A serial axial fan unit includes first and second axial fans and a spacer arranged therebetween and connected thereto. First and second impellers respectively provided in the first and second axial fans have a diameter in a range from approximately 25 mm to approximately 200 mm, for example. The axial height of the spacer is in a range of approximately 1.5 mm to approximately 8 mm, for example. Due to the spacer, the first and second axial fans are spaced apart from each other by an appropriate distance. Thus, a harsh noise caused by interference occurring when air from the first axial fan flows into the second axial fan is reduced. Also, the static pressure to airflow volume characteristics of the serial axial fan for a given sound value is improved.
FIG. 3
FIG. 4
FIG. 5
FIG. 14
FIG. 15
FIG. 21
SERIAL AXIAL FAN UNIT

BACKGROUND OF THE INVENTION

1. Field of the Invention
The present invention relates to a serial axial fan unit in which a plurality of axial fans are connected in series.

2. Description of the Related Art
Many electronic devices use fans for cooling electronic components therein. Those fans have been required to have an improved static pressure versus flow curve, for example, with increases in the heat associated with improvement of the performance of electronic components and increases in the density of the arrangement of the electronic components associated with size reduction of casing of the electronic devices. Serial axial fan units including a plurality of fans connected in series have been used in recent years in order to ensure a sufficiently high static pressure and a sufficiently large volume of air.

However, the serial axial fan units tend to produce a lot of noise because of the interference of exhaust air of one fan with intake air of an adjacent fan.

SUMMARY OF THE INVENTION

To overcome the problems described above, a preferred embodiment of the present invention provides a serial axial fan unit that includes a first axial fan and a second axial fan coaxial with each other and arranged in an axial direction parallel or substantially parallel to a center axis thereof, and a spacer arranged between the first axial fan and the second axial fan. Each of the first axial fan and the second axial fan includes an impeller having a plurality of blades which are arranged around the center axis to extend away from the center axis, a motor portion arranged to rotate the impeller, and a housing surrounding the impeller from outside in a radial direction perpendicular or substantially perpendicular to the center axis. The spacer includes a wall portion attached to the housing of each of the first axial fan and the second axial fan. The wall portion defines a space therein in which air flows. A radius of the impeller of each of the first axial fan and the second axial fan is preferably in a range of about 12.5 mm and about 100 mm, for example. An axial height of the spacer is preferably in a range of about 1.5 mm to about 8 mm, for example.

Other features, elements, advantages and characteristics of the present invention will become more apparent from the following detailed description of preferred embodiments thereof with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a serial axial fan unit according to a first preferred embodiment of the present invention.
FIG. 2 is a cross-sectional view of the serial axial fan unit according to the first preferred embodiment of the present invention, taken along a plane containing a center axis thereof.
FIG. 3 is a plan view of a first axial fan of the serial axial fan unit according to the first preferred embodiment of the present invention.
FIG. 4 is a bottom view of a second axial fan of the serial axial fan unit according to the first preferred embodiment of the present invention.
FIG. 5 is a plan view of a spacer of the serial axial fan unit according to the first preferred embodiment of the present invention.
FIG. 6 is an enlarged cross-sectional view of a portion around boundaries between a first housing and a second housing and between the spacer and a second housing in the serial axial fan unit according to the first preferred embodiment of the present invention.
FIG. 7 is an exploded perspective view of the serial axial fan unit according to the first preferred embodiment of the present invention.
FIG. 8 is a perspective view of the first axial fan according to the first preferred embodiment of the present invention.
FIG. 9 is a perspective view of the spacer according to the first preferred embodiment of the present invention.
FIG. 10 is another perspective view of the spacer according to the first preferred embodiment of the present invention.
FIG. 11 is a perspective view of the second axial fan according to the first preferred embodiment of the present invention.
FIG. 12 illustrates the connection of the spacer and the first axial fan to each other in the first preferred embodiment of the present invention.
FIG. 13 illustrates the connection of the spacer and the first axial fan to the second axial fan in the first preferred embodiment of the present invention.
FIG. 14 shows a relationship between a static pressure and an air flow rate according to the first preferred embodiment of the present invention.
FIG. 15 shows changes in the static pressure and the air flow rate with a change in the spacer height according to the first preferred embodiment of the present invention.
FIG. 16 is an exploded perspective view of a serial axial fan unit according to a second preferred embodiment of the present invention.
FIG. 17 is a cross-sectional view of the serial axial fan unit according to the second preferred embodiment of the present invention, taken along a plane containing its center axis.
FIG. 18 is a cross-sectional view of an example of a first supporting rib, a second supporting rib, and a spacer rib.
FIG. 19 is a cross-sectional view of another example of the first supporting rib, the second supporting rib, and the spacer rib.
FIG. 20 is a cross-sectional view of a serial axial fan unit according to a third preferred embodiment of the present invention.
FIG. 21 is an exploded perspective view of the serial axial fan unit according to the third preferred embodiment of the present invention.
FIG. 22 is a perspective view of the serial axial fan unit according to the third preferred embodiment of the present invention.
FIG. 23 is an exploded perspective view of the serial axial fan unit according to a fourth preferred embodiment of the present invention.
FIG. 24 is a cross-sectional view of the serial axial fan unit according to the fourth preferred embodiment of the present invention, taken along a plane containing its center axis.
FIG. 25 is a cross-sectional view of a first supporting rib and a spacer rib according to the fourth preferred embodiment of the present invention.

FIG. 26 is an enlarged cross-sectional view of a first housing, a second housing, and a spacer of an exemplary variation of the aforementioned preferred embodiments of the present invention.

FIGS. 27 and 28 illustrate another engagement structure for the serial axial fan unit.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to FIGS. 1 through 28, preferred embodiments of the present invention will be described in detail. It should be noted that in the explanation of the present invention, when positional relationships among and orientations of the different components are described as being up/down or left/right, positional relationships and orientations that are in the drawings are indicated. Positional relationships among and orientations of the components once having been assembled into an actual device are not indicated. In addition, in the following description, an axial direction indicates a direction parallel or substantially parallel to a center axis, and a radial direction indicates a direction perpendicular or substantially perpendicular to the center axis.

First Preferred Embodiment

FIG. 1 is a perspective view of a serial axial fan unit 1 according to a first preferred embodiment of the present invention. The serial axial fan unit 1 is provided to cool the inside of an electronic device, e.g., a server. The serial axial fan unit 1 includes a first axial fan 2 and a second axial fan 3 arranged coaxially with each other. In the present preferred embodiment, the first axial fan 2 is arranged above the second axial fan 3, as shown in FIG. 1. The serial axial fan unit 1 also includes a spacer 4 axially arranged between the first and second axial fans 2 and 3 and connected to the first and second axial fans 2 and 3. A first lead wire group 91 including a plurality of lead wires is connected to the first axial fan 2, while a second lead wire group 92 including a plurality of lead wires is connected to the second axial fan 3. The first and second lead wire groups 91 and 92 are arranged to extend along the outer surface of the first axial fan 2 and are then drawn upward therefrom as shown in FIG. 1. Outside the first axial fan 2 (above in FIG. 1), the first and second lead wire groups 91 and 92 are bound by a binding member 93 and are then connected to an external power supply (not shown).

