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- Maruyama, Yasuhiro,
c/o Sanyo Denki Co. Ltd.
Tokyo (JP)
- Murayama, Hayato,
c/o Sanyo Denki Co. Ltd.
Tokyo (JP)

4) Representative: **Wilson Gunn**
5th Floor
Blackfriars House
The Parsonage
Manchester M3 2JA (GB)

(57) A counter-rotating axial-flow fan includes a housing that is constituted from a first divided housing unit and a second divided housing unit. Engaging members and first stopper portions are integrally formed with a first flange portion of the first divided housing unit. The first stopper portions are arranged adjacent to the engaging members. Engaged members and second stopper portions are integrally formed with a second flange portion of the second divided housing unit. The second stopper portions are arranged adjacent to the engaged members. The second stopper portions have leading ends that are abutted onto leading ends of the first stopper portions when the engaging members are completely engaged with the engaged members. Thus, damage of the first and second divided housing units is prevented when the first and second divided housing units are coupled.



Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a counter-rotating axial-flow fan used for cooling the inside of an electric appliance or the like.

[0002] Japanese Patent No. 3904595 (Patent Document 1) discloses a counter-rotating axial-flow fan including a housing, which includes a housing body and a motor support frame. The housing body includes an air channel having a suction opening on one side in an axial line direction and a discharge opening on the other side in the axial line direction. The motor support frame is disposed in the central portion of the air channel. In this counter-rotating axial-flow fan, a first impeller that is rotated by a first motor is disposed within a first space that is defined between the motor support frame in the housing and the suction opening. Further, a second impeller that is rotated by a second motor is disposed within a second space that is defined between the motor support frame in the housing and the discharge opening. The first impeller rotates in a direction opposite to a rotating direction of the second impeller. In this counter-rotating axial-flow fan, the housing is constituted from first and second divided housing units that are coupled through a coupling structure. The first divided housing unit includes a first housing-body half-portion and a first support-frame half-portion. The first housing-body half-portion includes a first cylindrical air-channel half-portion containing therein a major part of the first space. The first support-frame half-portion is obtained by dividing the motor support frame into two along a virtual reference dividing plane that extends in a radial direction orthogonal to the axial line direction. The second divided housing unit includes a second housing-body half-portion and a second support-frame half-portion. The second housing-body half-portion includes a second cylindrical air-channel half-portion containing therein a major part of the second space. The second support-frame half-portion is obtained by dividing the motor support frame into two along the virtual reference dividing plane. The coupling structure is constituted from a fitting portion formed at one of the ends of the first cylindrical air-channel half-portion, and a fitted portion to be fitted with the fitting portion, formed at one of the ends of the second cylindrical air-channel half-portion.

[0003] In the conventional counter-rotating axial-flow fan, however, when the fitting portion of the first cylindrical air-channel half-portion and the fitted portion of the second cylindrical air-channel half-portion are strongly pressed against each other to couple the first and second divided housing units, undue force is applied to the fitting portions of the first and second divided housing units. The first and second divided housing units may be thereby broken.

[0004] Further, in the conventional counter-rotating axial-flow fan, the coupling of the first and second divided

housing unit is not strong enough. Accordingly, when external force is applied, the first and second divided housing units tend to be decoupled or disconnected. For this reason, it is necessary to use screws, an adhesive, or the like for reinforcing the coupling between the first and second divided housing units.

SUMMARY OF THE INVENTION

[0005] An object of the present invention is therefore to provide a counter-rotating axial-flow fan in which first and second divided housing units are prevented from being broken when the first and second divided housing units are coupled.

[0006] Another object of the present invention is to provide a counter-rotating axial-flow fan in which the first and second divided housing units are prevented from being readily decoupled or disconnected, even when external force is applied.

[0007] According to the present invention, there is provided a counter-rotating axial-flow fan comprising:

a housing (1) comprising a housing body (61) including an air channel (2) having a suction opening (11a) on one side in an axial line direction and a discharge opening (13a) on the other side in the axial line direction, and a motor support frame (63) disposed in a central portion of the air channel (2);

a first impeller (5) disposed in a first space (S1), which is defined between the motor support frame (63) in the housing (1) and the suction opening (11a), and including a plurality of blades (95);

a first motor (3) including a first rotary shaft (71) onto which the first impeller (5) is fixed, the first motor (3) rotating the first impeller (5) in a first rotating direction (R1) within the first space (S1);

a second impeller (9) disposed in a second space (S2), which is defined between the motor support frame (63) in the housing (1) and the discharge opening (13a), and including a plurality of blades (195); and

a second motor (7) including a second rotary shaft (171) onto which the second impeller (9) is fixed, the second motor (7) rotating the second impeller (9) in a second rotating direction (R2) opposite to the first rotating direction (R1) within the second space (S2); the motor support frame (63) comprising a support frame body (65) disposed in the central portion of the air channel (2) and a plurality of webs (69A - 69E) disposed between the support frame body (65) and the housing body (61) at predetermined intervals in a circumferential direction of the rotary shafts (71, 171), the webs (69A - 69E) connecting the support frame body (65) and the housing body (61);

the housing being constituted from first and second divided housing units (11, 13) that are coupled through a coupling structure;

the first divided housing unit (11) including a first

housing-body half-portion (15) and a first support-frame half-portion (17), the first housing-body half-portion (15) including a first flange portion (19) having the suction opening (11a) at one end thereof and a first cylindrical air-channel half-portion (21) of which one end is integrally formed with the first flange portion (19), the first cylindrical air-channel half-portion (21) containing therein a major part of the first space (S1), the first support-frame half-portion (17) being obtained by dividing the motor support frame (63) into two along a virtual reference dividing plane (F) extending in a radial direction of the rotary shafts (71, 171) orthogonal to the axial line direction; the second divided housing unit (13) including a second housing-body half-portion (33) and a second support-frame half-portion (35), the second housing-body half-portion (33) including a second flange portion (37) having the discharge opening (13a) at one end thereof and a second cylindrical air-channel half-portion (39) of which one end is integrally formed with the second flange portion (37), the second cylindrical air-channel half-portion (39) containing therein a major part of the second space (S2), the second support-frame half-portion (35) being obtained by dividing the motor support frame (63) into the two along the virtual reference dividing plane (F), characterized in that:

the coupling structure is constituted from:

a fitting portion formed at the other end (21a) of the first cylindrical air-channel half-portion (21),

a fitted portion to be fitted with the fitting portion, formed at the other end (39a) of the second cylindrical air-channel half-portion (39),

a plurality of engaging members (23A - 23D) integrally formed with the first flange portion (19), arranged at intervals in the circumferential direction, and extending along the first cylindrical air-channel half-portion (21), and a plurality of engaged members (41A - 41D) to be respectively engaged with the engaging members (23A - 23D), integrally formed with the second flange portion (37), arranged at intervals in the circumferential direction, and extending along the second cylindrical air-channel half-portion (39);

a plurality of first stopper portions (25A - 25D) are integrally formed with the first flange portion (19) and arranged adjacent to the engaging members (23A - 23D), and extend along the first cylindrical air-channel half-portion (21);

a plurality of second stopper portions (43A - 43D) are integrally formed with the second flange portion (37) and arranged adjacent

to the engaged members (41A - 41D), and extend along the second cylindrical air-channel half-portion (39); and leading ends of the first stopper portions (25A - 25D) are respectively abutted onto leading ends of the second stopper portions (43A - 43D) when the engaging members (23A - 23D) are completely engaged with the engaged members (41A - 41D).

[0008] Preferably, the first and second flange portions (19, 37) respectively have a contour shape including four corners 19a - 19d, 37a - 37d, first to fourth corners, arranged in the circumferential direction;

four of the engaging members (23A - 23D) and four of the first stopper portions (25A - 25D) are respectively arranged in the vicinity of the four corners (19a - 19d) of the first flange portion (19);

four of the engaged members (41A - 41D) and four of the second stopper portions (43A - 43D) are respectively arranged in the vicinity of the four corners (37a - 37d) of the second flange portion (37);

in the first flange portion (19), two of the engaging members (23A - 23D) are arranged in a region defined between the first corner (19a) and the second corner (19b), two of the first stopper portions (25A - 25D) are arranged in a region defined between the second corner (19b) and the third corner (19c), two of the engaging members (23A - 23D) are arranged in a region defined between the third corner (19c) and the fourth corner (19d), and two of the first stopper portions (25A - 25D) are arranged in a region defined between the fourth corner (19d) and the first corner (19a); and

in the second flange portion (37), two of the engaged members (41A - 41D) are arranged in a region defined between the first corner (37a) and the second corner (37b), two of the second stopper portions (43A - 43D) are arranged in a region defined between the second corner (37b) and the third corner (37c), two of the engaged members (41A - 41D) are arranged in a region defined between the third (37c) corner and the fourth corner (37d), and two of the second stopper portions (43A - 43D) are arranged in a region defined between the fourth corner (37d) and the first corner (37a).

[0009] Preferably, the engaging members (23A - 23D) are integrally coupled to the first cylindrical air-channel half-portion (21), and the engaged members (41A - 41D) are integrally coupled to the second cylindrical air-channel portion (39).

[0010] Preferably, when a first virtual diagonal line (D1) connecting two of the four corners (19a - 19d) opposed to each other in the radial direction of the rotary shafts (71, 171) and a second virtual diagonal line (D2) connecting remaining two of the four corners (19a - 19d) are assumed in the first flange portion (19), the engaging member (23A - 23D) and the first stopper portion (25A - 25D) corresponding to the engaging member (23A - 23D) are disposed so as to interpose the first or second virtual

diagonal line (D1, D2) therebetween;
 none of the engaging members (23A - 23D) and none of the first stopper portions (25A - 25D) are disposed at the four corners (19a - 19d) through which the first or second virtual diagonal line (D1, D2) passes;
 when a third virtual diagonal line (D3) connecting two of the four corners (37a - 37d) opposed to each other in the radial direction of the rotary shafts (71, 171) and a fourth virtual diagonal line (D4) connecting remaining two of the four corners (37a - 37d) are assumed in the second flange portion (37), the engaged member (41A - 41D) and the second stopper portion (43A - 43D) corresponding to the engaged member (41A - 41D) are disposed so as to interpose the third or fourth virtual diagonal line (D3, D4) therebetween; and
 none of the engaged members (41A - 41D) and none of the second stopper portions (43A - 43D) are disposed at the four corners (37a - 37d) through which the third or fourth virtual diagonal line (D3, D4) passes.

[0011] Preferably, one of the engaging member (23A - 23D) and the engaged member (41A - 41D) includes a claw portion (51b);

the other of the engaging member (23A - 23D) and the engaged member (41A - 41D) includes a hole portion (23g) to be engaged with the claw portion (51b);
 at least one of the engaging member (23A - 23D) and the engaged member (41A - 41D) is bent when engaging the engaging member (23A - 23D) with the engaged member (41A - 41D), and the claw portion (51b) and the hole portion (23g) get into engagement with each other once the engaging member (23A - 23D) is completely engaged with the engaged member (41A - 41D); and
 the hole portion (23g) is formed so as to allow for visual confirmation of the engagement of the claw portion (51b) engaged therewith.

[0012] Preferably, the engaging members (23A - 23D) and the first stopper portions (25A - 25D) are respectively shaped not to protrude outside the first flange portion (19) as the first flange portion (19) is seen from the first cylindrical air-channel half-portion (21); and
 the engaged members (41A - 41D) and the second stopper portions (43A - 43D) are respectively shaped not to protrude outside the second flange portion (37) as the second flange portion (37) is seen from the second cylindrical air-channel half-portion (39).

[0013] A counter-rotating axial-flow fan of the present invention comprises a housing, a first impeller, a first motor, a second impeller, and a second motor. The housing includes a housing body and a motor support frame. The housing body includes an air channel having a suction opening on one side in an axial line direction and a discharge opening on the other side in the axial line direction. The motor support frame is disposed in a central portion of the air channel. The first impeller is disposed in a first space that is defined between the motor support frame in the housing and the suction opening, and includes a plurality of blades. The first motor includes the first rotary shaft onto which the first impeller is fixed, and

rotates the first impeller in a first rotating direction within the first space. The second impeller is disposed in a second space that is defined between the motor support frame in the housing and the discharge opening, and includes a plurality of blades. The second motor includes the second rotary shaft onto which the second impeller is fixed, and rotates the second impeller in a second rotating direction opposite to the first rotating direction within the second space.

