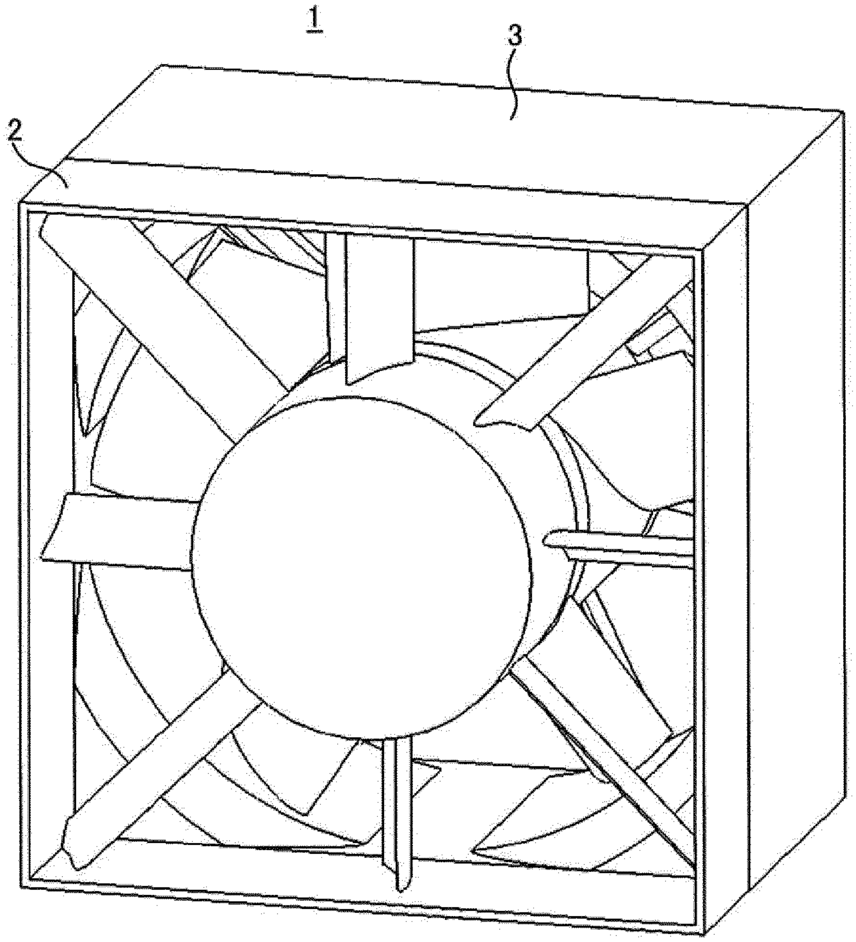


FIG.2

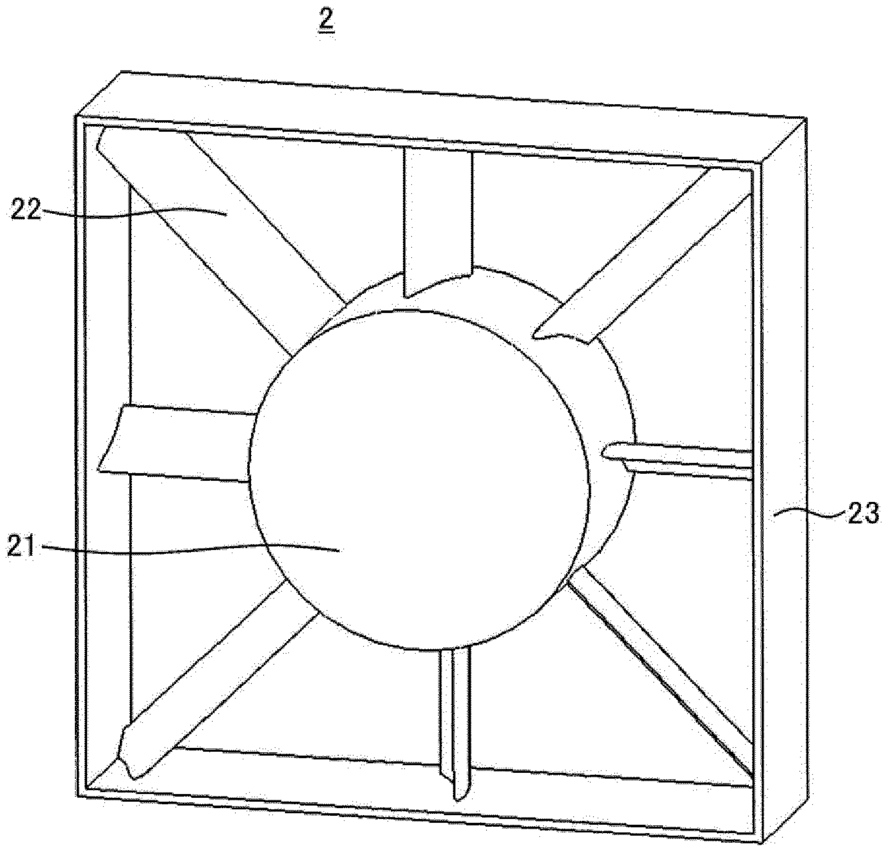


FIG.3

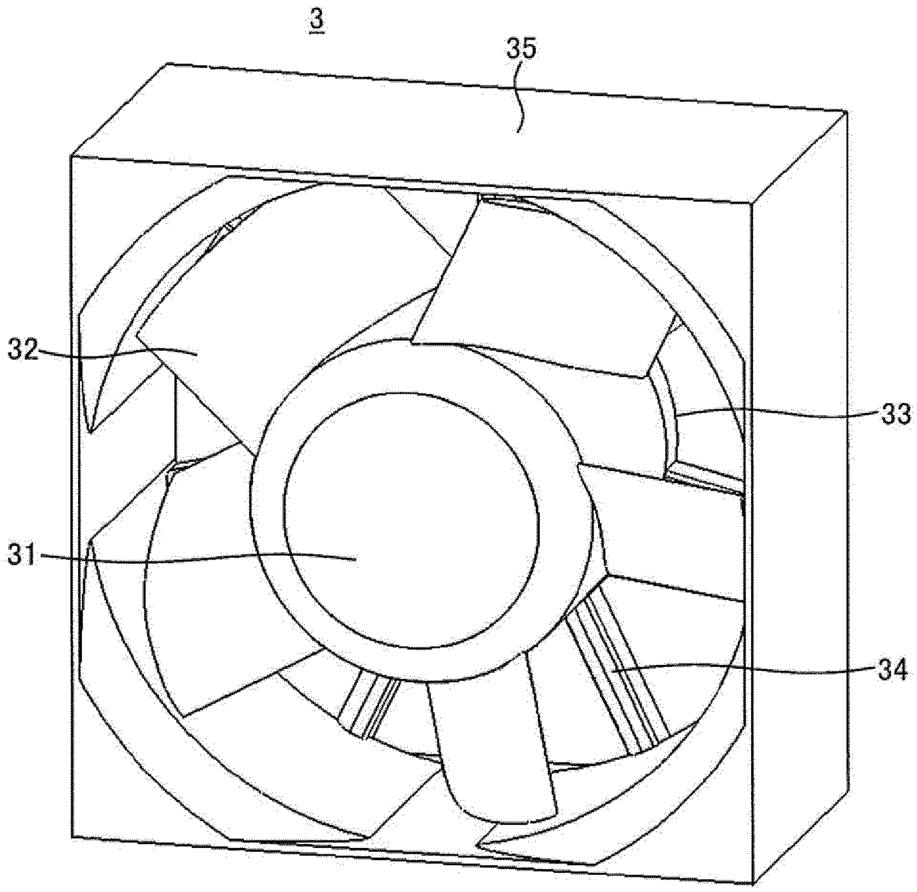