FIG. 2 is a cross-sectional view of the serial axial fan unit 1, taken along a plane containing a center axis J1 thereof. In the present preferred embodiment, the serial axial fan unit 1 is a counter-rotating type fan in which the first and second axial fans 2 and 3 rotate about the center axis J1 in opposite directions to each other. In the serial axial fan unit 1, the first and second axial fans 2 and 3 are arranged such that a first impeller 21 and first supporting ribs 24 of the first axial fan 2 and second supporting ribs 34 of the second axial fan 3 are arranged from top to bottom in the order along the center axis J1. When the first and second impellers 21 and 31 are rotated, air is taken into the serial axial fan unit 1 from above in FIG. 1 (i.e., from above the first axial fan 2) and is sent downward in FIG. 1 (i.e., to below the second axial fan 3). Since the first and second impellers 21 and 31 are rotated in opposite directions to each other, a sufficient volume of air can be ensured and a static pressure can be increased.

In the following description, an axial direction and a radial direction are defined as a direction substantially parallel to the center axis J1 and a direction substantially perpendicular to the center axis J1, respectively. The upper side in FIG. 1 from which air is taken into the serial axial fan unit 1 may be referred to as an "inlet side", and the lower side in FIG. 1 to which air is sent out may be referred to as an "outlet side". Please note that the "up" and "down" in the axial direction are not always coincident with "up" and "down" in the direction of gravity.

FIG. 3 is a plan view of the first axial fan 2 when viewed from the inlet side of the serial axial fan unit 1. As shown in FIGS. 2 and 3, the first axial fan 2 includes a first motor portion 22, a first impeller 21 which can be rotated about the center axis J1 by the first motor portion 22 to create an airflow flowing approximately along the axial direction, a first housing 23 surrounding the first impeller 21 from radially outside, and four first supporting ribs 24 supporting the first motor portion 22. The first impeller 21, the first motor portion 22, and the first supporting ribs 24 are arranged inside the first housing 23. The first supporting ribs 24 are arranged around the center axis J1 to extend from the first motor portion 22 outward in the radial direction and are connected to the inner side surface 231 of the first housing 23. Please note that FIG. 2 merely shows the general shapes of first blades 211 of the first impeller 21 and the first supporting ribs 24 on both sides of the center axis J1 for the sake of convenience. Moreover, in FIG. 2, the first motor portion 22 is shown larger than actual and parallel lines for representing a cross section of a component is omitted. This is the same in the diagrams of the second axial fan 3 and serial axial fan units of other preferred embodiments.

The first impeller 21 includes a cup 212 covering the outside of the first motor portion 22. In the present preferred embodiment, the cup 212 preferably is cylindrical or approximately cylindrical about the center axis J1 and is open at a lower end. The first impeller 21 also includes a plurality of first blades 211 arranged on the outer side surface of the cup 212 around the center axis J1. In the present preferred embodiment, preferably seven first blades 211 are arranged at regular angular intervals, for example. The first blades 211 extend outward in the radial direction. The diameter of the first impeller 21 preferably is in a range from approximately 25 mm to approximately 200 mm, for example, in the present preferred embodiment. Please note that the diameter of the first impeller 21 preferably is approximately twice as large as a distance between a radially outermost portion of the first blade 211 and the center axis J1. In the present preferred embodiment, the cup 212 is made of resin and the first blades 211 are also made of resin. The cup 212 and the first blades 211 are formed as one body by injection molding, for example.

Referring to FIG. 2, the first motor portion 2 includes a first rotor portion 222 as a rotating assembly and a first stationary portion 221 as a stationary assembly. The first rotor portion 222 is supported to be rotatable about the center axis J1 relative to the first stationary portion 221 by a bearing unit which will be described later.

The first rotor portion 222 includes a hollow yoke 2221 and a field-generating magnet 2222 attached to the inside of the yoke 2221. In the present preferred embodiment,
the yoke 2221 is cylindrical or approximately cylindrical around the center axis J1 and open at a lower end. The yoke 2221 is made of metal as a magnetic material. The field-generating magnet 222 is also cylindrical or approximately cylindrical around the center axis J1, for example. The first rotor portion 222 also includes a shaft 2223 extending downward from a central portion of a top portion of the yoke 2221. The first rotor portion 222 is integral with the first impeller 21 and covers the yoke 2221 by the cup 212.

[0043] The first stationary portion 221 includes a base portion 2211 having an opening at or around its center when viewed along the axial direction, a hollow bearing holder 2212 projecting upward from around the center of the base portion 2211, and an armature 2213 attached to the outer surface of the bearing holder 2212. In the present preferred embodiment, the bearing holder 2212 is approximately cylindrical about the center axis J1. To the base portion 2211 are connected the first supporting ribs 24 which are connected to the inner side surface 231 of the first housing 23. Thus, the base portion 2211 is supported by the inner side surface 231 of the first housing 23 via the first supporting ribs 24, and supports other components of the first stationary portion 221. In the present preferred embodiment, the first base portion 2211, the first supporting ribs 24, and the first housing 23 are made integral with one another by injection molding of resin, for example.

[0044] As shown in FIG. 2, a circuit board 2214 is arranged below the armature 2213 of the first stationary portion 221. In the present preferred embodiment, the circuit board 2214 has an approximately annular plate shape. The circuit board 2214 has a control circuit for controlling the armature 2213 which is electrically connected to the armature 2213 and also to the first lead wire group 91 (see FIG. 1). The armature 2213 is opposed to the field-generating magnet 2222 in the radial direction. When a driving current is supplied to the armature 2213 through the control circuit of the circuit board 2214, a torque centered on the center axis J1 is generated between the armature 2213 and the field-generating magnet 2222.

[0045] Inside the bearing holder 2212, ball bearings 2215 and 2216 defining a bearing unit are arranged in an upper region and a lower region in the axial direction, respectively. The shaft 2223 inserted into the bearing holder 2212 is rotatably supported by the ball bearings 2215 and 2216.

[0046] FIG. 4 shows the second axial fan 3 when viewed from the outlet side of the serial axial fan unit 1. That is, FIG. 4 is a bottom view of the second axial fan 3 when the first and second axial fans 2 and 3 are arranged as shown in FIG. 2. Referring to FIGS. 2 and 4, the second axial fan 3 includes a second motor portion 32 and a second impeller 31 which can be rotated about the center axis J1 by the second motor portion 32. The second axial fan 3 also includes a second housing 33 surrounding the second impeller 31 and four second supporting ribs 34 which support the second motor portion 32. In the second axial fan 3, the second impeller 31, the second motor portion 32, and the second supporting ribs 34 are arranged inside the second housing 33, as in the first axial fan 2. The second supporting ribs 34 are arranged around the center axis J1 to extend from the second motor portion 32 outward in the radial direction and are connected to the inner side surface 331 of the second housing 33.