[0014] The motor support frame includes a support frame body disposed in the central portion of the air channel and a plurality of webs disposed between the frame body and the housing body at predetermined intervals in a circumferential direction of the rotary shafts. The webs connect the support frame body and the housing body.

[0015] The housing is constituted from first and second divided housing units that are coupled through a coupling structure. The first divided housing unit includes a first housing-body half-portion and a first support-frame half-portion. The first housing-body half-portion includes a first flange portion having the suction opening at one end thereof and a first cylindrical air-channel half-portion of which one end is integrally formed with the first flange portion and that contains therein a major part of the first space. The first support-frame half-portion is obtained by dividing the motor support frame into two along a virtual reference dividing plane extending in a radial direction of the rotary shafts orthogonal to the axial line direction. The second divided housing unit includes a second housing-body half-portion and a second support-frame half-portion. The second housing-body half-portion includes a second flange portion having the discharge opening at one end thereof and a second cylindrical air-channel half-portion of which one end is integrally formed with the second flange portion and that contains therein a major part of the second space. The second support-frame half-portion is obtained by dividing the motor support frame into two along the virtual reference dividing plane.

[0016] The coupling structure adopted in the present invention is constituted from a fitting portion formed at the other end of the first cylindrical air-channel half-portion, a fitted portion formed at the other end of the second cylindrical air-channel half-portion, a plurality of engaging members integrally formed with the first flange portion and arranged at intervals in the circumferential direction, and a plurality of engaged members integrally formed with the second flange portion and arranged at intervals in the circumferential direction. The fitting portion is fitted into the fitted portion. The engaging members extend along the first cylindrical air-channel half-portion. The engaged members extend along the second cylindrical air-channel half-portion. The engaging members are respectively engaged with the engaged members.

[0017] A plurality of first stopper portions are integrally formed with the first flange portion and arranged adjacent to the engaging members, and extend along the first cylindrical air-channel half-portion. A plurality of second stopper portions are integrally formed with the second

flange portion and arranged adjacent to the engaged members, and extend along the second cylindrical air-channel half-portion. Leading ends of the first stopper portions are respectively abutted onto leading ends of the second stopper portions when the plurality of engaging members are completely engaged with the engaged members.

[0018] In the present invention, the engaging members integrally formed with the first flange portion and the engaged members integrally formed with the second flange portion are employed for the coupling structure that couples the first and second divided housing units. According to the present invention, the coupling of the first and second divided housing units is attained not only by a fitting structure constituted from the fitting portion of the first cylindrical air-channel half-portion and the fitted portion of the second cylindrical air-channel half-portion, but also by engagement of the engaging members and the engaged members. As a result, no force concentration will occur at the fitting structure of the first cylindrical air-channel half-portion and the second cylindrical air-channel half-portion. Moreover, the first and second divided housing units will not readily be decoupled or disconnected. Further, in the present invention, the first stopper portions are arranged adjacent to the engaging members, and the second stopper portions are arranged adjacent to the engaged members. Thus, even if force is concentrated and applied to the engaging members and the engaged members from the first flange portion and the second flange portion when the first divided housing unit and the second divided housing unit are coupled, the leading ends of the first stopper portions adjacent to the engaging members are respectively abutted onto the leading ends of the second stopper portions adjacent to the engaged members. As a result, even if the engaging members are strongly pressed against the engaged members, an engagement portion of the engaged member engaged with the engaging member, or the engaging member itself may be prevented from being broken.

[0019] Preferably, when the first and second flange portions respectively have a contour shape including four corners, first to fourth corners, arranged in the circumferential direction, four of the engaging members and four of the first stopper portions are respectively arranged in the vicinity of the four corners of the first flange portion, and four of the engaged members and four of the second stopper portions are respectively arranged in the vicinity of the four corners of the second flange portion. Then, in the first flange portion, two of the engaging members are arranged in a region defined between the first corner and the second corner, two of the first stopper portions are arranged in a region defined between the second corner and the third corner, two of the engaging members are arranged in a region defined between the third corner and the fourth corner, and two of the first stopper portions are arranged in a region defined between the fourth corner and the first corner. Further, in the second flange portion, two of the engaged members are arranged in a region

defined between the first corner and the second corner, two of the second stopper portions are arranged in a region defined between the second corner and the third corner, two of the engaged members are arranged in a region defined between the third corner and the fourth corner, and two of the second stopper portions are arranged in a region defined between the fourth corner and the first corner. With this arrangement, it is easy to secure a space for each corner of the first and second flange portions. Accordingly, the four engaging members, four engaged members, four first stopper portions, and four second stopper portions may be arranged in the circumferential direction. The first and second stopper portions in particular are arranged outside the engaging members and the engaged members. Even when excessive forces are applied to the four corners of the first and second flange portions, the first and second stopper portions located outside the engaging and engaged members absorb external forces. The excessive force may be prevented from being applied to the engaging and engaged members.

[0020] Preferably, the engaging members are integrally coupled to the first cylindrical air-channel half-portion, and the engaged members are integrally coupled to the second cylindrical air-channel portion. With this arrangement, the engaging and engaged members may be improved in mechanical strength. Further, after the engaging members have been engaged with the engaged members, the engaging and engaged members serve to reinforce the first and second cylindrical air-channel half-portions.

[0021] The engaging members, engaged members, and first and second stopper portions may be arranged in the following manner. When a first virtual diagonal line connecting two of the four corners opposed to each other in the radial direction of the rotary shafts and a second virtual diagonal line connecting remaining two of the four corners are assumed in the first flange portion, the engaging member and the first stopper portion corresponding to the engaging member are disposed so as to interpose the first or second virtual diagonal line therebetween. Further, none of the engaging members and none of the first stopper portions are disposed at the four corners through which the first or second virtual diagonal line passes. When a third virtual diagonal line connecting two of the four corners opposed to each other in the radial direction of the rotary shafts and a fourth virtual diagonal line connecting remaining two of the four corners are assumed in the second flange portion, the engaged member and the second stopper portion corresponding to the engaged member are disposed so as to interpose the third or fourth virtual diagonal line therebetween. Further, none of the engaged members and none of the second stopper portions are disposed at the four corners through which the third or fourth virtual diagonal line passes. With this arrangement, when forces are applied to the four corners of the first flange portion and the four corners of the second flange portion to couple the first and second divided housing units, the forces are applied to the en-

gaging and engaged members and the first and second stopper portions in good balance. The engaging members may be thereby engaged with the engaged members securely, and functions of the first and second stopper portions may positively be exhibited.

[0022] The engaging and engaged members of various types may be used. When one of the engaging member and the engaged member includes a claw portion, for example, the other of them may include a hole portion to be fitted with the claw portion. In this arrangement, at least one of the engaging member and the engaged member is bent when engaging the engaging member with the engaged member, and the claw portion and the hole portion get into engagement with each other once the engaging member is completely engaged with the engaged member. Then, the hole portion may be formed so as to allow for visual confirmation of the engagement of the claw portion engaged therewith. With this arrangement, the engaging member may readily be engaged with the engaged member just by elastically inserting the claw portion into the hole portion. Further, since the hole portion is formed to allow for visual confirmation of the engagement of the claw portion engaged with the hole portion, the engagement may visually be confirmed. Accordingly, the engagement between the engaging and engaged members may readily be confirmed.

[0023] Preferably, the engaging members and the first stopper portions are shaped not to protrude outside the first flange portion as the first flange portion is seen from the first cylindrical air-channel half-portion. Further, the engaged members and the second stopper portions are shaped not to protrude outside the second flange portion as the second flange portion is seen from the second cylindrical air-channel half-portion. In this arrangement, even when the engaging members, engaged members, and first and second stopper portions are provided, an increase in the contour size of the counter-rotating axial-flow fan may be suppressed.

[0024] In the present invention, the engaging member integrally formed with the first flange portion and the engaged member integrally formed with the second flange portion are employed for the coupling structure that couples the first divided housing unit and the second divided housing unit. The coupling of the first divided housing unit and the second divided housing unit are attained not only by a fitting structure constituted from the fitting portion of the first cylindrical air-channel half-portion and the engaged portion of the second cylindrical air-channel half-portion, but also by an engagement structure constituted from the engaging member and the engaged member. As a result, no force concentration will occur at the fitting structure of the first cylindrical air-channel half-portion and the second cylindrical air-channel half-portion. Moreover, the first and second divided housing units will not be readily decoupled or disconnected. In addition, in the present invention, the first stopper portions are provided adjacent to the engaging members, and the second stopper portions are provided adjacent to the en-

gaged members. Thus, even if force is concentrated and applied from the first flange portion and the second flange portion to the engaging members and the engaged members when the first divided housing unit and the second divided housing unit are coupled, the leading ends of the first stopper portions adjacent to the engaging members are respectively abutted onto the leading ends of the second stopper portions adjacent to the engaged members. As a result, even if the engaging members are strongly pressed against the engaged members, breakage of an engagement portion between the engaging member and the engaged member may be prevented.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] These and other objects and many of the attendant advantages of the present invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings.

Fig. 1 is a cross-sectional view showing a half portion of a counter-rotating axial-flow fan in an embodiment of the present invention.

Fig. 2 is a perspective view of a housing of the counter-rotating axial-flow fan shown in Fig. 1.

Fig. 3 is a plan view of the counter-rotating axial-flow fan shown in Fig. 1.

Fig. 4 is a left side view of the counter-rotating axial-flow fan shown in Fig. 1.

Fig. 5 is a partial cross-sectional view as taken along line V - V in Fig. 3.

Fig. 6 is a cross-sectional view as taken along line VI - VI in Fig. 4.

Fig. 7 is a perspective view of a first divided housing unit of the counter-rotating axial-flow fan shown in Fig. 1.

Fig. 8 is a diagram for explaining how a lead-wire guide web of the counter-rotating axial-flow fan shown in Fig. 1 is arranged.

Fig. 9 is a perspective view of a second divided housing unit of the counter-rotating axial-flow fan shown in Fig. 1.

Fig. 10 is a perspective view of a first impeller of the counter-rotating axial-flow fan shown in Fig. 1.

Fig. 11 is a perspective view of a second impeller of the counter-rotating axial-flow fan shown in Fig. 1.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

[0026] Now, an embodiment of the present invention will be described in detail with reference to the accompanying drawings. Fig. 1 is a cross-sectional view showing a half portion of a counter-rotating axial-flow fan in the embodiment of the present invention. As shown in Fig. 1, the counter-rotating axial-flow fan in this embod-

iment includes a housing 1, a first motor 3, a first impeller 5, a second motor 7, and a second impeller 9. The housing 1 comprises a housing body 61 including an air channel 2, a motor support frame 6 disposed in a central portion of the air channel 2. Further, as shown in Figs. 2 to 6, the housing 1 is constituted from a first divided housing unit 11 and a second divided housing unit 13 that are coupled through a coupling structure. Figs. 2 to 4 are a perspective view of the housing 1, a plan view of the housing 1, and a left side view of the housing 1, respectively. Fig. 5 is a partial cross-sectional view as taken along line V - V in Fig. 3. Fig. 6 is a cross-sectional view as taken along line VI - VI in Fig. 4.