FIG.4

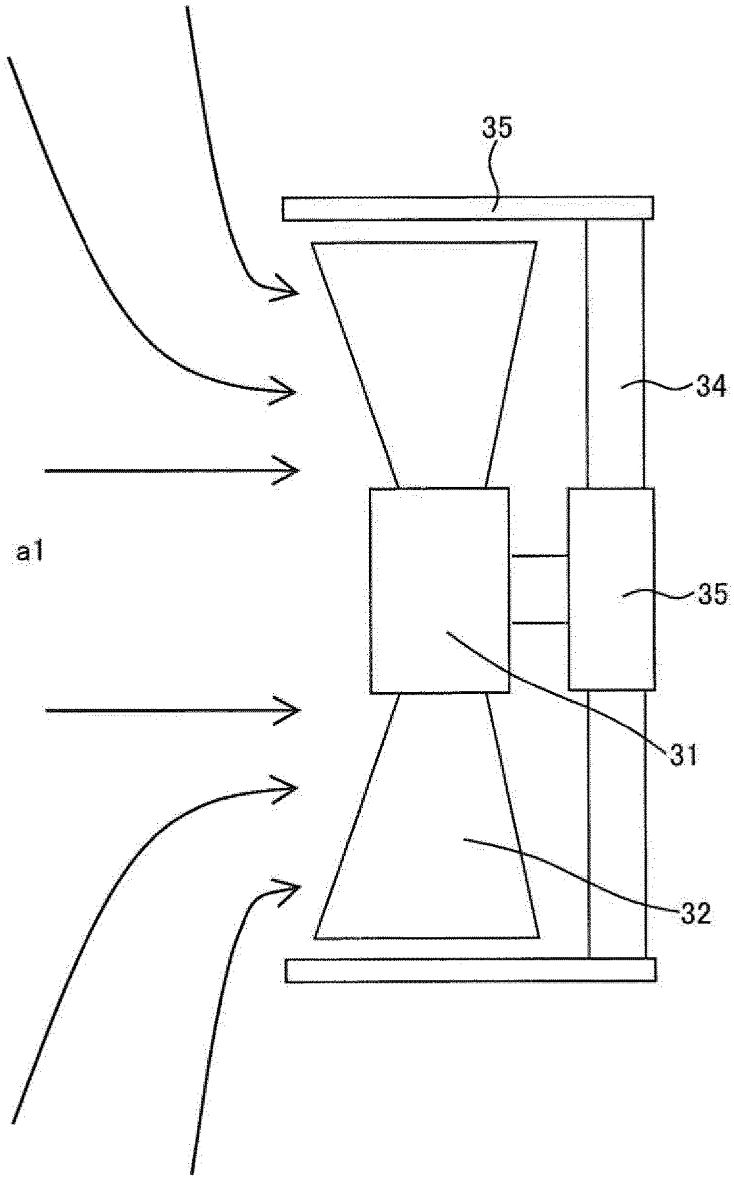


FIG.5

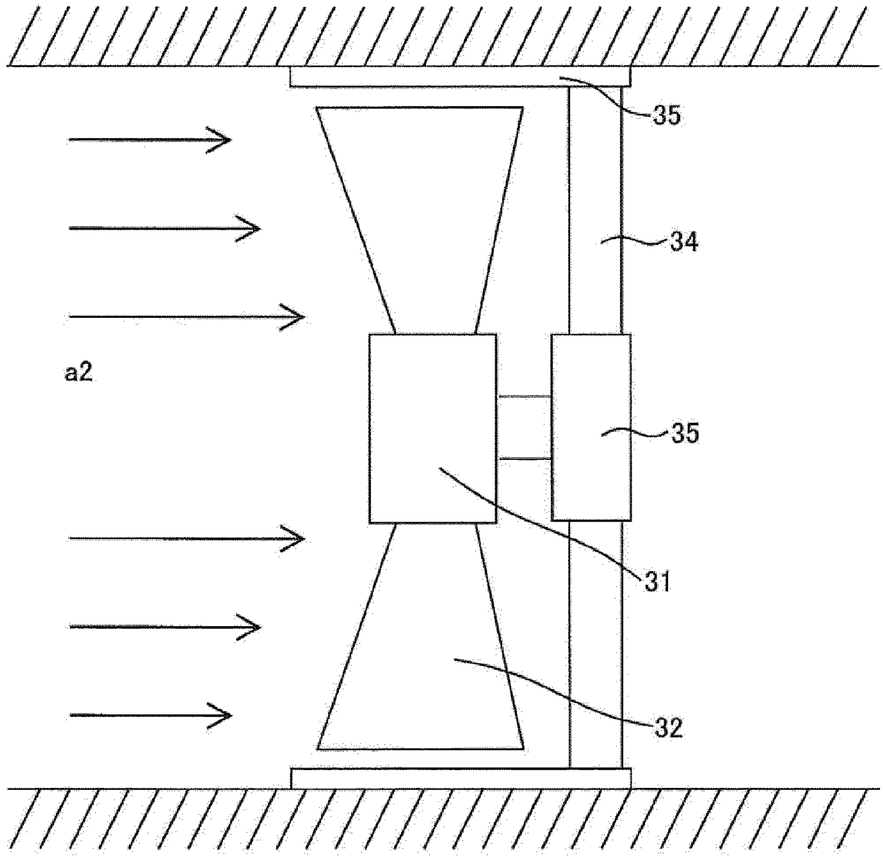


FIG.6