[0047] As shown in FIG. 2, the second motor portion 32 preferably has substantially the same structure as the first motor portion 22 except that the motor structure is turned upside down.

[0048] A second stationary portion 321 of the second motor portion 32 includes a base portion 3211, a hollow bearing holder 3212 projecting downward from around the center of the base portion 3211, ball bearings 3215 and 3216 disposed in an upper region and a lower region inside the bearing holder 3212, and an armature 3213 attached to the outer surface of the bearing holder 3212. In the present preferred embodiment, the bearing holder 3212 is cylindrical or approximately cylindrical around the center axis J1.

[0049] A circuit board 3214 is arranged above the armature 3213. The circuit board 3214 has a control circuit which is connected to an external power supply by the second lead wire group 92 (see FIG. 1).

[0050] A second rotor portion 322 of the second motor portion 32 includes a hollow yoke 3221, which is centered on the center axis J1 in the present preferred embodiment, a field-generating magnet 3222 secured to the inside of the yoke 3221, and a shaft 3223 projecting upward from a center of the yoke 3221. The field-generating magnet 3222 is cylindrical or approximately cylindrical around the center axis J1 in the present preferred embodiment. The field-generating magnet 3222 is opposed to the armature 3213 in the radial direction and, a torque centered on the center axis J1 is generated between the field-generating magnet 3222 and the armature 3213 when a driving current is supplied to the armature 3213 via the control circuit of the circuit board 3214.

[0051] Referring to FIGS. 2 and 4, the second impeller 31 includes a cup 312 covering the outer surface of the yoke 3221, and a plurality of second blades 311 arranged around the center axis J1 outside the cup 312 to extend outward in the radial direction. In the present preferred embodiment, preferably five second blades 311, for example, are provided on the outer side surface of the cup 312 and are arranged at regular circumferential intervals. Moreover, the cup 312 and the second blade 311 are integral with each other to define the second impeller 31 by being molded from resin in the present preferred embodiment. The diameter of the second impeller 31 is substantially the same as the first impeller 21, i.e., is preferably within a range from approximately 25 mm to approximately 200 mm, for example. Please note that the diameter of the second impeller 31 preferably is approximately twice as large as a distance between a radially outermost portion of the second blade 311 and the center axis J1 in the radial direction. Since the second impeller 31 is rotated about the center axis J1 in the opposite direction to the direction of rotation of the first impeller 21, an air flow is created by rotation of the second impeller 31 which flows in approximately the same direction as the air flow created by rotation of the first impeller 21. In this manner, air is sent to the outside the serial axial fan unit 1.

[0052] FIG. 5 is a plan view of the spacer 4 when viewed from the inlet side of the serial axial fan unit 1. In FIG. 5, the second lead wire group 92 is shown together with the spacer 4. The spacer 4 is made of a material which can absorb or reduce vibration transferred between the first and second axial fans 2 and 3, e.g., a material which can be deformed more easily than the material of the housings 23 and 33. Examples of the material are rubber and porous resin. The spacer 4 is a hollow member that is connected at its top and bottom surfaces to the first housing 23 and the second housing 33, respectively, as shown in FIGS. 2 and 5. The spacer 4 includes a wall portion 41 defining a space therein. The top surface of the wall portion 41 is in contact with the bottom surface of the first housing 23 over its entire circumference.
Similarly, the bottom surface of the wall portion 41 is in contact with the top surface of the second housing 33 over its entire circumference. The first housing 23 and the spacer 4 are connected to each other so that the boundary therebetween is closed in a sealing manner. Also, the second housing 33 and the spacer 4 are connected to each other so that the boundary therebetween is closed in a sealing manner. Thus, it is possible to prevent leakage of air flowing in the space defined by the wall portion 41 from the first axial fan 2 to the second axial fan 3, to the outside.

Similarly, the bottom surface of the wall portion 41 is in contact with the top surface of the second housing 33 over its entire circumference. The first housing 23 and the spacer 4 are connected to each other so that the boundary therebetween is closed in a sealing manner. Also, the second housing 33 and the spacer 4 are connected to each other so that the boundary therebetween is closed in a sealing manner. Thus, it is possible to prevent leakage of air flowing in the space defined by the wall portion 41 from the first axial fan 2 to the second axial fan 3, to the outside.

**[0053]** FIG. 6 is an enlarged cross-sectional view of a portion around the boundaries between the first housing 23 and the spacer 4 and between the second housing 33 and the spacer 4. As shown in FIG. 6, a lower edge (i.e., a spacer 4 side edge) of the inner side surface 411 of the wall portion 41 (hereinafter, referred to as a first housing edge 2311) is substantially coincident with an upper edge (i.e., a first housing 23 side edge) of the inner side surface 411 of the wall portion 41 (hereinafter, referred to as a first spacer edge 4111). Similarly, an upper edge (i.e., a second housing 33 side edge) of the inner side surface 331 of the second housing 33 (hereinafter, referred to as a second housing edge 3311) is substantially coincident with a lower edge (i.e., a second housing 33 side edge) of the inner side surface 411 of the spacer 4 (hereinafter, referred to as a second spacer edge 4112). Thus, the inner side surface 411 of the first housing 23 is continuous with the inner side surface 331 of the second housing 33. Therefore, resistance to air flow passing through the spacer 4 is reduced.

**[0054]** FIG. 7 is an exploded perspective view of the serial axial fan unit 1. In FIG. 7, the first and second lead wire groups 91 and 92 are shown. As shown in FIG. 7, an upper end portion 232 (i.e., a first housing 23 side end portion) and a lower end portion 233 (i.e., an outlet-side end portion) of the first housing 23 define a flange. That is, both of the end portions 232 and 233 project radially outward from other portions of the first housing at least at corners of the first housing 23. Both of the end portions 232 and 233 preferably have an approximately square outer shape when viewed along the axial direction in the present preferred embodiment. The first housing 23 is shaped such that an imaginary outer shape 234 defined by imagining the outer peripheries of the both end portions 232 and 233 to each other in the axial direction preferably has an approximately quadrangular prism, as shown in chain double-dashed line in FIG. 7. Also in the second axial fan 3, an upper end portion 332 (i.e., an inlet-side end portion) and a lower end portion 333 (i.e., an outlet-side end portion) of the second housing 33 define a flange and preferably have an approximately square outer shape when viewed along the axial direction. An imaginary outer shape 334 of the second housing 33, which is defined by imagining the outer peripheries of the end portions 332 and 333 to each other in the axial direction, is preferably in the form of an approximately quadrangular prism, as shown in FIG. 7 with chain double-dashed line. Hereinafter, the imaginary outer shapes 234 and 334 of the first and second housings 23 and 33 are simply referred to as the outer shapes 234 and 334 thereof, respectively. Moreover, an outer shape 412 of the spacer 4 preferably is also approximately square so as to be substantially aligned with the outer shapes of both the first and second housings 23 and 33 adjacent to the spacer 4, i.e., the outer shape of the lower end portion 233 of the first housing 23 and the outer shape of the upper end portion 332 of the second housing 33.

