



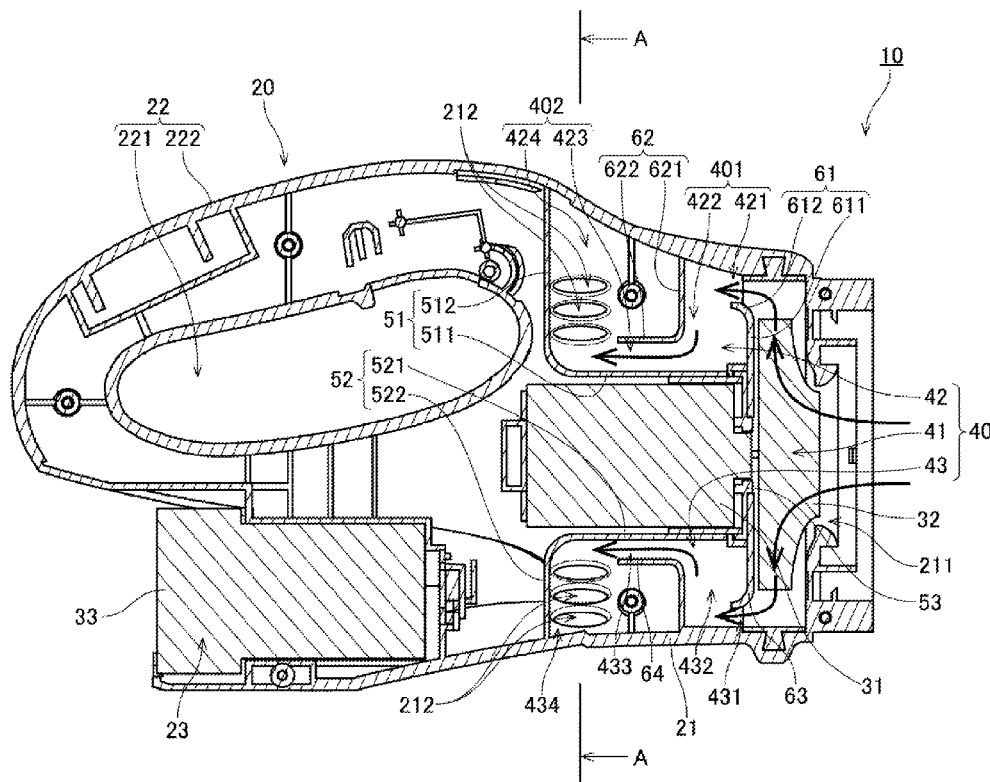
US 20180110384A1

(19) **United States**(12) **Patent Application Publication**
SAKUMA et al.(10) **Pub. No.: US 2018/0110384 A1**(43) **Pub. Date: Apr. 26, 2018**(54) **MOTOR MODULE AND VACUUM CLEANER**(71) Applicant: **Nidec Corporation**, Kyoto (JP)(72) Inventors: **Yuuichi SAKUMA**, Kyoto (JP); **Jun MURAKAMI**, Kyoto (JP)(21) Appl. No.: **15/786,628**(22) Filed: **Oct. 18, 2017**(30) **Foreign Application Priority Data**

Oct. 21, 2016 (JP) 2016-206579

Publication Classification(51) **Int. Cl.***A47L 5/24* (2006.01)*A47L 9/00* (2006.01)*A47L 9/22* (2006.01)(52) **U.S. Cl.**CPC *A47L 5/24* (2013.01); *A47L 9/22* (2013.01);*A47L 9/0081* (2013.01)(57) **ABSTRACT**

This motor module includes a motor, a fan, and a casing arranged to house the motor and the fan therein. The casing includes a tubular body portion arranged to extend in an axial direction, an air inlet, an air outlet, a flow passage, and a partitioning portion. The flow passage is a space arranged to join the air inlet and the air outlet to each other between the body portion and the motor. The partitioning portion is arranged in the flow passage to partition the flow passage. The flow passage includes a fan accommodating portion, a first silencing chamber arranged to be in communication with the fan accommodating portion through a first communicating passage, and a second silencing chamber arranged to be in communication with the first silencing chamber through a second communicating passage. The second silencing chamber is arranged to be in communication with the air outlet. The first silencing chamber is arranged to have a flow passage cross-sectional area greater than that of the first communicating passage. The second silencing chamber is arranged to have a flow passage cross-sectional area greater than that of the second communicating passage. Two expansion-type silencers, one defined by the first communicating passage and the first silencing chamber and the other defined by the second communicating passage and the second silencing chamber, are arranged between the fan and the air outlet, so that noise generated in the fan can be reduced with high efficiency.