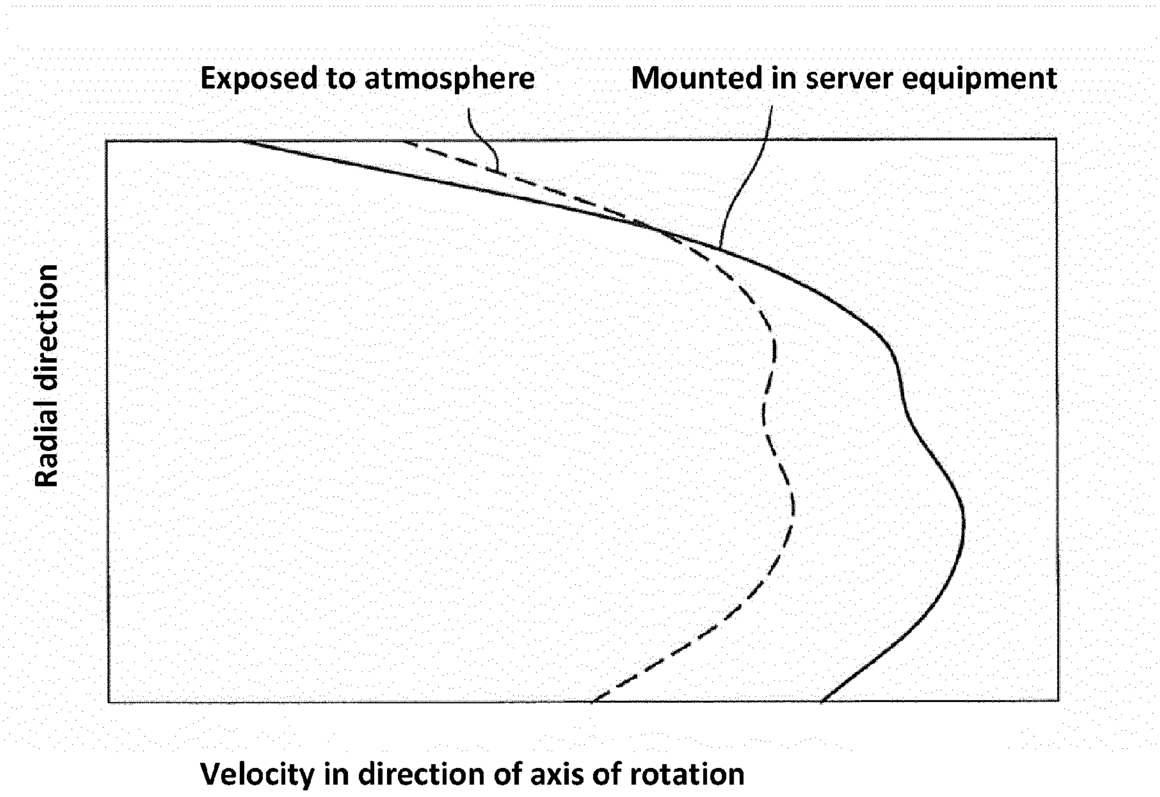

Exposed to atmosphere
Mounted in server equipment
Radial direction
Velocity in direction of axis of rotation