**[0055]** The first housing 23 is provided with a guiding portion 235 at the nearest corner 2341 of the outer shape 234 of the first housing 23 in FIG. 7. The guiding portion 235 guides the lead wire groups 91 and 92 (see FIG. 1) parallel to or approximately parallel to the center axis J1 to the inlet side of the first housing 23 without allowing the lead wire groups 91 and 92 to protrude beyond the outer shape 234 of the first housing 23, and then guides them to the outside of the first housing 23. The guiding portion 235 has a first guiding portion 2351 provided for the first lead wire group 91 and a second guiding portion 2352 provided for the second lead wire group 92 at two side surfaces forming the nearest corner 2341, respectively. The first guiding portion 2351 guides the first lead wire group 91, while the second guiding portion 2352 guides the second lead wire group 92. The first guiding portion 2351 is provided with hooks 2321 and 2331 at the upper and lower end portions 232 and 233 of the first housing 23, respectively. Similarly, the second guiding portion 2352 is provided with hooks 2332 and 2332 at the upper and lower end portions 232 and 233 of the first housing 23, respectively.

**[0056]** The spacer 4 is also provided with a guiding portion 42 for guiding the second lead wire group 92 from the second motor portion 32 (see FIG. 2) to the inlet side of the first housing 23 without allowing the second lead wire group 92 to protrude beyond the outer shape 412 of the spacer 4, as shown in FIGS. 5 and 7. The guiding portion 42 is arranged at the corner 4122 of the spacer 4 which is axially covered by the nearest corner 2341 of the first housing 23. Moreover, the spacer 4 is provided with a hook 4121 to radically cover the guiding portion 42. In a state where the spacer 4 and the first housing 23 are connected to each other, the second guiding portion 2352 of the guiding portion 235 of the first housing 23 is located immediately above and adjacent to the guiding portion 42 of the spacer 4 in the axial direction. With this configuration, the second lead wire group 92 is guided to the first housing 23 via the spacer 4.

**[0057]** Returning to FIG. 1, in the serial axial fan unit 1, the first lead wire group 91 extending from the inside of the first axial fan 2 is guided approximately parallel to the center axis J1 by the first guiding portion 2351 of the guiding portion 235 of the first housing 23, and is finally drawn from the inlet side of the first housing 23 to the outside. Since the hooks 2321 and 2331 provided at both axial ends of the first guiding portion 2351 catch the first lead wire group 91, the first lead wire group 91 can be prevented from protruding beyond the outer shape 234 of the first housing 23 (see FIG. 7). The second lead wire group 92 extending from the inside of the second axial fan 3 is guided to the second guiding portion 2352 of the guiding portion 235 of the first housing 23 via the guiding portion 42 of the spacer 4, is then guided approximately parallel to the center axis J1 by the second guiding portion 2352, and is finally drawn from the inlet side of the first housing 23 to the outside. Since the hooks 2332 and 2332 provided at both the axial ends of the second guiding portion 2352 and the hook 4121 provided on the guiding portion 42 of the spacer 4 catch the second lead wire group 92, the second lead wire group 92 can be prevented from protruding beyond the outer shape 234 of the first housing 23 (see FIG. 7).

**[0058]** FIG. 8 is a perspective view of the first axial fan 2, in which the lower end portion 233 of the first housing 23 is shown. FIG. 9 is a perspective view of the spacer 4, in which the upper portion of the spacer 4 is shown. As shown in FIGS. 8 and 9, the lower end portion 233 of the first housing 23 is provided with an engagement portion at each of four corners.
2341 of the outer shape 234 of the first housing 23. That is, portions of the first housing 23 which are closest to the spacer 4 form the engagement portions, respectively. Hereinafter, those engagement portions are referred to as first housing engagement portions 236a, 236b, 236c, and 236d. Similarly, the upper portion 413 of the spacer 4, which is the closest to the first housing 23, is provided with an engagement portion at each of four corners 4122 of the outer shape 412 of the spacer 4. Hereinafter, those engagement portions of the spacer 4 are referred to as first spacer engagement portions 43a, 43b, 43c, and 43d. Each of the first spacer engagement portions 43a, 43b, 43c, and 43d can engage with an associated one of the first housing engagement portions 236a, 236b, 236c, and 236d. In the following description, the first housing engagement portions 236a, 236b, 236c, and 236d are collectively referred to as "the first housing engagement portions 236", and the first spacer engagement portions 43a, 43b, 43c, and 43d are collectively referred to as "the first spacer engagement portions 43".

Referring to FIG. 9, at the nearer corners 4122 of the outer shape 412 of the spacer 4 are arranged the first spacer engagement portions 43a, 43b, and 43d, respectively. The first spacer engagement portion 43a projects upward from the upper portion 413 of the spacer 4 and includes a projection 431 provided at its tip. The projection 431 projects toward the first spacer engagement portion 43b. The first spacer engagement portions 43b and 43d project upward from the upper portion 413 and include projections 432 and 433 provided at their tips, respectively. The projections 432 and 433 project toward the first spacer engagement portion 43c.

Returning to FIG. 8, at the other three corners 2341 of the outer shape 234 of the first housing 23, the first housing engagement portions 236a, 236b, and 236d are arranged and have approximately L-shaped grooves which can engage with the first spacer engagement portions 43a, 43b, and 43d, respectively. Referring to FIG. 8, at the farthest corner 2341 of the outer shape 234 of the first housing 23, the first housing engagement portion 236c includes two projections 2364 and 2365 which project downward from the lower end portion 233. Each projection 2364 or 2365 has an approximately L shape at its tip. The projections 2364 and 2365 are arranged such that they get closer to each other as they move toward the tips of the approximately L-shaped portions. The first spacer engagement portion 43c at the farthest corner 4122 of the outer shape 412 of the spacer 4 is provided with two concave portions 434 and 435. The concave portions 434 and 435 are arranged to engage with the projections 2364 and 2365 of the first housing engagement portion 236c, respectively.