[0027] The first divided housing unit 11 is made of a synthetic resin or aluminum. As shown in Fig. 7, the first divided housing unit 11 integrally includes a first housing-body half-portion 15 and a first support-frame half-portion 17. The first housing-body half-portion 15 includes a first flange portion 19, a first cylindrical air-channel half-portion 21, four engaging members 23A to 23D, and four first stopper portions 25A to 25D. The first flange portion 19 has a contour of substantially a quadrilateral having four corners. The four corners, a first corner 19a, a second corner 19b, a third corner 19c, and a fourth corner 19d are disposed in a circumferential direction of a rotary shaft 71 of the first motor 3 and a rotary shaft 171 of the second motor 7 that are arranged on the same axis line A. This direction will be hereinafter simply referred to as the circumferential direction. The first divided housing unit 11 has a suction opening 11a at one end of the housing 1 in an axial line direction, which will be described later. A first space S1 is defined between the motor support frame 6 in the housing 1 and the suction opening 11a. The four corners of the first flange portion 19 are rounded. Then, a through-hole 19e, into which a fixture for mounting the counter-rotating axial-flow fan to an electric appliance is inserted, is formed in each of the four corners. One end of the first cylindrical air-channel half-portion 21 is integrally formed with the first flange portion 19. The first cylindrical air-channel half-portion 21 contains therein a major part of the first space S1. This first cylindrical air-channel half-portion 21 extends in the axial line direction of the rotary shafts 71 and 171 (which will be hereinafter simply referred to as the axial line direction). At four locations of an outer peripheral portion of the other end 21a of the first cylindrical air-channel half-portion 21, wall portions 21b that project outward in a radial direction of the rotary shafts 71 and 171 (which will be hereinafter simply referred to as the radial direction) are formed at equidistant intervals in the circumferential direction, respectively. At locations of an inner peripheral portion of the other end 21a of the first cylindrical air-channel half-portion 21, corresponding to the wall portions 21b, flat surface portions 21c, linearly extending, are respectively formed. In this embodiment, the inner peripheral portion of the other end 21a including the flat surface portions 21c constitutes a fitting portion.

[0028] As shown in Figs. 3, 4, and 7, the four engaging

members 23A to 23D are integrally formed with the first flange portion 19 and the first cylindrical air-channel half-portion 21, and are arranged at intervals in the circumferential direction. The four engaging members 23A to 23D are respectively engaged with four engaged members 41A to 41D of the second divided housing unit 13, which will be described later. The four engaging members 23A to 23D are respectively arranged in the vicinity of the four corners 19a to 19d, being integrally coupled to the first cylindrical air-channel half-portion 21. These four engaging members 23A to 23D extend in the axial line direction along the first cylindrical air-channel half-portion 21 so that the four engaging members 23A to 23D do not protrude outside from the contour of the first flange portion 19 as the flange portion is seen from the first cylindrical air-channel half-portion 21. By using the engaging member 23B shown in Figs. 5 and 7 as a typical example and by assigning reference numerals to respective portions of the engaging member 23B, the structure of an engaging member will be described. Each of the engaging members 23A to 23D includes two plate portions 23a and 23b and three connecting portions 23c to 23e that are connected to the plate portions 23a, 23b. The plate portions 23a and 23b are opposed to each other in a direction orthogonal to the axial line direction and a vertical direction in the pages of Figs. 5 and 7. The three connecting portions 23c to 23e are arranged at predetermined intervals in the axial line direction. The two connecting portions 23c and 23d completely extend in the vertical direction between the two plate portions 23a and 23b and partition a space defined between the two plate portions 23a and 23b. The connecting portion 23e connects only upper edge portions of the two plate portions 23a and 23b, slightly extending downward from between the two plate portions 23a and 23b. Thus, an opening portion 23f is formed among the two plate portions 23a and 23b, the connecting portion 23e, and the first cylindrical air-channel half-portion 21. A hole portion 23g that faces upward is formed between the connecting portions 23d and 23e.

[0029] The four first stopper portions 25A to 25D respectively have a shape of substantially a rectangular flat plate, being integrally formed with the first flange portion 19. Base portions of the first stopper portions are integrally coupled to the first cylindrical air-channel half-portion 21. The four stopper portions 25A to 25D extend in the axial line direction along the first cylindrical air-channel half-portion 21 so that the four stopper portions 25A to 25D do not protrude outside from the contour of the first flange portion 19 as the first flange portion is seen from the first cylindrical air-channel half-portion 21. How the four first stopper portions 25A to 25B are disposed will be described later.

[0030] As shown in Fig. 7, the first support-frame half-portion 17 includes a first support-frame-body half-portion 27 and five first web half-portions 28A to 28E. The first support-frame-body half-portion 27 includes a circular plate portion 27b having an opening portion 27a in

the center thereof and a peripheral wall portion 27c that extends in the axial line direction from an outer peripheral portion of the circular plate portion 27b. A first metal bearing holder 77 made of brass is fixedly fitted into the opening portion 27a, as shown in Fig. 1. A stator board 85 of the first motor 3 is disposed within a space defined, being bordered by the circular plate portion 27b and the peripheral wall portion 27c, as shown in Fig. 1. In the first support-frame-body half-portion 27, four first through-hole half-portions 29A to 29D that pass through the first support-frame-body half-portion 27 in the axial line direction of the rotary shaft 71 of the first motor 3 are formed. The four first through-hole half-portions 29A to 29D are formed at equidistant intervals in the circumferential direction. One through-hole half-portion 29A of the four first through-hole half-portions 29A to 29D communicates with an internal space of a first lead-wire guide-path half-portion 31 of the first web half-portion 28A, which will be described later.

[0031] Five first web half-portions 28A to 28E are disposed at predetermined intervals in the circumferential direction between the peripheral wall portion 27c of the first support-frame-body half-portion 27 and an inner peripheral surface of the first housing body half-portion 15, thereby coupling the first support-frame-body half-portion 27 and the first housing body half-portion 15. The first web half-portion 28A of the five first web half-portions 28A to 28E constitutes a web half-portion that includes therein the first lead-wire guide-path half-portion 31. This first web half-portion 28A will be hereinafter simply referred to as the first lead-wire guide web half-portion 28A. As shown in Figs. 7 and 8, the first lead-wire guide web half-portion 28A includes a bottom wall 28a and a pair of side wall portions 28b that respectively rise up from the bottom wall 28a toward the second motor 7. The first lead-wire guide-path half-portion 31, as shown in Fig. 7, is formed by a region bordered by the bottom wall 28a and the pair of side wall portions 28b. As shown in Fig. 8, one raised or convex portion 28d, protruding toward a second lead-wire guide web half-portion 55A that will be described later, is formed on the side wall portions 28b in the pair. Then, one recessed or concave portion 28e, which is recessed toward the bottom wall 28a, is formed also in the side wall portions 28b in the pair. In this embodiment, the raised portion 28d and the recessed portion 28e provided at one of the side wall portions 28b in the pair are respectively opposed, in the circumferential direction, to the raised portion 28d and the recessed portion 28e provided at the other side wall portion 28b in the pair. The contour shapes of the raised portion 28d and the recessed portion 28e are respectively an isosceles trapezoid having two non-parallel opposite sides of equal length. The raised portion 28d and the recessed portion 28e respectively have two inclined surfaces which correspond to the trapezoid's pair of non-parallel opposite sides of equal length, and one of the two inclined surfaces 28d1 of the raised portion 28d is continuous with one of the two inclined surfaces 28e1 of the recessed portion

28e adjacent to the raised portion 28d. The raised portion 28d protrudes toward the second lead-wire guide web half-portion 55A beyond a virtual reference dividing plane F. The virtual reference dividing plane F is the dividing plane along which a motor support frame is divided into two, the first support-frame half-portion 17 and the second support-frame half-portion 35 that will be described later. Then, an end surface 28f of each side wall portion 28b in the pair, except portions where the raised portion 28d and the recessed portion 28e are formed, lies or is in the virtual reference dividing plane F. Further, as shown in Fig. 4, an opening portion 21d, which opens toward an inside of the first lead-wire guide web half-portion 28A, is formed in the first cylindrical air-channel half-portion 21 in the vicinity of a location to which the first lead-wire guide web half-portion 28A is joined. Lead wires L are led out through the opening portion 21d.

[0032] The second divided housing unit 13 is also made of a synthetic resin or aluminum. As shown in Fig. 9, the second divided housing unit 13 integrally includes a second housing-body half-portion 33 and a second support-frame half-portion 35. The second housing-body half-portion 33 includes a second flange portion 37, a second cylindrical air-channel half-portion 39, four engaged members 41A to 41D, and four second stopper portions 43A to 43D. The second flange portion 37 has a contour of substantially a quadrilateral having four corners. The four corners, a first corner 37a, a second corner 37b, a third corner 37c, and a fourth corner 37d are disposed in the circumferential direction. The second flange portion 37 has a discharge opening 13a at the other end of the housing 1 in the axial line direction. A second space S2 is defined between the motor support frame 6 in the housing 1 and the discharge opening 13a. The four corners 37a to 37d of the second flange portion 37 are rounded, and a through-hole 37e, into which the fixture for mounting the counter-rotating axial-flow fan to the electric appliance is inserted, is formed in each of the four corners. One end of the second cylindrical air-channel half-portion 39 is integrally formed with the second flange portion 37. The second cylindrical air-channel half-portion 39 contains therein a major part of the second space S2.

[0033] Four flat surface portions 45 are formed at equal angle intervals in the circumferential direction on an outer peripheral portion (a fitted portion) of the other end 39a of the second cylindrical air-channel portion 39. The four flat surface portions 45 come into contact with the flat surface portions 21c of the other end 21a of the first cylindrical air-channel half-portion 21 when the first divided housing unit 11 and the second divided housing unit 13 are coupled. Positioning of the first divided housing unit 11 and the second divided housing unit 13 in the circumferential direction is determined by aligning the flat surface portions 21c and the flat surface portions 45.

[0034] The four engaged members 41A to 41D are integrally formed with the second flange portion 37 and arranged at intervals in the circumferential direction. The

four engaged members 41A to 41D are respectively disposed in the vicinity of the four corners 37a to 37d of the second flange portion 37 with the four engaged members 41A to 41D being integrally coupled to the second cylindrical air-channel half-portion 39. The four engaged members 41A to 41D extend along the second cylindrical air-channel half-portion 39 in the axial line direction so that the four engaged members 41A to 41D do not protrude outside from the contour of the second flange portion 37 as the second flange portion is seen from the second cylindrical air-channel half-portion 39. By using the engaged member 41B shown in Figs. 5 and 9 as a typical example and by assigning reference numerals to respective portions of the engaging member 41B, the structure of an engaged member 41B will be described. The engaged members 41A to 41D each include a support portion 47 integrally provided at the second flange portion 27, a rib 49 coupled to the support portion 47 and the second cylindrical air-channel half-portion 39, and a claw-forming member 51 with one end thereof supported by the support portion 47. The claw-forming member 51 includes a plate-like portion 51a, a claw portion 51b integrally formed with the plate-like portion 51a, and a projecting portion 51c. The plate-like portion 51a is connected to the support portion 47, being spaced from the rib 49. The plate-like portion 51a extends from the support portion 47 toward the first divided housing unit 11. The claw portion 51b projects from a leading end of the plate-like portion 51a in a direction orthogonal to the surface of the plate-like portion 51a, or in the upward direction in the page of Fig. 5. The upper side of the claw portion 51b has an inclined surface 51d so that the thickness of the claw portion 51b increases more toward the support portion 47. Specifically, the respective claw portions 51b of the engaged members 41A and 41B project in the upward direction in the page of Fig. 9, while the respective claw portions 51b of the engaged members 41C and 41D project in the downward direction in the page of Fig. 9. The projecting portion 51c is spaced from the claw portion 51b in the axial line direction. The projecting portion 51c projects from the plate-like portion 51a in the same direction as the one where the claw portion 51b projects. A cross-sectional surface of the projecting portion 51c is substantially a rectangle in shape. It will be described later in detail how the four engaged members 41A to 41D are respectively engaged with the four engaging members 23A to 23D of the first divided housing unit 11.