FIG.7

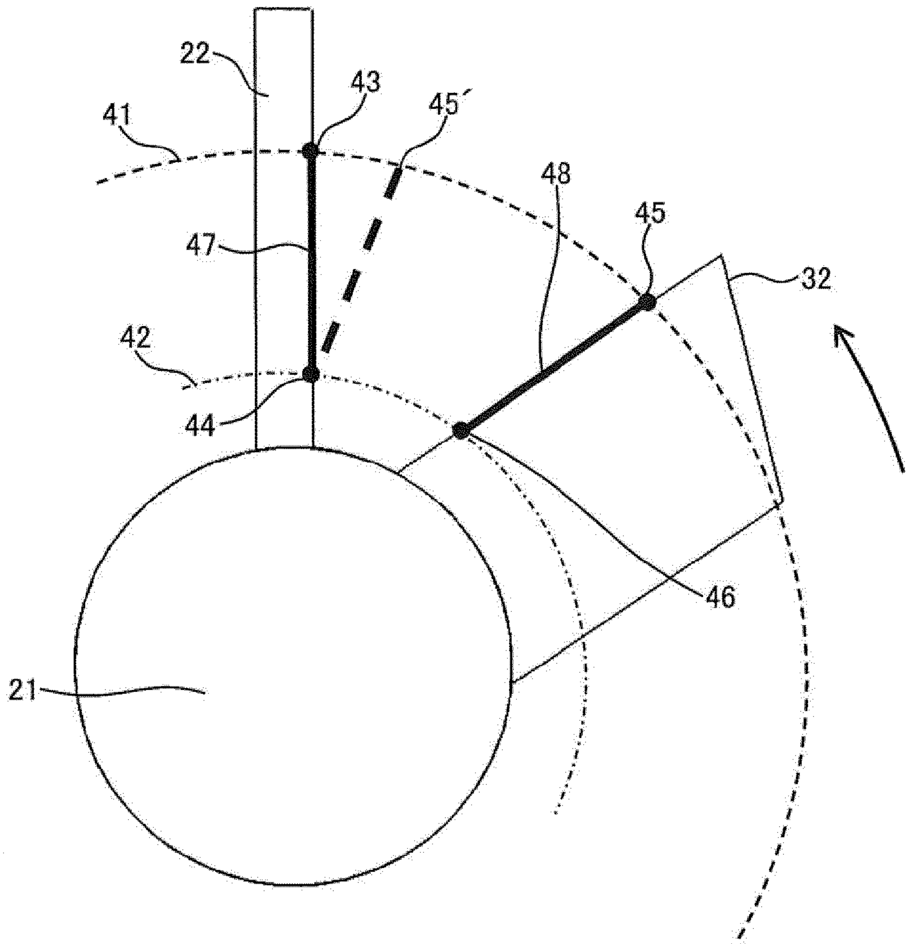


FIG.8

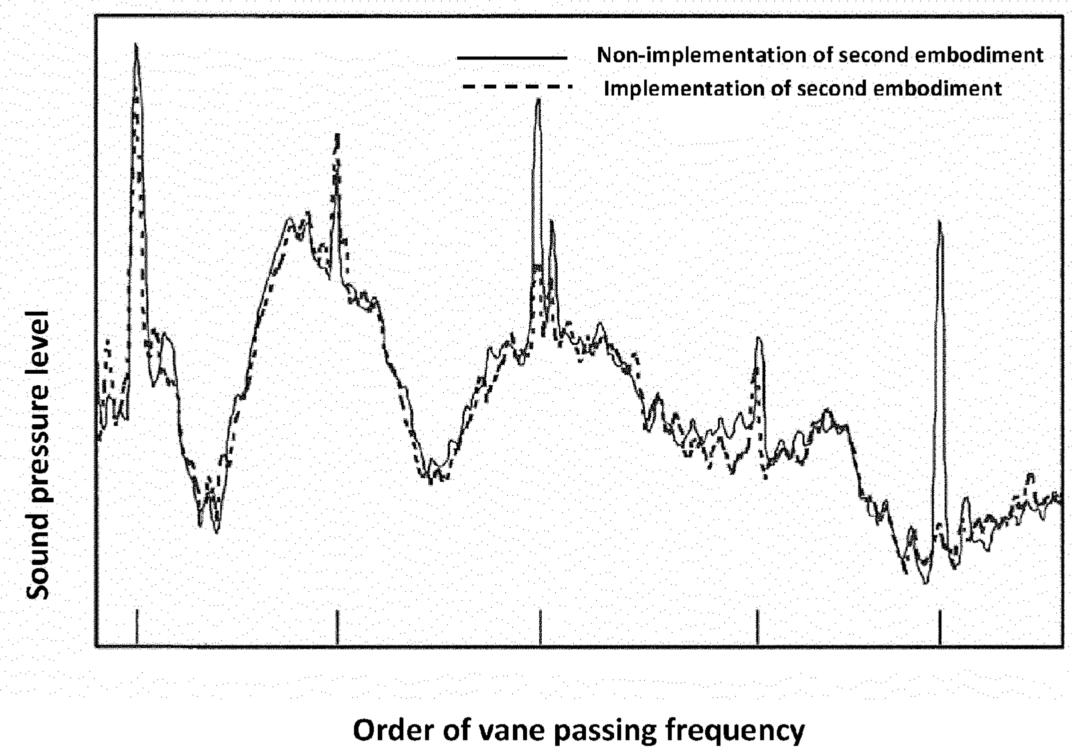

Non-implementation of second embodiment
Implementation of second embodiment
Sound pressure level
Order of vane passing frequency