FIG. 10 is another perspective view of the spacer 4, in which the lower portion 414 of the wall portion 41 is shown. The lower portion 414, which is closest to the second housing 33, is provided with engagement portions having substantially the same shape as the first housing engagement portions 236 (see FIG. 8) of the lower end portion 233 of the first housing 23. Those engagement portions of the lower portion 414 are hereinafter referred to as second spacer engagement portions 44. At three corners 4122 of the spacer 4, other than the farthest corner, the second spacer engagement portions 44a, 44b, and 44d are provided in the form of grooves. At the farthest corner 4122, the second spacer engagement portion 44c is provided to have two projections 444 and 445 projecting downward from the lower portion 414. The projections 444 and 445 are arranged such that they get closer to each other as they move toward their tips.
FIG. 14 shows the static pressure versus flow curves obtained for five serial axial fan units 1 in which the axial height of the spacer 4 is different from one another, and the static pressure versus flow curves obtained for another serial axial fan unit having no spacer. In all of the six serial axial fan units for which the measurement was performed, the radius of the first impeller and the second impeller was about 43 mm. In FIG. 14, curve 81 in chain double-dashed line, curve 82 in large broken line, curve 83 in solid line, curve 84 in chain dashed line, and curve 85 in small broken line represent the measurement results for the serial axial fan units 1 having the spacer 4 of the axial height of 1.57 mm, 3.18 mm, 4.47 mm, 6.31 mm, and 7.90 mm, respectively. Curve 86 in solid line represents the measurement result for the serial axial fan unit having no spacer.

When the air flow rate was about 1 mm²/min less, the values were different between the curves. That is, the order of the curves was varied. On the other hand, when the air flow rate exceeded about 1 mm²/min, the static pressure value of curve 83 was the highest and curve 84 was the second highest. Curves 82 and 85 were at approximately the same level and lower than curve 84. Curve 81 was lower than curves 82 and 85. Curve 86 was the lowest. Thus, the measurement results show that the serial axial fan units 1 including the spacer 4 having an axial height in a range from about 1.5 mm to about 8 mm provide improved static pressure versus flow curves, as compared with the serial axial fan unit having no spacer.

FIG. 15 is a graph obtained by plotting the static pressure values of the respective curves 81 to 86 on the X-axis in FIG. 14 and the air flow rate values of those curves on the Y-axis are plotted against the axial height of the spacer 4. The largest air flow rates and the highest static pressure corresponding thereto were plotted against the axial height of the spacer 4 in FIG. 15. In the description of FIG. 15, the largest air flow rate and the highest static pressure are simply referred to as the "flow rate" and the "static pressure", respectively. Curve 87, obtained by connecting black squares and shown with solid line, represents the change in the flow rate with the change in the axial height of the spacer 4. Curve 88, obtained by connecting black triangles and shown with broken line, represents the change in the static pressure. As shown in FIG. 15, the flow rate was the largest when the axial height of the spacer 4 was approximately 5 mm, while the static pressure was the highest when the axial height of the spacer 4 was approximately 6 mm to approximately 7 mm. From those results, the serial axial fan unit 1 can have the most preferable static pressure versus flow curve when the axial height of the spacer 4 is in the range from approximately 5 mm to approximately 7 mm.

As described above, the serial axial fan unit 1 of the present preferred embodiment includes the spacer 4 between the first axial fan 2 and the second axial fan 3, and therefore, the first axial fan 2 and the second axial fan 3 are spaced apart from each other by an appropriate distance. In other words, the distance between the first impeller 21 and the second impeller 31 is increased to an appropriate distance. With this configuration, a harsh noise caused by interference occurring when air enters the second axial fan 3 from the first axial fan 2 is reduced. Thus, for a given sound value, it is possible to increase the rotation speeds of the first and second impellers 21 and 31. In this case, when the axial height of the spacer 4 is in the range of about 1.5 mm to about 8 mm, the static pressure versus flow curve of the serial axial fan unit 1 is improved.

Moreover, in the measurements producing the results shown in FIGS. 14 and 15, the radius of the first and second impellers 21 and 31 was about 43 mm. However, even when the radius of the impellers 21 and 31 is changed within a range from about 12.5 mm to about 100 mm, which is a typical range for the radius of fans used for cooling the inside of an electronic device, the first axial fan 2 and the second axial fan 3 can be spaced apart from each other by an appropriate distance as long as the spacer 4 having the axial height of the aforementioned range is provided between the first and second axial fans 2 and 3. Thus, the interference noise can be improved. In a case where the characteristics of fans are compared on the basis of the sound value, the rotation speed of the first and second axial fans 2 and 3 can be increased by an amount corresponding to the reduction in the interference noise. Consequently, the static pressure versus flow curve of the serial axial fan unit 1 can be improved.

Moreover, the inner side surface 411 of the spacer 4, the inner side surface 231 of the first housing 23, and the inner side surface 331 of the second housing 33 are continuously connected to each other in the serial axial fan unit 1 of the present preferred embodiment, as shown in FIG. 6. Thus, the occurrence of turbulence in the air flow passing through the spacer 4 can be prevented, which further reduces the noise. In addition, since the spacer 4 is made of a vibration-proof member, interference of the vibrations of the motor portions 22 and 32 with each other (and resonance) can be reduced, which further reduces the noise. It should be noted that the material of the spacer 4 is not limited to a material which prevents, absorbs, or reduces vibration. For example, a resin such as PEI can be used. In this case, it is also possible to reduce the sound value of the serial axial fan unit and improve the static pressure versus flow curve thereof. Furthermore, since the rotation directions of the first impeller 21 and the second impeller 31 are opposite to each other, a harsh noise can be further reduced.

In the serial axial fan unit 1 of the present preferred embodiment, the first housing 23 and the spacer 4 have to be shifted relative to each other in the diagonal direction in order to separate them from each other. Thus, it is much less likely that when another component is placed inside an electronic device, a force which causes the separation of the first housing 23 and the spacer 4 from each other is applied to the first housing 23 and/or the spacer 4 because of contact with a hand or the other component. In other words, unwanted or unintentional separation of the first housing 23 and the spacer 4 from each other can be prevented. Similarly, in order to separate the spacer 4 and the second housing 33 from each other, at least one of the spacer 4 and the second housing 33 have to be shifted relative to the other in the diagonal direction of the spacer 4. Thus, for the reasons described above, unwanted or unintentional separation of the spacer 4 and the second housing 33 from each other can be prevented.

Moreover, since the first and second axial fans 2 and 3 are connected to the spacer 4 in a detachable manner, it is possible to replace the spacer 4 with another spacer 4 having a different axial height. Thus, the axial height of the entire serial axial fan unit 1 can be easily changed.

Furthermore, the first spacer engagement portions 236 of the first housing 23 and the second spacer engagement portions 44 of the spacer 4 have substantially the same shape.
as each other, and the first spacer engagement portions 43 of the spacer 4 and the second housing engagement portions 335 of the second housing 33 have substantially the same shape as each other. Thus, even if the spacer 4 must be omitted in order to reduce the axial height of the serial axial fan unit 1, it is possible to directly connect the first and second axial fans 2 and 3 to each other.