[0035] The four second stopper portions 43A to 43D have the shape of a rectangular flat plate integrally formed with the second flange portion 37, and are arranged adjacent to the four engaged members 41A to 41D, respectively. The four second stopper portions 43A to 43D are integrally coupled to the second cylindrical air-channel half-portion 39. The four second stopper portions 43A to 43D extend along the second cylindrical air-channel half-portion 39 in the axial line direction so that the four second stopper portions 43A to 43D do not protrude outside from the contour of the second flange por-

tion 37 as the second flange portion is seen from the second cylindrical air-channel half-portion 39. The first corner 37a and the third corner 37c are opposed to each other in the radial direction with respect to the axis line A. The engaged members 41A and 41C are also opposed to each other in the radial direction. The second stopper portions 43A and 43C are provided for the engaged members 41A and 41C, respectively. Specifically, when a virtual diagonal line D3 that connects the first corner 37a and the third corner 37c of the second flange portion 37 is assumed as shown in Figs. 6 and 9, the engaged member 41A and the second stopper portion 43A are arranged so as to interpose the virtual diagonal line D3 therebetween, and the engaged member 41C and the second stopper portion 43C are arranged so as to interpose the virtual diagonal line D3 therebetween. Likewise, the second corner 37b and the fourth corner 37d are opposed to each other in the radial direction with respect to the axis line A. The engaged members 41B and 41D are also opposed to each other in the radial direction. The second stopper portions 43B and 43D are provided for the engaged members 41B and 41D, respectively. When a virtual diagonal line D4 that connects the second corner 37b and the fourth corner 37d, which are the remaining two corners of the second flange portion 37, is assumed, the engaged member 41B and the second stopper portion 43B are arranged so as to interpose the virtual diagonal line D4 therebetween, and the engaged member 41D and the second stopper portion 43D are arranged so as to interpose the virtual diagonal line D4 therebetween. Then, at the four corners 37a to 37d through which the virtual diagonal lines D3 and D4 (the third and fourth virtual diagonal lines) pass, none of the engaged members 41A to 41D and none of the second stopper portions 43A to 43D are arranged. In other words, in a region defined between the first corner 37a and the second corner 37b of the second flange portion 37, the engaged members 41A and 41B are arranged, and in a region defined between the second corner 37b and the third corner 37c, the second stopper portions 43B and 43C are arranged. Then, in a region defined between the third corner 37c and the fourth corner 37d, the engaged members 41C and 41D are arranged, and in a region defined between the fourth corner 37d and the first corner 37a, the second stopper portions 43D and 43A are arranged.

[0036] The four first stopper portions 25A to 25D shown in Figs. 4 and 7 are also arranged adjacent to the four engaging members 23A to 23D, respectively. A positional relationship among the four first stoppers 25A to 25D and the four engaging members 23A to 23D is the same as the positional relationship among the four second stopper portions 43A to 43D and the four engaged members 41A to 41D, shown in Fig. 6. As shown in Fig. 7, the first corner 19a and the third corner 19c are opposed to each other in the radial direction with respect to the axis line A. The engaging members 23A and 23C are opposed to each other in the radial direction. The first stopper portions 25A and 25C are provided for the en-

gaging members 23A and 23C, respectively. Specifically, when a virtual diagonal line D1 that connects the first corner 19a and the third corner 19c of the first flange portion 19 is assumed as shown in Fig. 7, the engaging member 23A and the first stopper portion 25A are arranged so as to interpose the virtual diagonal line D1 therebetween, and the engaging member 23C and the first stopper portion 25C are arranged so as to interpose the virtual diagonal line D1 therebetween. The second corner 19b and the fourth corner 19d are opposed to each other in the radial direction with respect to the axis line A. The engaging members 23B and 23D are opposed to each other in the radial direction. The first stopper portions 25B and 25D are provided for the engaging members 23B and 23D, respectively. When a virtual diagonal line D2 that connects the second corner 19b and the fourth corner 19d, which are the remaining two corners of the first flange portion 19, is assumed, the engaging member 23B and the first stopper portion 25B are arranged so as to interpose the virtual diagonal line D2 therebetween, and the engaging member 23D and the first stopper portion 25D are arranged so as to interpose the virtual diagonal line D2 therebetween. Then, at the four corners 19a to 19d through which the virtual diagonal lines D1 and D2 (the first and second virtual diagonal lines) pass, none of the engaging members 23A to 23D and none of the first stopper portions 25A to 25D are arranged. In other words, in a region defined between the first corner 19a and the second corner 19b of the first flange portion 19, the engaging members 23A and 23B are arranged, and in a region defined between the second corner 19b and the third corner 19c, the first stopper portions 25B and 25C are arranged. Then, in a region defined between the third corner 19c and the fourth corner 19d, the engaging members 23C and 23D are arranged, and in a region defined between the fourth corner 19d and the first corner 19a, the first stopper portions 25D and 25A are arranged. The four first stopper portions 25A to 25D and the four second stopper portions 43A to 43D are shaped and sized so that leading ends of the four first stopper portions 25A to 25D are respectively abutted onto leading ends of the four second stopper portions 43A to 43D, when the claw portions 51b are completely engaged with the hole portions 23g of the engaging members 23A to 23D, respectively.

[0037] As shown in Fig. 9, the second support frame half-portion 35 includes a second support-frame-body half-portion 53 and five second web half-portions 55A to 55E. The second support-frame-body half-portion 53 includes a circular plate portion 53b having an opening portion 53a in the center thereof and a peripheral wall portion 53c that extends in the axial line direction from an outer peripheral portion of the circular plate portion 53b. A second metal bearing holder 177 made of brass is fixedly fitted into the opening portion 53a, as shown in Fig. 1. Within a space bordered by the circular plate portion 53b and the peripheral wall portion 53c, a stator board 185 of the second motor 7 is arranged, as shown

in Fig. 1. Four second through-hole half-portions 57A to 57D that pass through the second support-frame-body half-portion 53 in the axial line direction of the rotary shaft 171 of the second motor 7, which will be described later, are formed in the second support-frame-body half-portion 53. The four second through-hole half-portions 57A to 57D are formed at equidistant intervals in the circumferential direction of the rotary shaft 171 (shown in Fig. 1). One through-hole half-portion 57A of the four second through-hole half-portions 57A to 57D communicates with an internal space of a second lead-wire guide-path half-portion 59 of the second web half-portion 55A, which will be described later. The four second through-hole half-portions 57A to 57D are formed to have the same shape as the four first through-hole half-portions 29A to 29D of the first support-frame-body half-portion 27, respectively. The five second web half-portions 55A to 55E are arranged at predetermined intervals in the circumferential direction between the peripheral wall portion 53c of the second support-frame-body half-portion 53 and an inner peripheral surface of the second housing-body half-portion 33, thereby connecting the second support-frame-body half-portion 53 and the second housing-body half-portion 33. The second web half-portion 55A of the five second web half-portions 55A to 55E constitutes the web half-portion that includes a second lead-wire guide-path half-portion 59 therein. Thus, the second web half-portion 55A will be hereinafter simply referred to as the second lead-wire guide web half-portion 55A. The second lead-wire guide web half-portion 55A includes a bottom wall 55a and a pair of side wall portions 55b that respectively rise up from the bottom wall 55a. The second lead-wire guide-path half-portion 59 is formed by a region bordered by the bottom wall 55a and the pair of side wall portions 55b. One raised or convex portion 55d, protruding toward the first lead-wire guide web half-portion 28A, is formed on the side wall portions 55b in the pair. Then, one recessed or concave portion 55e, which is recessed toward the bottom wall 55a, is formed also in the side wall portions 55b in the pair. In this embodiment, the raised portion 55d and the recessed portion 55e provided at one of the side wall portions 55b in the pair are respectively opposed, in the circumferential direction, to the raised portion 55d and the recessed portion 55e provided at the other side wall portion 55b in the pair. As shown in Fig. 8, the raised portion 55d protrudes toward the first lead-wire guide web half-portion 28A beyond the virtual reference dividing plane F, which is the dividing plane along which the motor support frame is divided into the first support-frame half-portion 17 and the second support-frame half-portion 35. As shown in Figs. 4 and 9, an opening portion 39d that opens toward an inside of the second lead-wire guide web half-portion 55A is formed in the second cylindrical air-channel half-portion 39 in the vicinity of a location to which the second lead-wire guide web half-portion 55A is joined. It will be described in detail how the first lead-wire guide web half-portion 28A and the second lead-wire guide half-portion 55A are coupled.

[0038] In the counter-rotating axial-flow fan in this embodiment, the first divided housing unit 11 and the second divided housing unit 13 are coupled in the following manner. Actually, the first motor 3 (shown in Fig. 1) and the first impeller 5 are arranged within the first divided housing unit 11, and lead wires are arranged within the first lead-wire guide web half-portion 28A. A first axial-flow fan unit is thus assembled. Then, the second motor 7 (shown in Fig. 1) and the second impeller 9 are arranged within the second divided housing unit 13, and the lead wires are arranged within the second lead-wire guide web half-portion 55A. A second axial-flow fan unit is thus assembled. Then, by coupling the first axial-flow fan unit and the second axial-flow fan unit, the first divided housing unit 11 and the second divided housing unit 13 are coupled. First, the first divided housing unit 11 and the second divided housing unit 13 are brought close to each other, and then leading ends of the claw portions 51b of the four engaged members 41A to 41D of the second divided housing unit 13 are inserted into the opening portions 23f of the four engaging members 23A to 23D of the first divided housing unit 11, respectively. Referring to Fig. 5, when the engaged member 41B and the engaging member 23B are brought close to each other after the insertion, the inclined surface 51d of the claw portion 51b comes into contact with a lower edge of the connecting portion 23e. By the contact between the inclined surface 51d and the connecting portion 23e, the plate-like portion 51a bends so as to be closer to the rib 49. When the engaged member 41B and the engaging member 23B are further brought close to each other, and then the contact between the inclined surface 51d and the connecting portion 23e is released, the connecting portion 23e is fitted into a recessed or concave portion that is defined between the claw portion 51b and the raised portion 51c of the engaged member 41B. The claw portion 51b is thereby engaged with the hole portion 23g. This completes engagement between the engaging member 23B and the engaged member 41B. In this structure, the rib 49 functions as a stopper that prevents the claw-forming member 51 from bending more than necessary. The projecting portion 51c serves as a stopper that prevents the claw portion 51b from moving toward the first cylindrical air-channel half-portion 21. In this embodiment, the claw portion 51b and the hole portion 23g are formed so as to allow for visual confirmation of the engagement when the claw portion 51b is engaged with the hole portion 23g.

[0039] In order to attain the engagement as described above, the fitting portion formed by the inner peripheral surface portion of the other end 21a of the first cylindrical air-channel half-portion 21 is fitted into the fitted portion formed by the outer peripheral surface portion of the other end 39a of the second cylindrical air-channel half-portion 39, thereby forming a fitting structure. The first divided housing unit 11 is coupled to the second divided housing unit 13 not only by the fitting structure mentioned above but also by the engagement of the claw portions 51b men-

tioned above and the hole portions 23g of the engaging members 23A to 23D. Then, with the first divided housing unit 11 coupled to the second divided housing unit 13 as described above, leading ends of the first stopper portions 25A to 25D are respectively abutted onto leading ends of the four second stopper portions 43A to 43D.

[0040] A housing body 61 is constituted from the first housing-body half-portion 15 included in the first divided housing unit 11 and the second housing-body half-portion 33 included in the second divided housing unit 13 that are coupled as mentioned above and as shown in Fig. 2. Further, a motor support frame 63 is constituted from the first support-frame half-portion 17 included in the first divided housing unit 11 and the second support-frame half-portion 35 included in the second divided housing unit 13. In other words, as shown in Fig. 8, the first support-frame half-portion 17 and the second support-frame half-portion 35 are obtained by dividing the motor support frame 63 into two along the virtual reference dividing plane F that extends in the radial direction. Further, a support frame-body 65 is constituted from the first support-frame body half-portion 27 included in the first support-frame half-portion 17 and the second support-frame-body half-portion 53 included in the second support-frame half-portion 35. With this arrangement, the first through-hole half-portions 29A to 29D of the first divided housing unit 11 are respectively combined with the second through-hole half-portions 57A to 57D of the second divided housing unit 13, thereby forming four through-holes 67A to 67D. The four through-holes 67A to 67D partially define an internal space IS of the support frame body 65. Further, the five first web half-portions 28A to 28E included in the first support-frame half-portion 17 are respectively combined with the five second web half-portions 55A to 55E included in the second support-frame half-portion 35, thereby forming five webs 69A to 69E. The five webs 69A to 69E constitute stationary blades. Then, the web 69A of the five webs 69A to 69E constitutes the lead-wire guide web 69A. This lead-wire guide web 69A is constituted by combining the first lead-wire guide web half-portion 28A with the second lead-wire guide web half-portion 55A. In this lead-wire guide web 69A, as shown in Fig. 8, the raised portion 28d of the first lead-wire guide web half-portion 28A is fitted into the recessed portion 55e of the second lead-wire guide web half-portion 55A, and the recessed or concave portion 28e of the first lead wire guide web half-portion 28A is fitted with the raised or convex portion 55d of the second lead wire guide web half-portion 55A. Then, a lead-wire guide path GP (as shown in Fig. 2) is formed within the lead-wire guide web 69A. The lead-wire guide path GP guides a plurality of lead wires and a plurality of signal lines for supplying power to the first motor 3 and the second motor 7. Then, as shown in Fig. 4, a plurality of the lead wires L shown by dotted lines are led out from the lead wire guide path of the lead-wire guide web 69A through the opening portions 21d and 39d. The remaining four webs 69B to 69E of the five webs 69A to 69E are

respectively divided into the first web half-portion 28B and the second web half-portion 55B, the first web half-portion 28C and the second web half-portion 55C, the first web half-portion 28D and the second web half-portion 55D, and the first web half-portion 28E and the second web half-portion 55E, along the virtual reference dividing plane F.