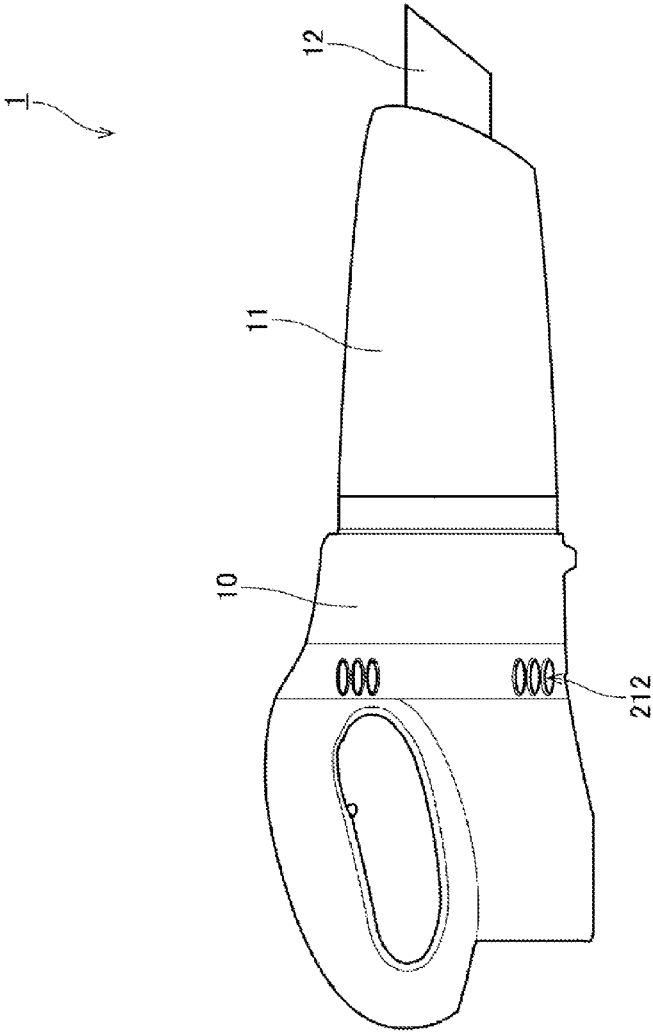


FIG. 1