Second Preferred Embodiment

[0074] FIG. 16 is an exploded perspective view of a serial axial fan unit 1a according to a second preferred embodiment of the present invention. A spacer 4a of the serial axial fan unit 1a of the present preferred embodiment includes the structure of the spacer 4 of the first preferred embodiment and additionally includes a central portion 45 and spacer ribs 451. The central portion 45, which has a substantially circular plate shape, for example, is arranged at a central portion of the space defined by the wall portion 41. The spacer ribs 451 are arranged around the center axis J1 to extend from the central portion 45 outward in the radial direction, and are connected to the wall portion 41. In the present preferred embodiment, four spacer ribs 451 are provided. The spacer 4a is made of material which prevents, absorbs, or reduces vibration as in the first preferred embodiment. This is the same in the following preferred embodiments. The number of the first supporting ribs 24 (see FIG. 8) of the first axial fan 2 and the number of the second supporting rib 34 of the second axial fan 3 are the same as the number of the spacer rib 451 of the spacer 4a. Thus, in the present preferred embodiment, four first supporting ribs 24 and four second supporting ribs 34 preferably are provided, for example. Except for the spacer 4a, the serial axial fan unit 1a of the present preferred embodiment preferably has substantially the same structure as that of the first preferred embodiment. Thus, in the serial axial fan unit 1a of the present preferred embodiment, similar components identified with the same reference characters and the detailed description thereof is omitted.

[0075] In the serial axial fan unit 1a, the first axial fan 2 and the second axial fan 3 can be arranged to be spaced apart from each other due to the spacer 4a by an appropriate distance. Thus, interference noise which is generated when air from the first axial fan 2 enters the second axial fan 3 can be reduced. Consequently, for a given sound value, the rotation speeds of the first and second axial fans 2 and 3 can be increased as in the first preferred embodiment. This contributes to an improved static pressure versus flow curve of the serial axial fan unit 1a.

[0076] FIG. 17 is a cross-sectional view of the serial axial fan unit 1a of the present preferred embodiment, taken along a plane containing the center axis J1. FIG. 18 is a cross-sectional view of the first supporting rib 24, the second supporting rib 34, and the spacer rib 451, taken along a plane perpendicular or substantially perpendicular to the direction in which those ribs 24, 34, and 451 extend. As shown in FIG. 17, the central portion 45 of the spacer 4a is arranged between the first motor portion 22 of the first axial fan 2 and the second motor portion 32 of the second axial fan 3. As shown in FIG. 18, the spacer rib 451 is arranged between the first supporting rib 24 and the second supporting rib 34. The cross sections of those three ribs are aligned in a straight line inclined to the axial direction. The bottom surface 241 of the first supporting rib 24 and the top surface 341 of the second supporting rib 34 are displaced from each other in the circumferential direction. The top surface 4511 of the spacer rib 45 is in contact with the bottom surface 241 of the first supporting rib 24 with their contours being substantially aligned with each other. Similarly, the bottom surface 4512 of the spacer rib 451 is in contact with the top surface 341 of the second supporting rib 34 with their contours being substantially aligned with each other. Each of the four spacer ribs 451 is arranged between an associated one of the first supporting ribs 24 and an associated one of the second supporting ribs 34 over its entire length. Thus, turbulence in an air flow can be prevented from occurring between the first supporting ribs 24 and the second supporting ribs 34, and therefore, the noise can be reduced.

[0077] FIG. 19 shows another exemplary spacer rib in the present preferred embodiment. In the spacer rib 451a shown in FIG. 19, the cross section thereof perpendicular to the extending direction thereof extends parallel or substantially parallel to the axial direction. The top surface 4511 of the spacer rib 451a is substantially aligned with the bottom surface 241 of the first supporting rib 24. The bottom surface 4512 of the spacer rib 451a is substantially aligned with the top surface 341 of the second supporting rib 34. With this configuration, the occurrence of turbulence in an air flow can be prevented between the first supporting ribs 24 and the second supporting ribs 34, and therefore, the noise can be reduced. Moreover, the spacer rib 451a in the example of FIG. 19 has a shape such that the cross section perpendicular to the extending direction thereof is parallel or substantially parallel to the axial direction. Thus, even if the axial height of the spacer 4 is changed, the spacer ribs 451a can be brought into contact with the associated first and second supporting ribs 24 and 34, respectively, without changing the circumferential positions of the first and second supporting ribs 24 and 34.

Third Preferred Embodiment

[0078] FIG. 20 is a cross-sectional view of a serial axial fan unit 1b according to a third preferred embodiment of the present invention. In the serial axial fan unit 1b, a second axial fan 3b has a structure obtained by turning the arrangement of the second impeller 31 and the second motor portion 32 of the second axial fan 3 of the first preferred embodiment upside down. Except for the structure of the second axial fan unit 3b, the serial axial fan unit 1b preferably has substantially the same structure as that of the first preferred embodiment. Thus, similar components are identified with the same reference characters and the detailed description thereof is omitted. In the serial axial fan unit 1b, the first impeller 21 and the first supporting ribs 24 of the first axial fan 2, the spacer 4, and the second impeller 31 and the second supporting ribs 34 of the second axial fan 3b are arranged along the center axis J1 in that order from top to bottom.

[0079] FIG. 21 is an exploded perspective view of the serial axial fan 1b. The upper end portion 332 (i.e., the spacer 4 side end portion) of the second housing 33 of the second axial fan 3b is provided with second housing engagement portions 335 having substantially the same shape as the first spacer engagement portions 43 provided in the upper portion of the spacer 4. The second housing engagement portions 335 engage with the second spacer engagement portions 44 provided in the lower portion of the spacer 4, thereby connecting the second housing 33 and the spacer 4 to each other.

[0080] FIG. 22 shows the serial axial fan unit 1b with the first and second lead wire groups 91 and 92 connected thereto. The circuit board 3214 (see FIG. 20) of the second axial fan 3b is arranged near the outlet side end of the second axial fan 3b. Thus, the second lead wire group 92 connected to the
circu**t board 3214 are arranged to extend from the inside of the second housing 33 at or near the lower end of the second housing 33. The second housing 33 is provided with the second guiding portion 336 for guiding the second lead wire group 92 to the first housing 23 substantially parallel to the center axis J1. The second guiding portion 336 is arranged at the nearest corner 3341 of the second housing 33 between the inner side surface 331 (see FIG. 20) and the outer shape 334 of the second housing 33. When the spacer 4 and the second housing 33 are connected to each other, the guiding portion 42 of the spacer 4 is located immediately above and adjacent to the second guiding portion 336 of the second housing 33 in the axial direction. The second lead wire group 92 extend along the second housing 33 and the spacer 4 and are guided to the first housing 23. The second lead wire group 92 extending from the second axial fan 3 is caught by hooks 3322 and 3332 provided at upper and lower axial ends of the second guiding portion 336 of the second housing 33, thereby being prevented from protruding beyond the outer shape 334 of the second housing 33. The second lead wire group 92 is also prevented from protruding beyond the outer shape 412 of the spacer 4 and the outer shape 234 of the first housing 23 by the hooks 2322, 2332, and 4121 provided in the second guiding portion 2352 of the first housing 23 and the spacer guiding portion 42.