FIG.9

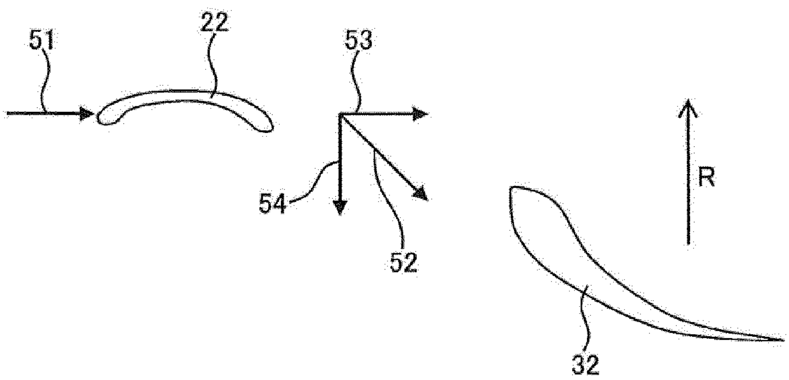

51
22
53
54
52
R
32

FIG.10

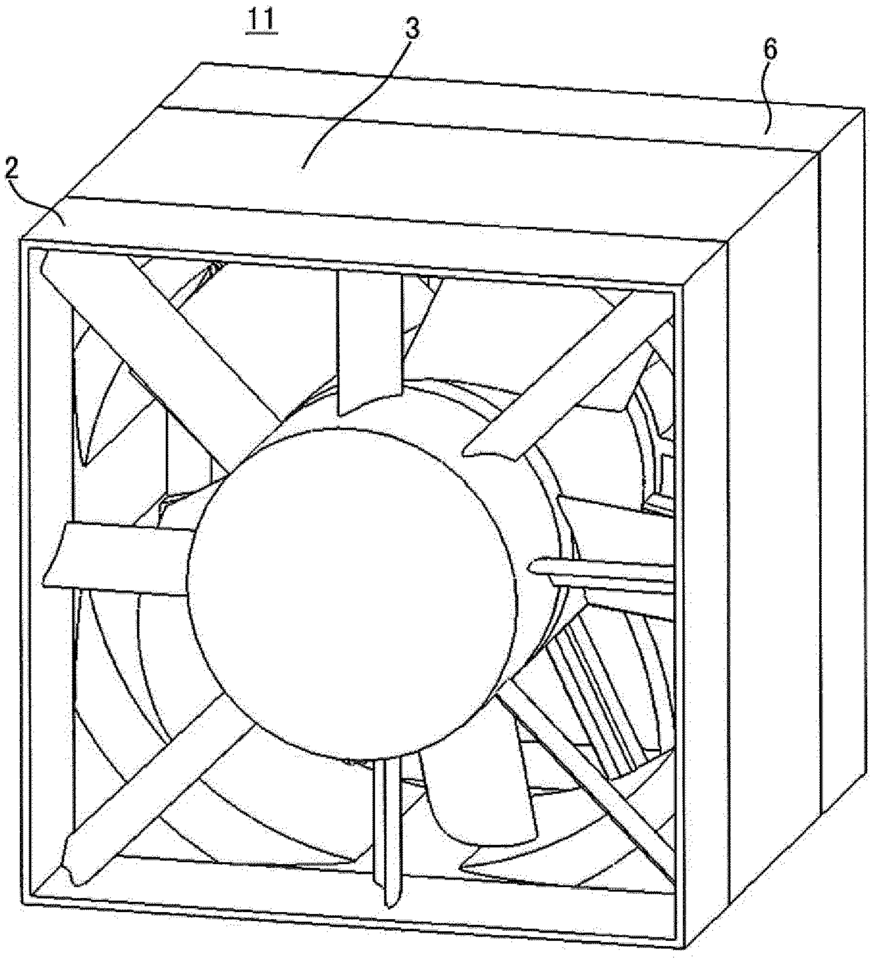


FIG.11

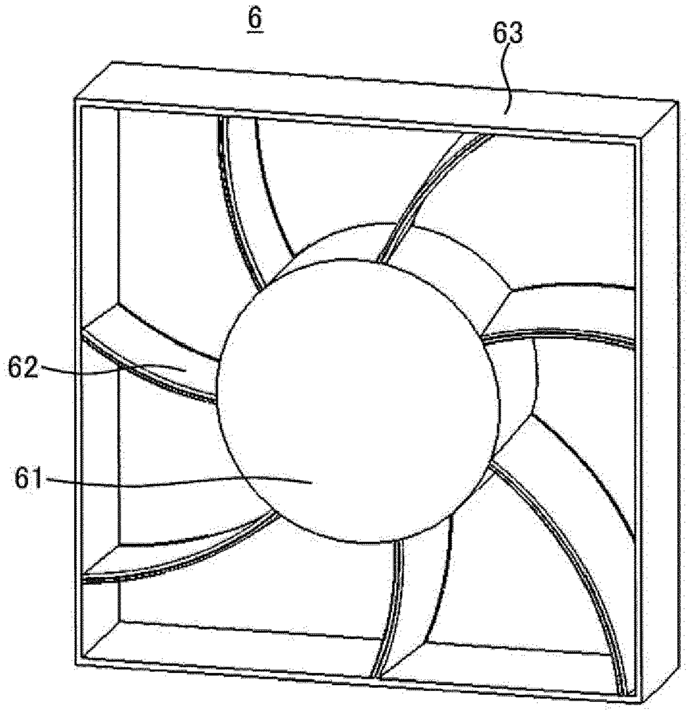


FIG.12

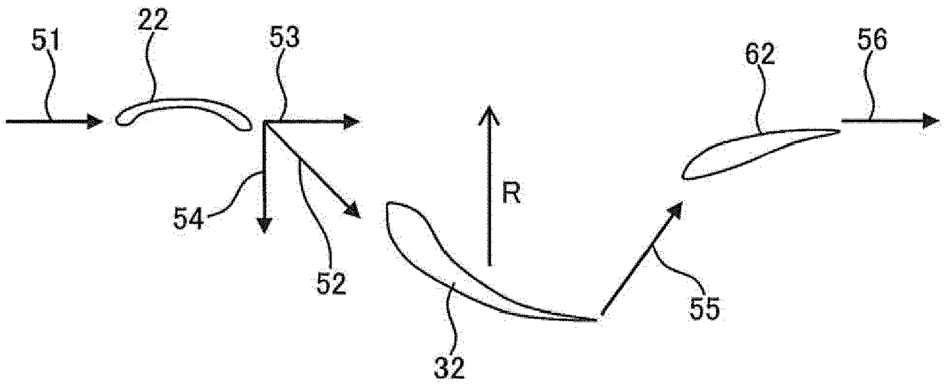