[0041] Referring again to Fig. 1, the first motor 3 includes the rotary shaft 71, a stator 73, and a rotor 75. The rotary shaft 71 is rotatably supported onto the first bearing holder 77 by two bearings 79 fitted into the first bearing holder 77.

[0042] The stator 73 includes a stator core 81, exciting windings 83, and a circuit board 85. The stator core 81 is formed by lamination of a plurality of steel plates and is fixed to the first bearing holder 77. The stator core 81 includes a plurality of projecting pole portions 81a arranged in the circumferential direction of the rotary shaft 71. The exciting windings 83 are respectively attached to the projecting pole portions 81a through insulators 84. The circuit board 85 is arranged along the first support-frame-body half-portion 27, being disposed apart from the first support-frame-body half-portion 27 by predetermined spacing. An exciting current supply circuit for flowing exciting current to the exciting windings 83 is mounted on the circuit board 85. In this embodiment, the exciting current supply circuit on the circuit board 85 and the exciting windings 83 are electrically connected by winding lead wires of the exciting windings 83 around a terminal pin 87 that passes through a through-hole of the circuit board 85 and is soldered to an electrode on the circuit board 85. In the circuit board 85, a plurality of board through-holes 85a are formed. The board through holes 85a are formed in the circumferential direction of the rotary shaft 71 at equidistant intervals. Air that has flown from around the stator 73 toward the four first through-hole half-portions 29A to 29D of the first support-frame-body half-portion 27 passes through the board through-holes 85a.

[0043] The rotor 75 includes an annular member 89 and a plurality of permanent magnets 91 fixed onto an inner peripheral surface of the annular member 89. The annular member 89 is fixed inside a peripheral wall portion 93a of a cup-like member 93 of the first impeller 5, which will be described later.

[0044] As shown in Fig. 10, the first impeller 5 includes the cup-like member 93 and nine blades 95. The cup-like member 93 includes the peripheral wall portion 93a onto which the nine blades 95 are fixed and a bottom wall portion 93b integrally formed with one end of the peripheral wall portion 93a. One end of the rotary shaft 71 of the first motor 3 is connected to the bottom wall portion 93b. A plurality of ventilation slots 93c are formed in the bottom wall portion 93b and are disposed in the circumferential direction of the rotary shaft 71 at equidistant intervals. Each ventilation slot 93c has an elongated shape that extends in the radial direction of the rotary shaft 71 of the first motor 3. The ventilation slots 93c serve to

introduce air sucked through the suction opening 11a into an internal space of the first motor 3.

[0045] As described above, the annular member 89 of the rotor 75 is fixed inside the peripheral wall portion 93a of the cup-like member 93 of the first impeller 5. Thus, the first impeller 5 is rotated by the first motor 3 in a first rotating direction R1, which is a counterclockwise direction in the page of Fig. 10, within the first space S1.

[0046] As shown in Fig. 1, the second motor includes the rotary shaft 171, a stator 173, and a rotor 175. The rotary shaft 171 is rotatably supported onto the second bearing holder 177 by two bearings 179 fitted into the second bearing holder 177. The rotary shaft 171 rotates in a direction opposite to the rotating direction of the rotary shaft 71 of the first motor 3. Structures of the rotary shaft 171, stator 173, and rotor 175 are the same as those of the rotary shaft 71, stator 73, and rotor 75 of the first motor 3, respectively. Thus, 100 is added to reference numerals assigned to the rotary shaft, stator, and rotor of the first motor 3, and descriptions of the rotary shaft, stator, and rotor of the second motor 7 will be omitted.

[0047] As shown in Fig. 11, the second impeller 9 includes a cup-like member 193 and seven blades 195. The cup-like member 193 includes a peripheral wall portion 193a onto which the seven blades 195 are fixed and a bottom wall portion 193b integrally formed with one end of the peripheral wall portion 193a. One end of the rotary shaft 171 of the second motor 7 is fixed onto the bottom wall portion 193b. A plurality of ventilation slots 193c are formed in the bottom wall portion 193b and are disposed at equidistant intervals in the circumferential direction of the rotary shaft 171, being disposed apart from the rotary shaft 171. Each ventilation slot 193c has an elongated arc shape and extends in the circumferential direction of the rotary shaft 171 of the second motor 7. The ventilation slots 193c serve to discharge air introduced into the internal space of the second motor 7 to the outside. As shown in Fig. 1, an annular member 189 of the rotor 175 of the second motor 7 is fixed inside the peripheral wall portion 193a of the cup-like member 193 of the second impeller 9. As described above, the rotary shaft 171 of the second motor 7 rotates in the direction opposite to the rotating direction of the rotary shaft 71 of the first motor 3. Thus, the second impeller 9 is rotated by the second motor 7 in a second rotating direction R2, which is opposite to the first rotating direction R1 and is a clockwise direction in the page of Fig. 11, within the second space S2.

[0048] In the counter-rotating axial-flow fan in this embodiment, when the first impeller 5 rotates in the first rotating direction and the second impeller 9 rotates in the second rotating direction opposite to the first rotating direction, air sucked through the suction opening 11a is discharged from the discharge opening 13a, as shown in Fig. 1, thereby cooling the inside of the electric appliance.

[0049] In the counter-rotating axial-flow fan in this embodiment, at least one raised portion 28d is provided at the side wall portions 28b in the pair of the first web half-

portions 28A to 28E, and at least one raised or convex portion 55d is provided at the side wall portions 55b in the pair of the second web half-portions 55A to 55E. Then, the raised portions 28d and 55d extend beyond the virtual reference dividing plane F. The height of the side wall portions 28b and 55b may be thereby increased. As a result, lead wires may be much less likely to protrude or run off from between the side wall portions 28b and between the side wall portions 55b. Further, when the first and second divided housing units are coupled, a plurality of the lead wires may be much less likely to be sandwiched between the side wall portions of the first web half-portions 28A to 28E and second web half-portions 55A to 55E. In the counter-rotating axial-flow fan of the present invention, the engaging members 23A to 23D integrally formed with the first flange portion 19 and the engaged members 41A to 41D integrally formed with the second flange portion 37 are employed for the coupling structure that couples the first divided housing unit 11 and the second divided housing unit 13. Therefore, the coupling of the first divided housing unit 11 and the second divided housing unit 13 are attained not only by the engagement of the engaging members 23A to 23D and the engaged members 41A to 41D as well as by the fitting of the other end 21a of the first cylindrical air-channel half-portion 21 and the other end 39a of the second cylindrical air-channel half-portion 39. As a result, no force concentration will occur at the fitting structure of the first cylindrical air-channel half-portion and the second cylindrical air-channel half-portion. Moreover, the first and second divided housing units will not be readily disconnected or decoupled. In addition, the first stopper portions 25A to 25D are respectively provided adjacent to the engaging members 23A to 23D, and the second stopper portions 43A to 43D are respectively provided adjacent to the engaged members 41A to 41D. Thus, even if force is concentrated and applied from the first flange portion 19 and the second flange portion 37 to the engaging members 23A to 23D and the engaged members 41A to 41D when the first divided housing unit 11 and the second divided housing unit 13 are coupled, the leading ends of the first stopper portions 25A to 25D adjacent to the engaging members 23A to 23D are respectively abutted onto the leading ends of the second stopper portions 43A to 43D adjacent to the engaged members 41A to 41D. As a result, even if the engaging members 23A to 23D are strongly pressed against the engaged members 41A to 41D, it may be possible to prevent breakage of engagement portions where the engaging member 23A to 23D and the engaged member 41A to 41D are engaged with each other.

Claims

1. A counter-rotating axial-flow fan comprising:

a housing (1) comprising a housing body (61)

including an air channel (2) having a suction opening (11a) on one side in an axial line direction and a discharge opening (13a) on the other side in the axial line direction, and a motor support frame (63) disposed in a central portion of the air channel (2);

a first impeller (5) disposed in a first space (S1), which is defined between the motor support frame (63) in the housing (1) and the suction opening (11a), and including a plurality of blades (95);

a first motor (3) including a first rotary shaft (71) onto which the first impeller (5) is fixed, the first motor (3) rotating the first impeller (5) in a first rotating direction (R1) within the first space (S1); a second impeller (9) disposed in a second space (S2), which is defined between the motor support frame (63) in the housing (1) and the discharge opening (13a), and including a plurality of blades (195); and

a second motor (7) including a second rotary shaft (171) onto which the second impeller (9) is fixed, the second motor (7) rotating the second impeller (9) in a second rotating direction (R2) opposite to the first rotating direction (R1) within the second space (S2);

the motor support frame (63) comprising a support frame body (65) disposed in the central portion of the air channel (2) and a plurality of webs (69A - 69E) disposed between the support frame body (65) and the housing body (61) at predetermined intervals in a circumferential direction of the rotary shafts (71, 171), the webs (69A - 69E) connecting the support frame body (65) and the housing body (61);

the housing being constituted from first and second divided housing units (11, 13) that are coupled through a coupling structure;

the first divided housing unit (11) including a first housing-body half-portion (15) and a first support-frame half-portion (17), the first housing-body half-portion (15) including a first flange portion (19) having the suction opening (11a) at one end thereof and a first cylindrical air-channel half-portion (21) of which one end is integrally formed with the first flange portion (19), the first cylindrical air-channel half-portion (21) containing therein a major part of the first space (S1), the first support-frame half-portion (17) being obtained by dividing the motor support frame (63) into two along a virtual reference dividing plane (F) extending in a radial direction of the rotary shafts (71, 171) orthogonal to the axial line direction;

the second divided housing unit (13) including a second housing-body half-portion (33) and a second support-frame half-portion (35), the second housing-body half-portion (33) including a

second flange portion (37) having the discharge opening (13a) at one end thereof and a second cylindrical air-channel half-portion (39) of which one end is integrally formed with the second flange portion (37), the second cylindrical air-channel half-portion (39) containing therein a major part of the second space (S2), the second support-frame half-portion (35) being obtained by dividing the motor support frame (63) into the two along the virtual reference dividing plane (F), **characterized in that:**

the coupling structure is constituted from:

a fitting portion formed at the other end (21a) of the first cylindrical air-channel half-portion (21),
 a fitted portion to be fitted with the fitting portion, formed at the other end (39a) of the second cylindrical air-channel half-portion (39),
 a plurality of engaging members (23A - 23D) integrally formed with the first flange portion (19), arranged at intervals in the circumferential direction, and extending along the first cylindrical air-channel half-portion (21), and
 a plurality of engaged members (41A - 41D) to be respectively engaged with the engaging members (23A - 23D), integrally formed with the second flange portion (37), arranged at intervals in the circumferential direction, and extending along the second cylindrical air-channel half-portion (39);
 a plurality of first stopper portions (25A - 25D) are integrally formed with the first flange portion (19) and arranged adjacent to the engaging members (23A - 23D), and extend along the first cylindrical air-channel half-portion (21);
 a plurality of second stopper portions (43A - 43D) are integrally formed with the second flange portion (37) and arranged adjacent to the engaged members (41A - 41D), and extend along the second cylindrical air-channel half-portion (39); and
 leading ends of the first stopper portions (25A-25D) are respectively abutted onto leading ends of the second stopper portions (43A - 43D) when the engaging members (23A - 23D) are completely engaged with the engaged members (41A - 41D).