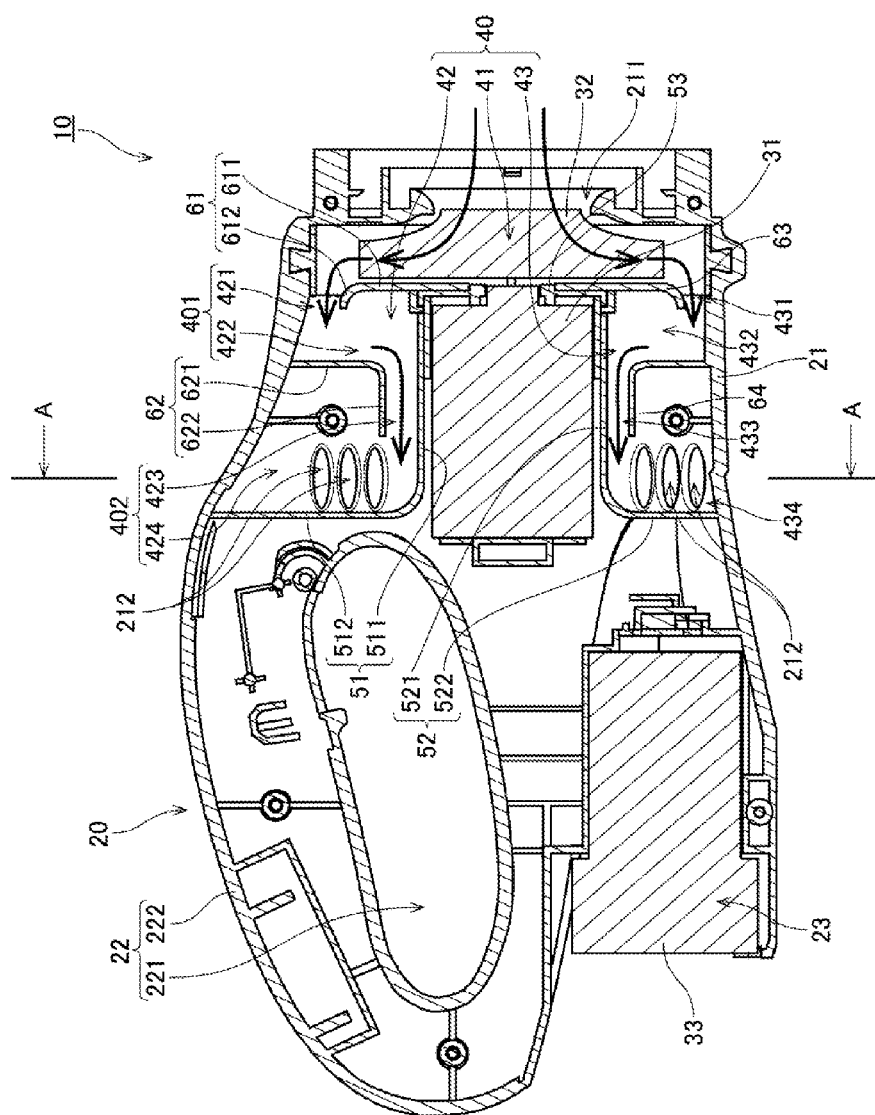


FIG. 2

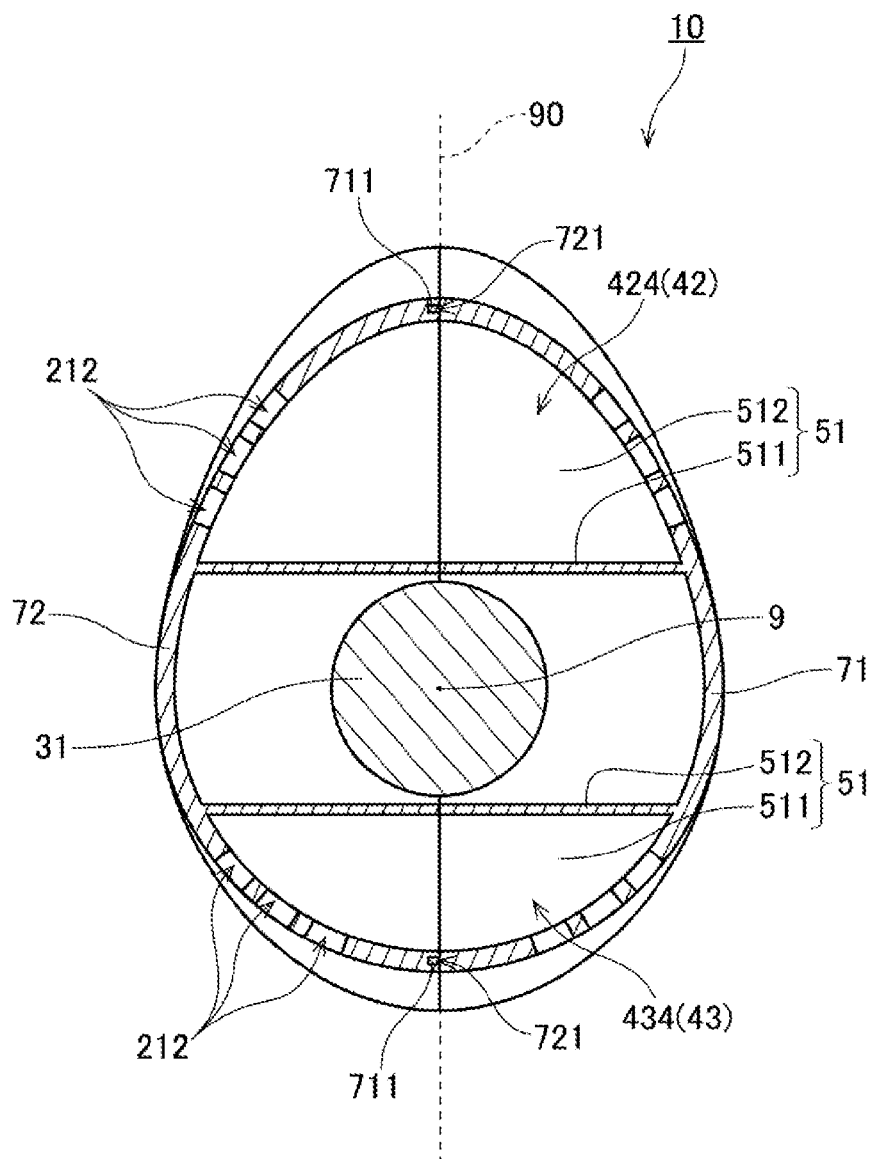