0081] In the serial axial fan unit 1f of the present preferred embodiment, the first axial fan 2 and the second axial fan 3a can be arranged to be spaced apart from each other by the spacer 4 by an appropriate distance, as in the aforementioned preferred embodiments. Thus, the interference noise generated when air from the first axial fan 2 enters the second axial fan 3a can be reduced. In accordance with the reduced interference noise, the rotation speeds of the first and second axial fans 2 and 3a can be increased. Therefore, the static pressure versus flow curve of the serial axial fan unit 1f can be improved.

Fourth Preferred Embodiment

0082] FIG. 23 is an exploded perspective view of a serial axial fan unit 1c according to a fourth preferred embodiment of the present invention. FIG. 24 is a cross-sectional view of the serial axial fan unit 1c, taken along a plane containing the center axis J1. The serial axial fan unit 1c of the present preferred embodiment includes a spacer 4b which preferably has substantially the same structure of the spacer 4a of the serial axial fan unit 1a of the second preferred embodiment. That is, the spacer 4b includes inside the wall portion 41 the central portion 45 axially covered by the first motor portion 22 when the first axial fan 2 and the spacer 4b are connected to each other, and the spacer ribs 451. In the present preferred embodiment, the number of the spacer ribs 451 is four as in the second preferred embodiment, and the number of the first supporting ribs 24 (see FIG. 8) of the first axial fan 2 is also four. Except for the spacer 4b, the serial axial fan unit 1c preferably has substantially the same structure as the serial axial fan unit 1b of the third preferred embodiment. Thus, similar components are identified with the same reference characters and the detailed description thereof is omitted. In the present preferred embodiment, due to the spacer 4b, the interference noise can be reduced and the static pressure versus flow curve for a given sound value can be improved.

0083] FIG. 25 is a cross-sectional view of the spacer rib 451 and the first supporting rib 24, taken along a plane perpendicular to the extending direction thereof. The cross sections of those ribs 451 and 24 are straight and inclined with respect to the axial direction. As shown in FIGS. 24 and 25, the top surface 4511 of the spacer rib 451 is substantially aligned with the bottom surface 241 of the first supporting rib 24. Each of the spacer ribs 451 is in contact with an associated one of the first supporting ribs 24 over its entire length. With this configuration, the spacer ribs 451 can adjust an air flow without causing turbulence in air flowing into the spacer 4b.

0084] The first to fourth preferred embodiments of the present invention are described above. However, the present invention is not limited thereto and may be modified in various ways. For example, as shown in FIG. 26, the inner side surface 411 of the wall portion 41 of the spacer 4 may be located radially outside the inner side surface 231 of the first housing 23 and the inner side surface 331 of the second housing 33. In other words, the upper edge 4111 of the inner side surface 411 may be located radially outside the lower edge 2311 of the inner side surface 231 of the first housing 23, while the lower edge 4112 of the inner side surface 411 may be located radially outside the upper edge 3311 of the inner side surface 331 of the second housing 33. Even in this configuration, it is possible to reduce the amount of air delivered from the first axial fan 2 which hits the inner side surface 411 of the spacer 4. Thus, air turbulence can be prevented and the noise can be reduced.

0085] In the aforementioned preferred embodiments, the first housing 23, the second housing 33, and the spacer 4, 4a, or 4b are preferably connected to each other by the engagement structure shown in FIGS. 8 to 11. Alternatively, another engagement structure shown in FIGS. 27 and 28 may be used.

0086] FIG. 27 is an enlarged cross-sectional view of the boundary between the first housing 23 and the spacer 4 and the boundary between the spacer 4 and the second housing 33. FIG. 28 is a view of the portion shown in FIG. 27 when viewed from the right. The first housing 23 includes at a portion of the lower end portion 231 a first housing engagement portion 237 projecting from the remaining portion of the lower end portion 231. The first housing engagement portion 237 includes a convex portion 2371 at the end thereof, as shown in FIG. 27. Similarly, the second housing 33 includes at a portion of the upper end portion 331 a second housing engagement portion 337 projecting from the remaining portion of the upper end portion 331. The second housing engagement portion 337 includes a convex portion 3371 at the end thereof. The spacer 4 includes a first spacer engagement portion 461 and a second spacer engagement portion 462 as portions of the wall portion 41. Concave portions 4611 and 4621 provided in the first and second spacer engagement portions 461 and 462 are arranged to engage with the convex portion 2371 of the first housing engagement portion 237 and the convex portion 3371 of the second housing engagement portion 333, respectively, when the spacer 4 is connected to the first and second housings 23 and 33. With this configuration, the first housing 23, the second housing 33, and the spacer 4 are connected to each other in a detachable manner.

0087] In the aforementioned preferred embodiments, the engagement structure is described in which the first housing 23 is preferably shifted relative to the spacer 4 in the diagonal direction thereof. However, the engagement structure for joining two objects is not limited thereto. For example, engagement may be achieved by rotating at least one of the first housing 23 and the spacer 4 about an axis substantially parallel to the center axis J1 relative to the other.
Moreover, in addition to the engagement structure, a fixing element such as a screw, a rivet, or a clip may be used to fix the first housing 23, the second housing 33, and the spacer 4 to each other.

In the aforementioned preferred embodiments, the first lead wire group 91 and the second lead wire group 92 are preferably individually guided to the inlet side of the first housing 23 by the first guiding portion 2351 and the second guiding portion 2352 of the guiding portion 235 provided at the corner 2341 of the first housing 23, respectively. However, both of the first and second lead wire groups 91 and 92 may be guided by a single guiding portion provided in the first housing 23, as long as those lead wire groups 91 and 92 do not protrude beyond the outer shape 234 of the first housing 23. Moreover, the outer shape of a portion of the first housing 23 between the upper end portion 232 and the lower end portion 233 may be approximately square similar to the end portions 232 and 233. Similarly, the outer shape of a portion of the second housing 33 between the upper end portion 332 and the lower end portion 333 may be approximately square similar to the end portions 332 and 333.

In the aforementioned preferred embodiments, the spacer 4, 4a, or 4b is preferably in contact with the first and second housings 23 and 33 over its entire circumference. However, only a portion of the spacer 4, 4a, or 4b may be in contact with the first and second housings 23 and 33 as long as the static pressure versus flow curve of the serial axial fan unit is not reduced.

In the second preferred embodiment, the spacer ribs 451 preferably are in contact with the first supporting ribs 24 and the second supporting ribs 34 over their entire length. However, it is not necessary that the spacer ribs 451 are in contact with the first supporting ribs 24 and the second supporting ribs 34. That is, the spacer rib 451 may be arranged close to the first supporting ribs 24 and the second supporting ribs 34. Similarly, in the fourth preferred embodiment, the spacer ribs 451 may be arranged close to the first supporting ribs 24 and the second supporting ribs 34, instead of being in contact therewith.