2. The counter-rotating axial-flow fan according to claim 1, **characterized in that:**

the first and second flange portions (19, 37) respectively have a contour shape including four corners 19a - 19d, 37a - 37d), first to fourth corners, arranged in the circumferential direction; four of the engaging members (23A - 23D) and four of the first stopper portions (25A - 25D) are respectively arranged in the vicinity of the four corners (19a - 19d) of the first flange portion (19); four of the engaged members (41A - 41D) and four of the second stopper portions (43A - 43D) are respectively arranged in the vicinity of the four corners (37a - 37d) of the second flange portion (37);

in the first flange portion (19), two of the engaging members (23A - 23D) are arranged in a region defined between the first corner (19a) and the second corner (19b), two of the first stopper portions (25A - 25D) are arranged in a region defined between the second corner (19b) and the third corner (19c), two of the engaging members (23A-23D) are arranged in a region defined between the third corner (19c) and the fourth corner (19d), and two of the first stopper portions (25A - 25D) are arranged in a region defined between the fourth corner (19d) and the first corner (19a); and

in the second flange portion (37), two of the engaged members (41A-41D) are arranged in a region defined between the first corner (37a) and the second corner (37b), two of the second stopper portions (43A - 43D) are arranged in a region defined between the second corner (37b) and the third corner (37c), two of the engaged members (41A - 41D) are arranged in a region defined between the third (37c) corner and the fourth corner (37d), and two of the second stopper portions (43A - 43D) are arranged in a region defined between the fourth corner (37d) and the first corner (37a).

3. The counter-rotating axial-flow fan according to claim 1 or 2, **characterized in that:**

the engaging members (23A-23D) are integrally coupled to the first cylindrical air-channel half-portion (21), and the engaged members (41A - 41D) are integrally coupled to the second cylindrical air-channel portion (39).

4. The counter-rotating axial-flow fan according to claim 2, **characterized in that:**

when a first virtual diagonal line (D1) connecting two of the four corners (19a - 19d) opposed to each other in the radial direction of the rotary shafts (71, 171) and a second virtual diagonal line (D2) connecting remaining two of the four corners (19a - 19d) are assumed in the first

flange portion (19), the engaging member (23A - 23D) and the first stopper portion (25A - 25D) corresponding to the engaging member (23A - 23D) are disposed so as to interpose the first or second virtual diagonal line (D1, D2) therebetween; 5

none of the engaging members (23A - 23D) and none of the first stopper portions (25A - 25D) are disposed at the four corners (19a - 19d) through which the first or second virtual diagonal line (D1, D2) passes; 10

when a third virtual diagonal line (D3) connecting two of the four corners (37a - 37d) opposed to each other in the radial direction of the rotary shafts (71, 171) and a fourth virtual diagonal line (D4) connecting remaining two of the four corners (37a - 37d) are assumed in the second flange portion (37), the engaged member (41A - 41D) and the second stopper portion (43A - 43D) corresponding to the engaged member (41A - 41D) are disposed so as to interpose the third or fourth virtual diagonal line (D3, D4) therebetween; and 15

none of the engaged members (41A - 41D) and none of the second stopper portions (43A - 43D) are disposed at the four corners (37a - 37d) through which the third or fourth virtual diagonal line (D3, D4) passes. 20 25

5. The counter-rotating axial-flow fan according to claim 1, **characterized in that:** 30

one of the engaging member (23A - 23D) and the engaged member (41A - 41D) includes a claw portion (51b); 35

the other of the engaging member (23A - 23D) and the engaged member (41A - 41D) includes a hole portion (23g) to be engaged with the claw portion (51b);

at least one of the engaging member (23A - 23D) and the engaged member (41A - 41D) is bent when engaging the engaging member (23A - 23D) with the engaged member (41A - 41D), and the claw portion (51b) and the hole portion (23g) get into engagement with each other once the engaging member (23A - 23D) is completely engaged with the engaged member (41A - 41D); 40 45

and

the hole portion (23g) is formed so as to allow for visual confirmation of the engagement of the claw portion (51b) engaged therewith. 50

6. The counter-rotating axial-flow fan according to claim 1, **characterized in that:** 55

the engaging members (23A - 23D) and the first stopper portions (25A - 25D) are respectively shaped not to protrude outside the first flange

portion (19) as the first flange portion (19) is seen from the first cylindrical air-channel half-portion (21); and

the engaged members (41A - 41D) and the second stopper portions (43A - 43D) are respectively shaped not to protrude outside the second flange portion (37) as the second flange portion (37) is seen from the second cylindrical air-channel half-portion (39).