FIG.13

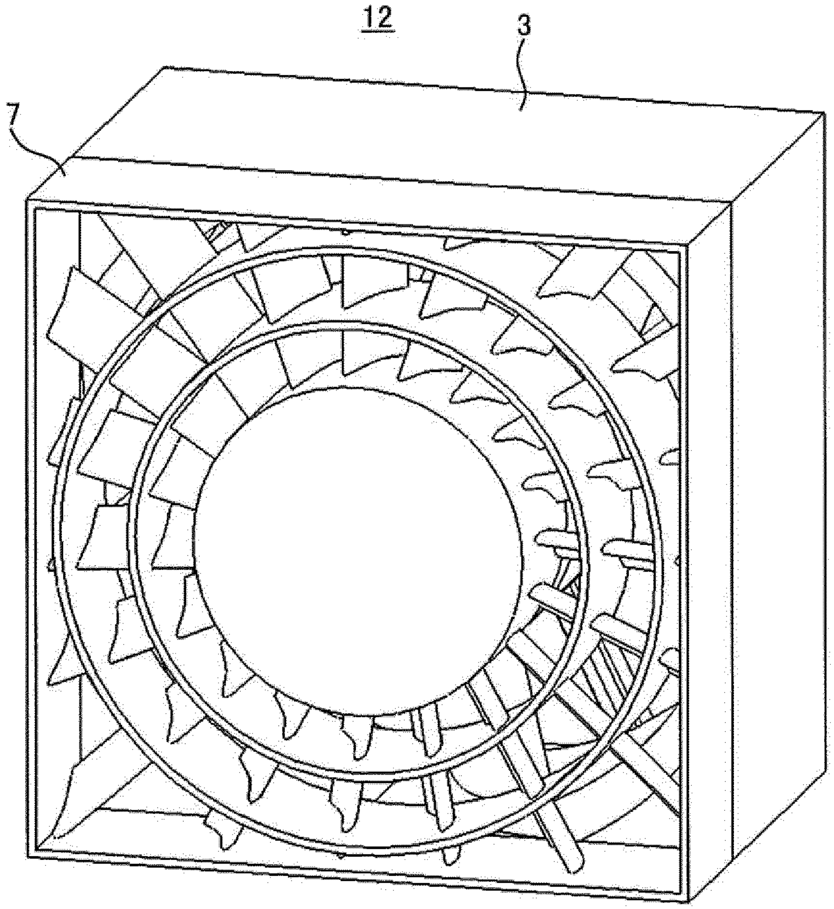


FIG.14

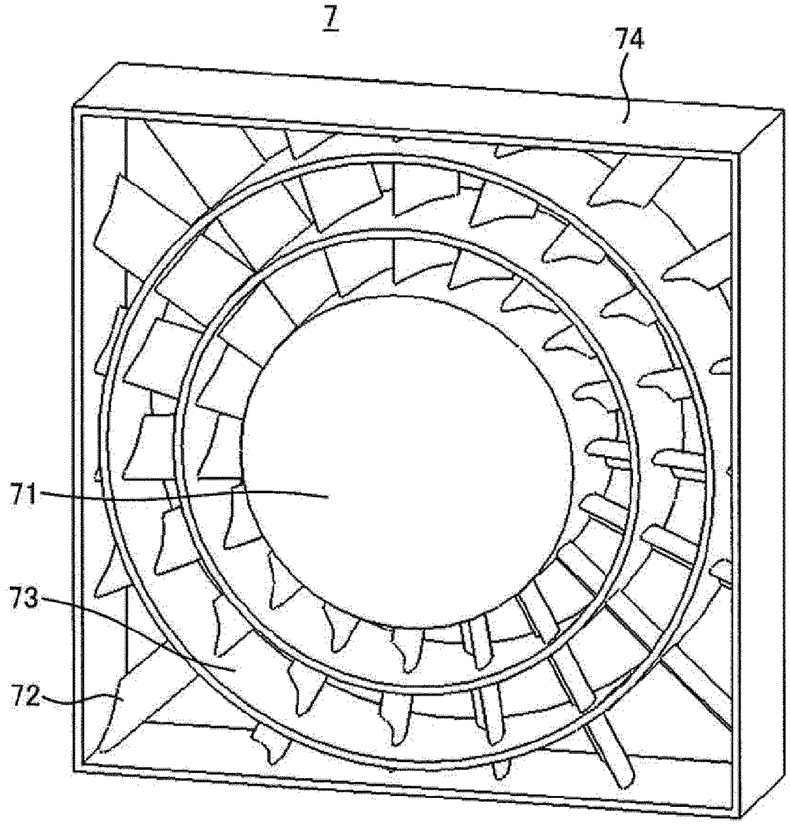


FIG.15

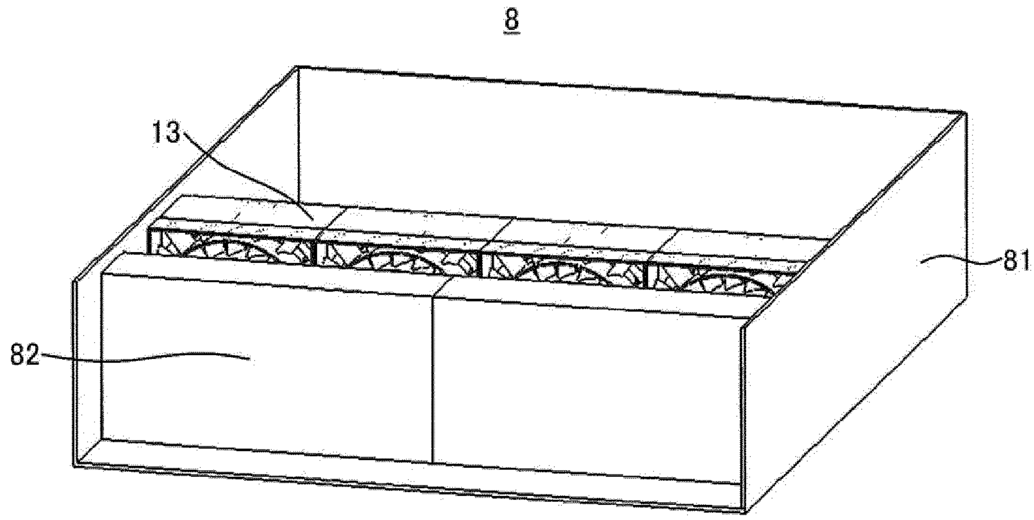


FIG.16

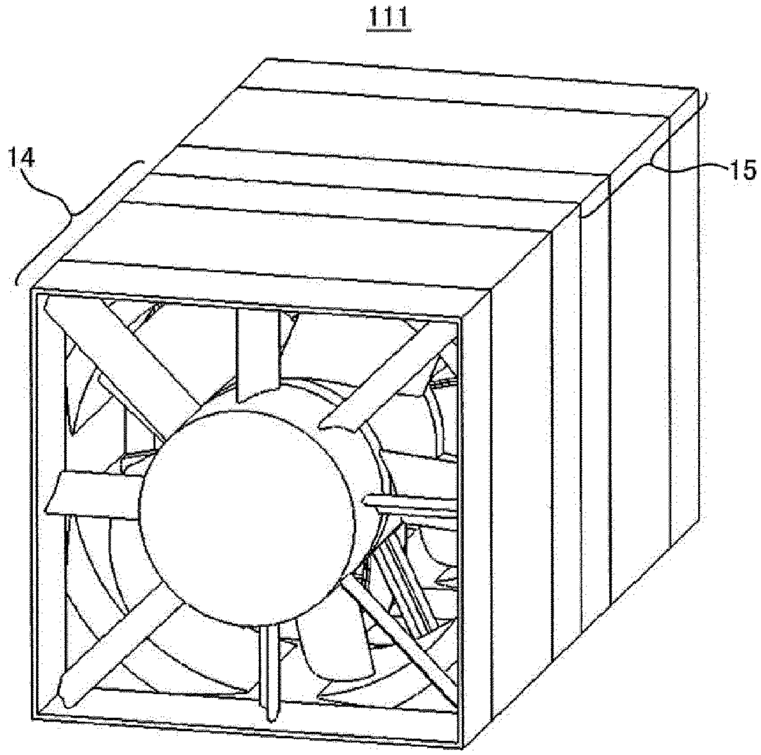