The numbers of the first supporting ribs 24, the second supporting ribs 34, and the spacer ribs 451 are not limited to those described in the aforementioned preferred embodiments.

In the serial axial fan units of the aforementioned preferred embodiments, the first impeller 21 of the first axial fan 2 and the second impeller 31 of the second axial fan 3 may be rotated in the same direction as each other. Moreover, the serial axial fan units in the aforementioned preferred embodiments may be modified so that air is taken in from the second axial fan 3 side and is discharged from the first axial fan 2 side. More specifically, in order to create an air flow from the second axial fan 3 to the first axial fan 2, the shape and the arrangement of the blades of each impeller and the rotation direction of each impeller can be changed. In this case, the lead wire group is drawn to the outside of the serial axial fan unit from the outlet side. Furthermore, the serial axial fan units in the aforementioned preferred embodiments may be modified to additionally include at least one axial fan and/or at least one spacer which are arranged in the axial direction coaxially with the first and second axial fans 2 and 3.

As described above, according to the preferred embodiments of the present invention, an interference noise generated when air from one of the fans enters another fan in a serial axial fan unit can be reduced. This contributes to an improvement in the static pressure versus flow curve of the serial axial fan unit. Moreover, according to the preferred embodiments, it is possible to easily change the axial height of the serial axial fan unit.

While preferred embodiments of the present invention have been described above, it is to be understood that variations and modifications will be apparent to those skilled in the art without departing the scope and spirit of the present invention. The scope of the present invention, therefore, is to be determined solely by the following claims.

What is claimed is:

1. A serial axial fan unit comprising:
   a first axial fan and a second axial fan coaxial with each other and arranged in an axial direction substantially parallel to a center axis thereof; and
   a spacer arranged between the first axial fan and the second axial fan; wherein
   each of the first axial fan and the second axial fan includes:
   an impeller having a plurality of blades which are arranged around the center axis so as to extend away from the center axis;
   a motor portion arranged to rotate the impeller;
   a housing surrounding the impeller from outside in a radial direction substantially perpendicular to the center axis;
   the spacer includes a wall portion connected to the housing of each of the first axial fan and the second axial fan, the wall portion defining a space therein in which air flows;
   a radius of the impeller of each of the first axial fan and the second axial fan is in a range of approximately 12.5 mm to approximately 100 mm; and
   an axial height of the spacer is in a range from approximately 1.5 mm to approximately 8 mm.

2. The serial axial fan unit according to claim 1, wherein the axial height of the spacer is in a range from approximately 5 mm to approximately 7 mm.

3. The serial axial fan unit according to claim 1, wherein
   an inner side surface of the wall portion of the spacer includes a first spacer edge adjacent to the first axial fan and a second spacer edge adjacent to the second axial fan;
   an inner side surface of the housing of the first axial fan includes a first housing edge adjacent to the spacer, and
   an inner side surface of the housing of the second axial fan includes a second housing edge adjacent to the spacer; and
   the first spacer edge is substantially aligned with or radially outward of the first housing edge, and the second spacer edge is substantially aligned with or radially outward of the second housing edge.

4. The serial axial fan unit according to claim 3, wherein the first spacer edge is substantially aligned with the first housing edge, and the second spacer edge is substantially aligned with the second housing edge.

5. The serial axial fan unit according to claim 1, wherein
   each of the first axial fan and the second axial fan further includes a plurality of supporting ribs arranged around the center axis, the supporting ribs extending outward from the corresponding motor portion in the radial direction and being connected to the corresponding housing, and the impeller and the supporting ribs of the first axial fan and the supporting ribs and the impeller of the second axial fan are arranged in the axial direction in that order.
6. The serial axial fan unit according to claim 5, wherein the spacer includes a central portion and a plurality of spacer ribs arranged around the center axis; the central portion is arranged between the motor portion of the first axial fan and the motor portion of the second axial fan; and the spacer ribs extend outward from the central portion in the radial direction and are connected to the wall portion, and each of the spacer ribs is arranged between a corresponding one of the supporting ribs of the first axial fan and a corresponding one of the supporting ribs of the second axial fan over substantially its entire length.

7. The serial axial fan unit according to claim 6, wherein each of the first axial fan and the second axial fan further includes a plurality of supporting ribs arranged around the center axis, the supporting ribs extending outward from the corresponding motor portion in the radial direction and being connected to the corresponding housing; and the impeller and the supporting ribs of the first axial fan and the impeller and the supporting ribs of the second axial fan are arranged in the axial direction in that order.

8. The serial axial fan unit according to claim 7, wherein the spacer includes a central portion and a plurality of spacer ribs arranged around the center axis; the central portion is arranged between the motor portion of the first axial fan and the motor portion of the second axial fan; and the spacer ribs extend outward from the central portion in the radial direction and are connected to the wall portion, and each of the spacer ribs is arranged between a corresponding one of the supporting ribs of the first axial fan and a corresponding one of the supporting ribs of the second axial fan over its entire length.

9. The serial axial fan unit according to claim 1, wherein the impeller of the first axial fan and the impeller of the second axial fan are rotated in opposite directions relative to each other.

10. The serial axial fan unit according to claim 1, wherein the spacer is made of a material that absorbs or reduces vibration transferred between the first axial fan and the second axial fan.

11. The serial axial fan unit according to claim 1, wherein the housing of each of the first axial fan and the second axial fan is provided with a housing engagement portion at a portion thereof adjacent to the spacer; the wall portion is provided with a first spacer engagement portion at a portion thereof adjacent to the first axial fan and a second spacer engagement portion at a portion thereof adjacent to the second axial fan; and the first spacer engagement portion and the second spacer engagement portion engage with the housing engagement portion of the first axial fan and the housing engagement portion of the second axial fan, respectively, to connect the housing of the first axial fan and the housing of the second axial fan to the spacer in a detachable manner.

12. The serial axial fan unit according to claim 11, wherein the housing engagement portion of the first axial fan and the second spacer engagement portion have substantially the same shape as each other, and the first spacer engagement portion and the housing engagement portion of the second axial fan have substantially the same shape as each other.

13. The serial axial fan unit according to claim 1, wherein both axial end portions of the housing have an approximately square outer shape; the spacer has an approximately square outer shape which is substantially aligned with the outer shape of the end portions of the housing of each of the first axial fan and the second axial fan; the spacer is provided with a spacer guiding portion guiding a lead wire group from the second axial fan to the first axial fan, the spacer guiding portion being arranged between an inner side surface and the outer shape of the spacer; and the housing of the first axial fan is provided with a housing guiding portion guiding the lead wire group substantially parallel to the center axis to outside of the first axial fan, the housing guiding portion being arranged between an inner side surface and the outer shape of the housing of the first axial fan.

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