Fig.1

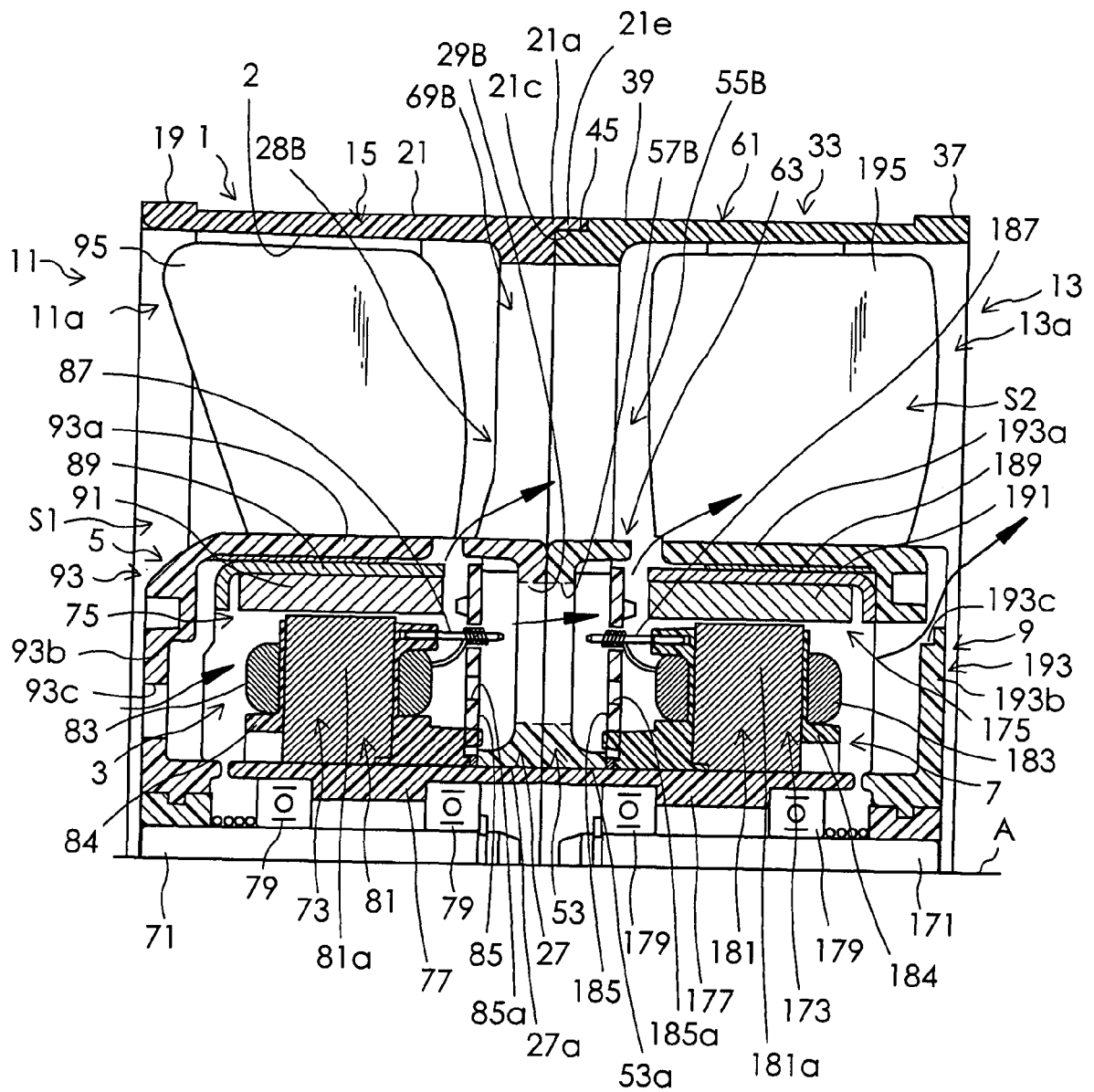


Fig.2

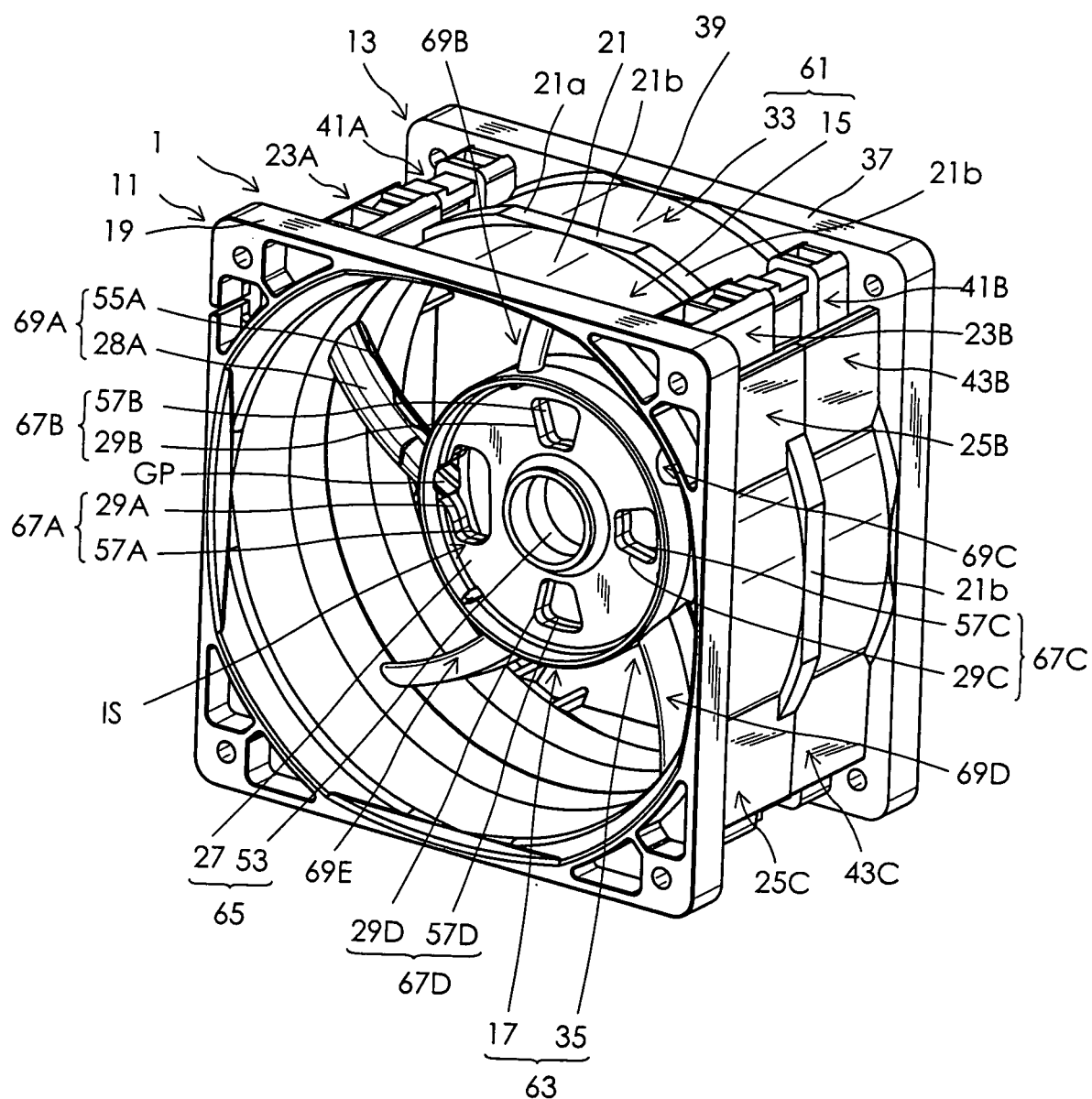


Fig.3

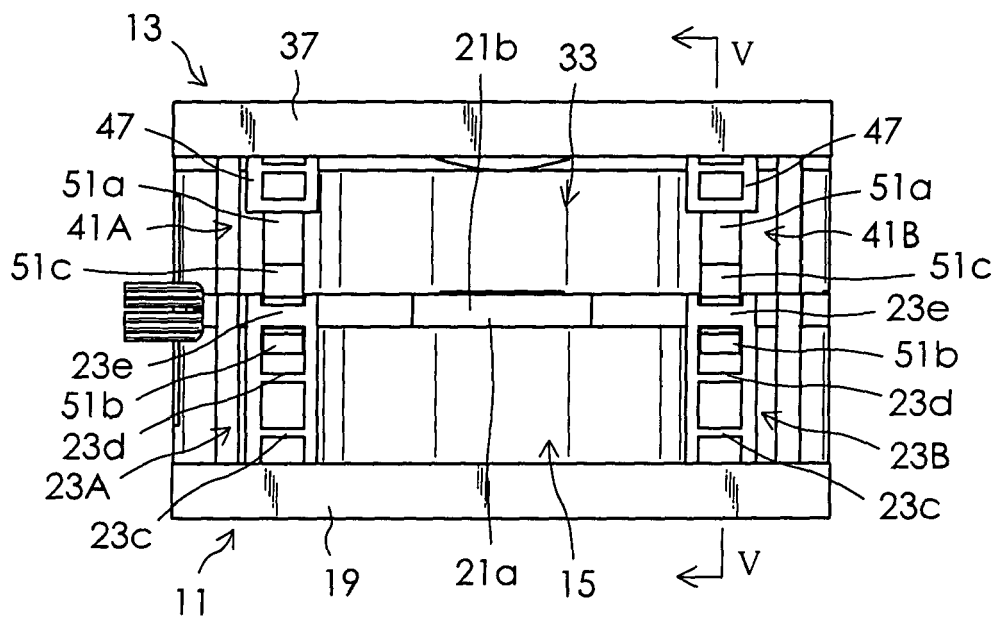


Fig.4

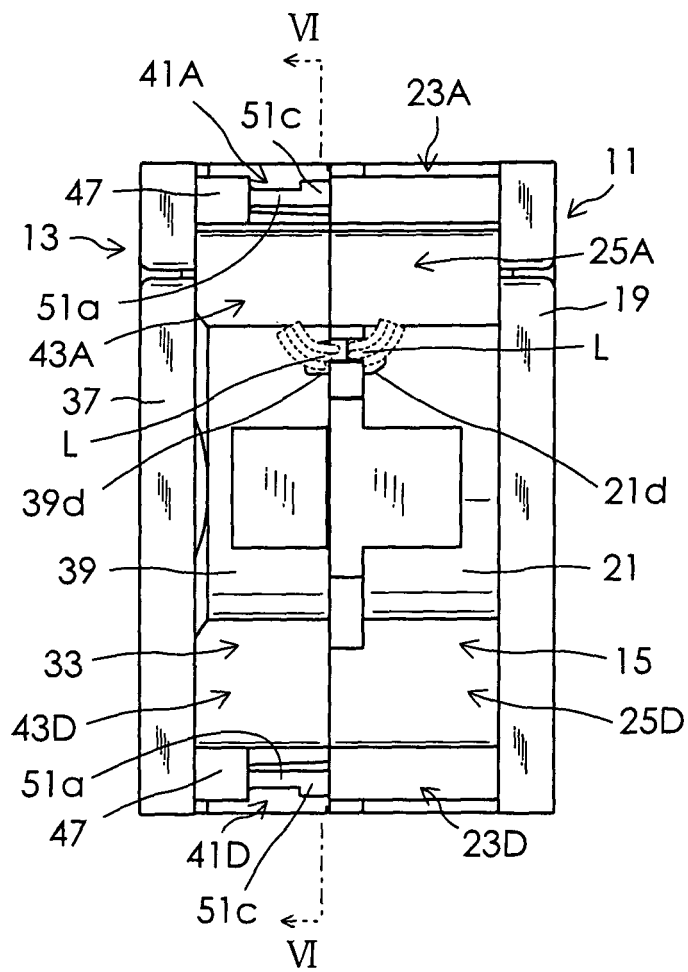


Fig.5

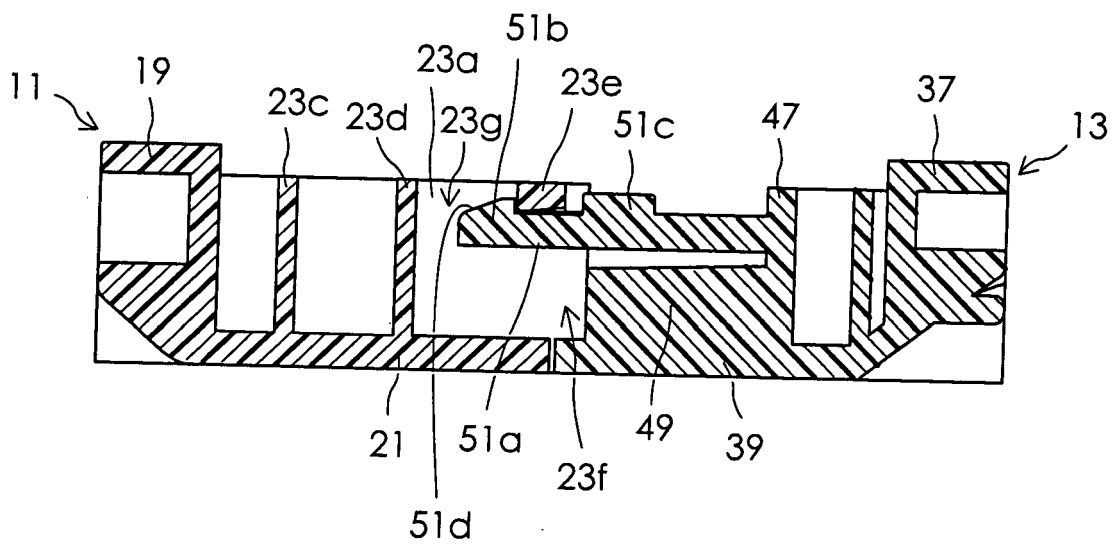


Fig.6

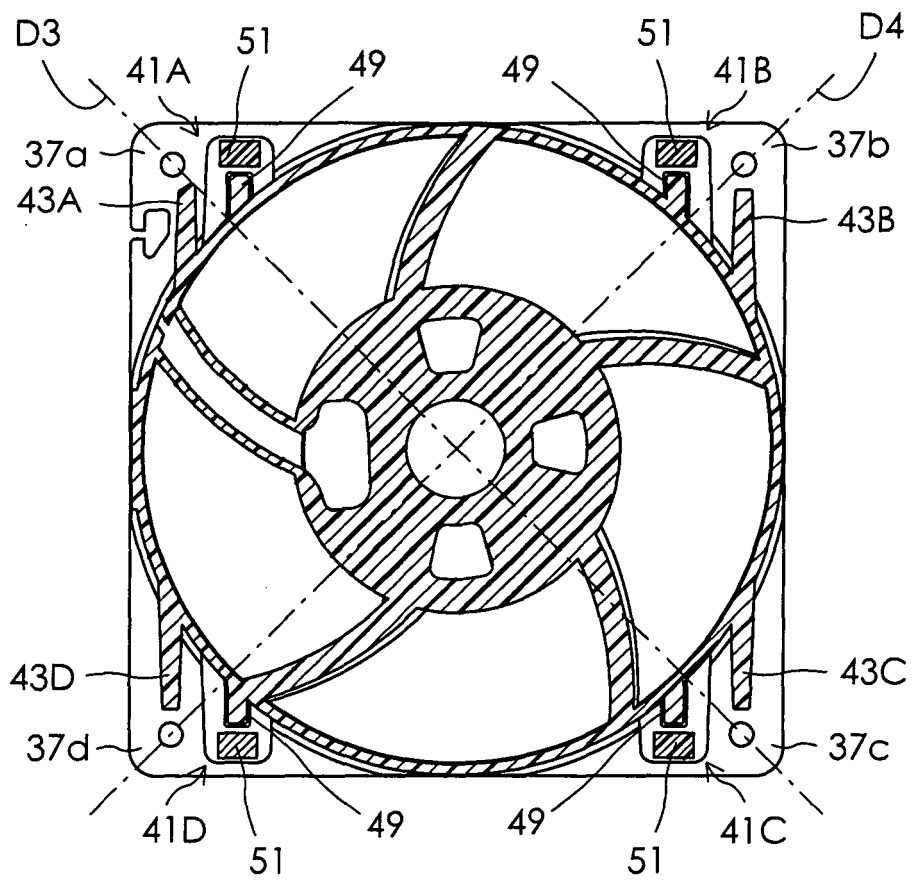


Fig.7

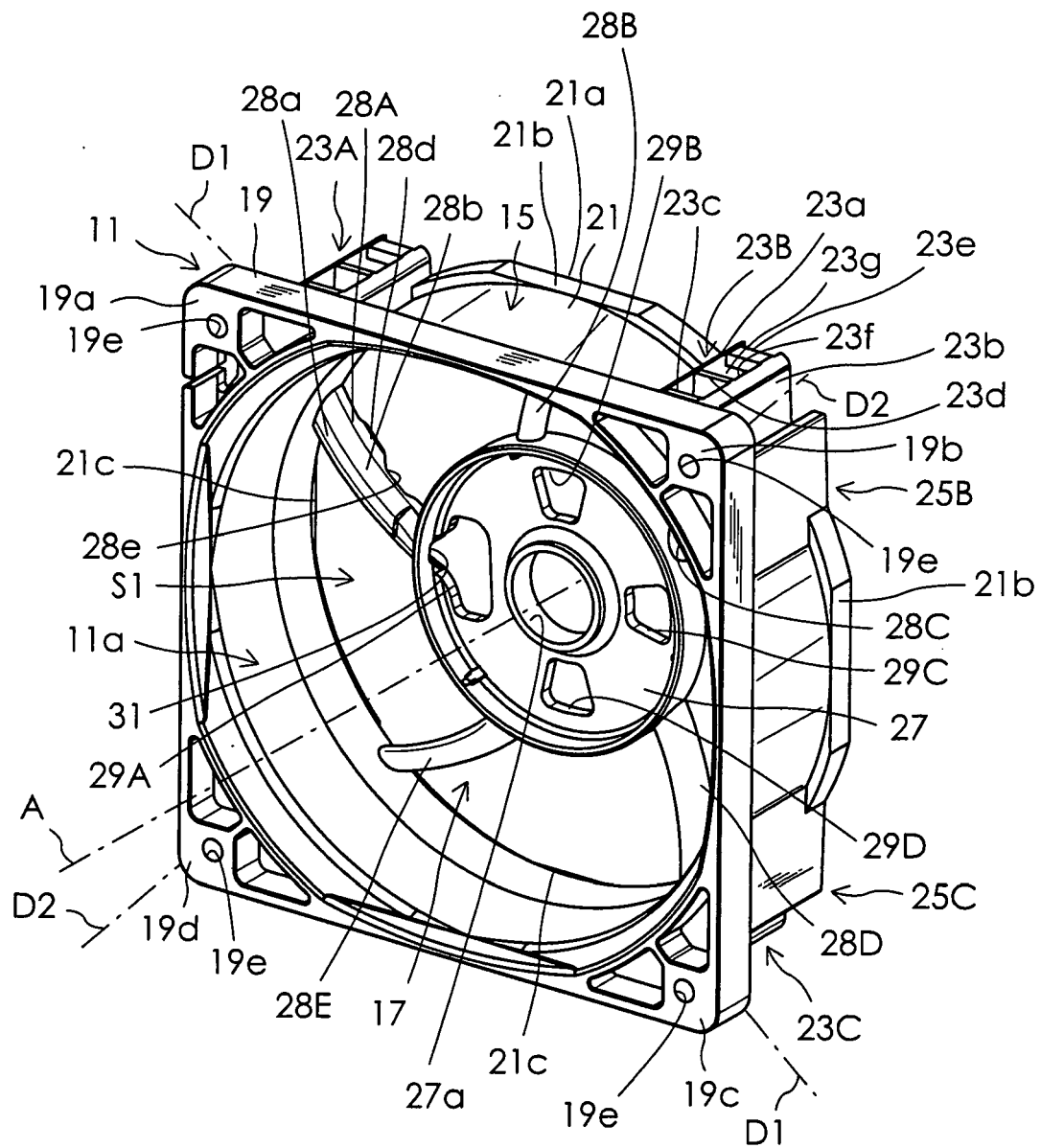