111
14
15

FIG.17

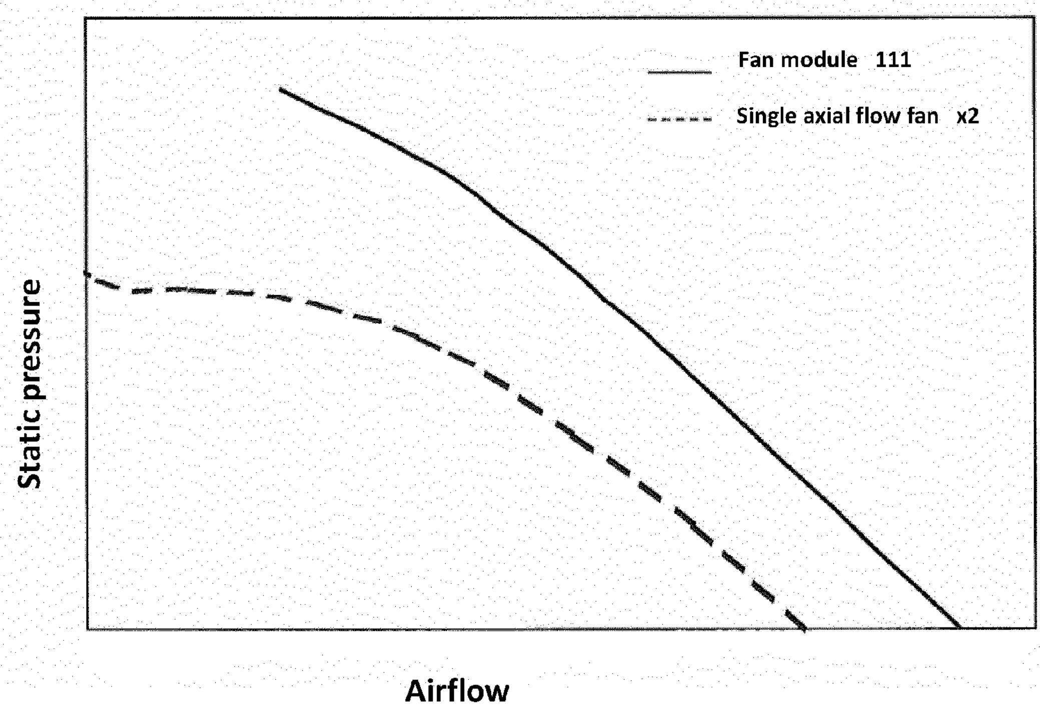

Fan module 111
Single axial flow fan x2
Static pressure
Airflow

FIG.18

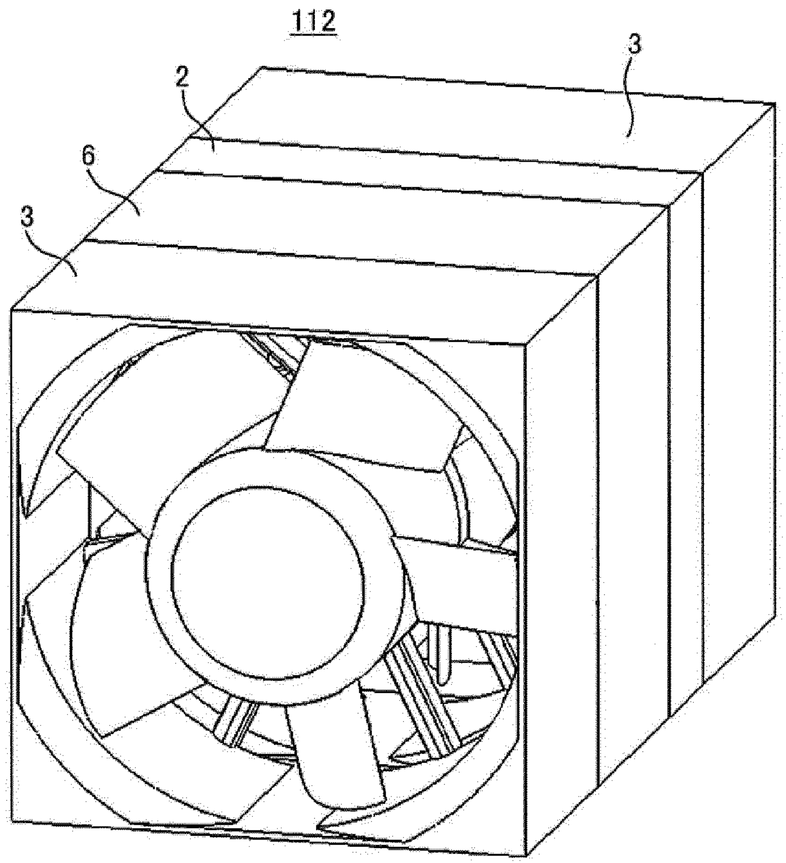


FIG.19