Fig.8

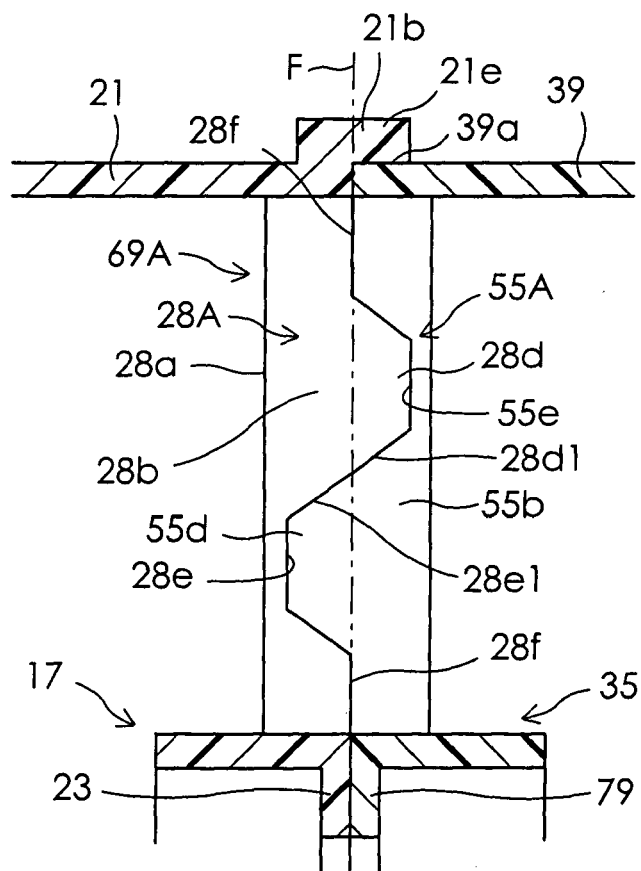


Fig.9

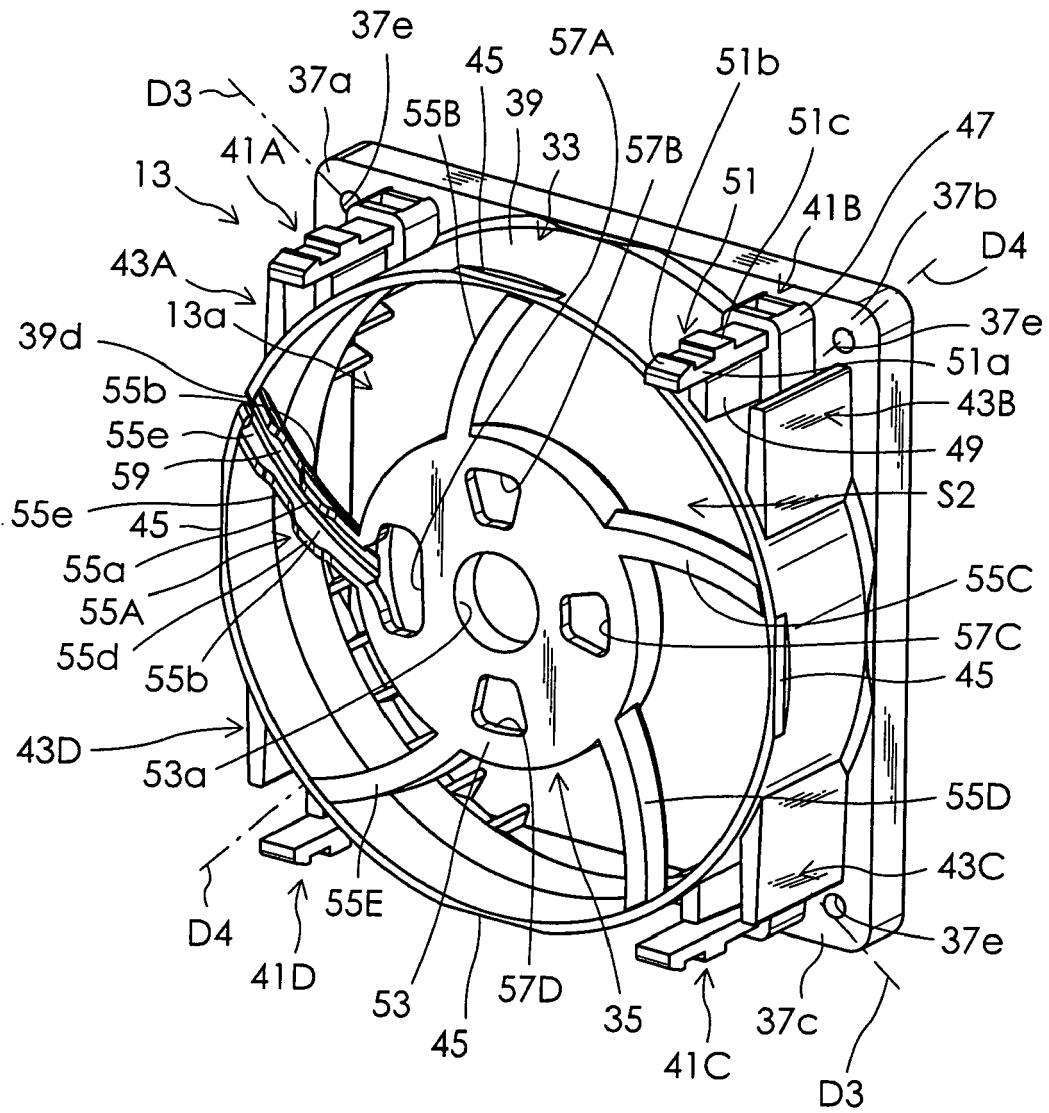


Fig.10

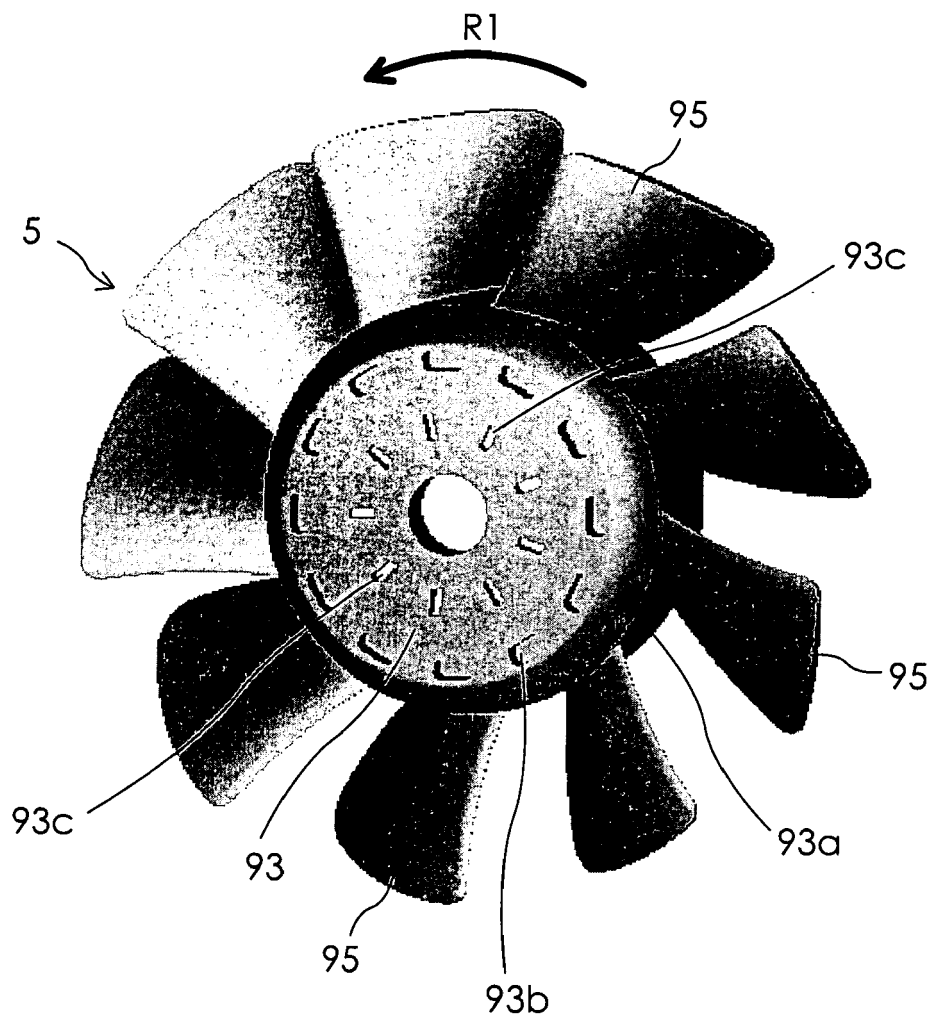
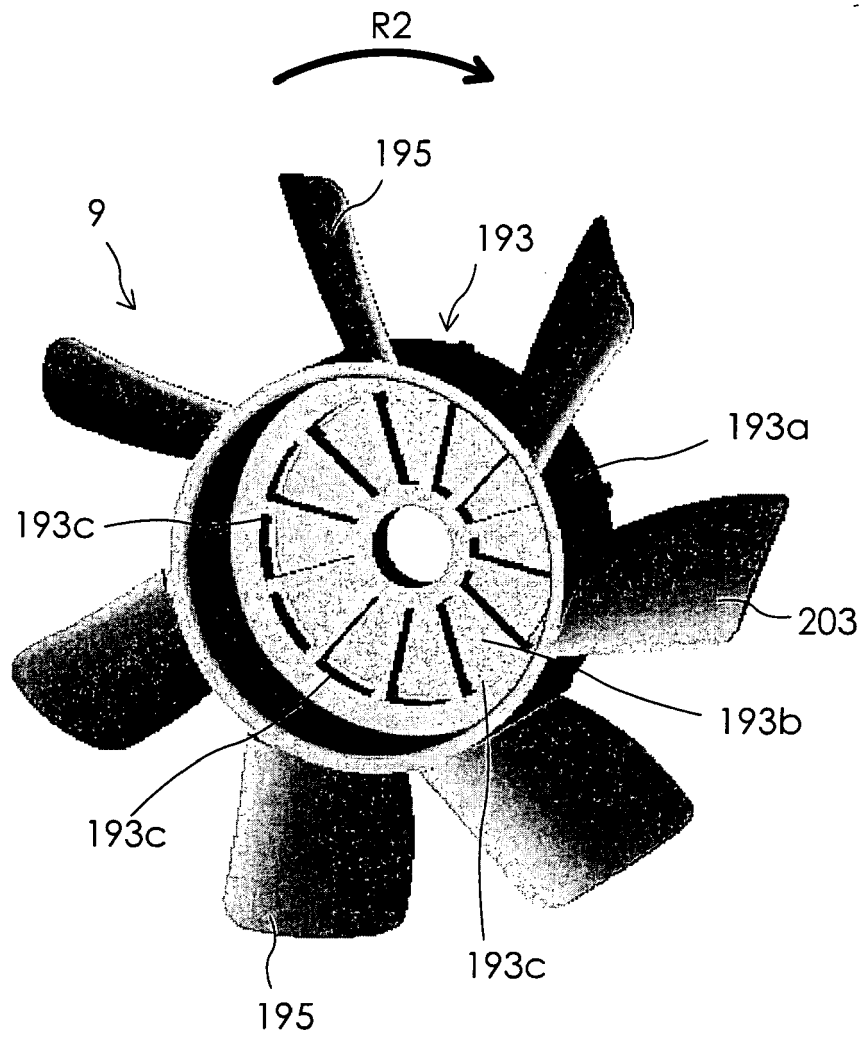


Fig.11



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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