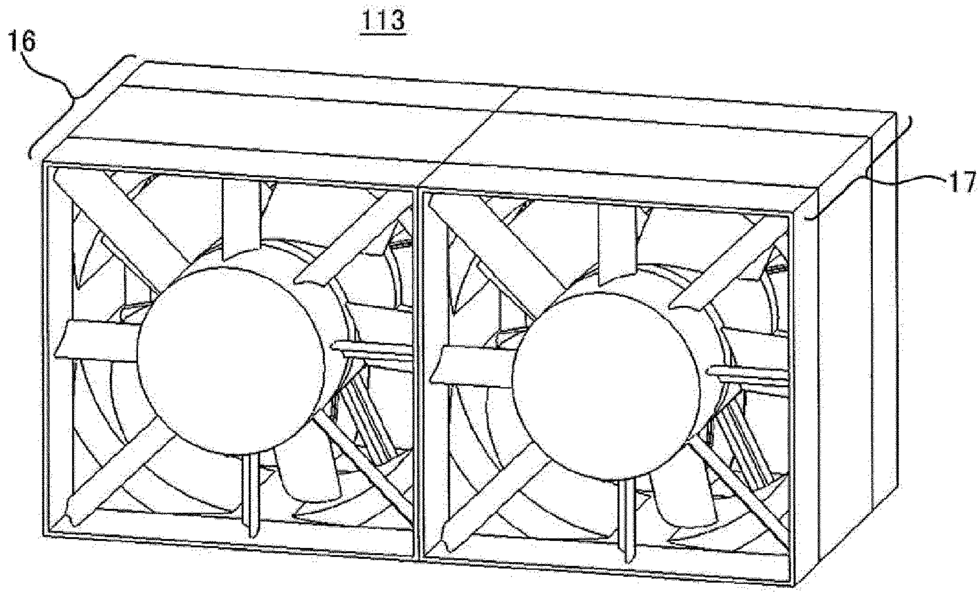
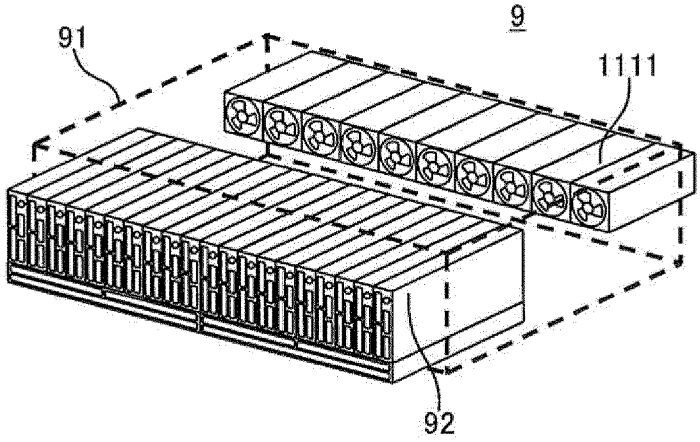


FIG.20



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Patent documents cited in the description

- WO 2008062835 A **[0007]**