Fig.3

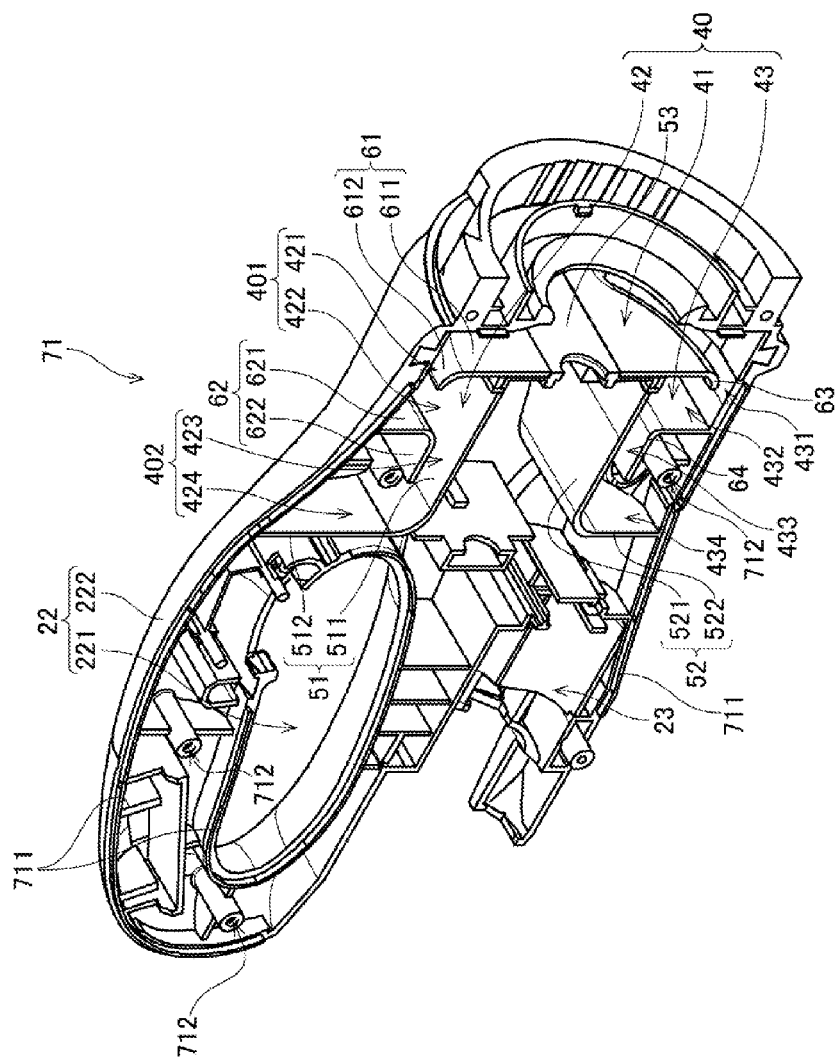


FIG. 4

FIG. 5

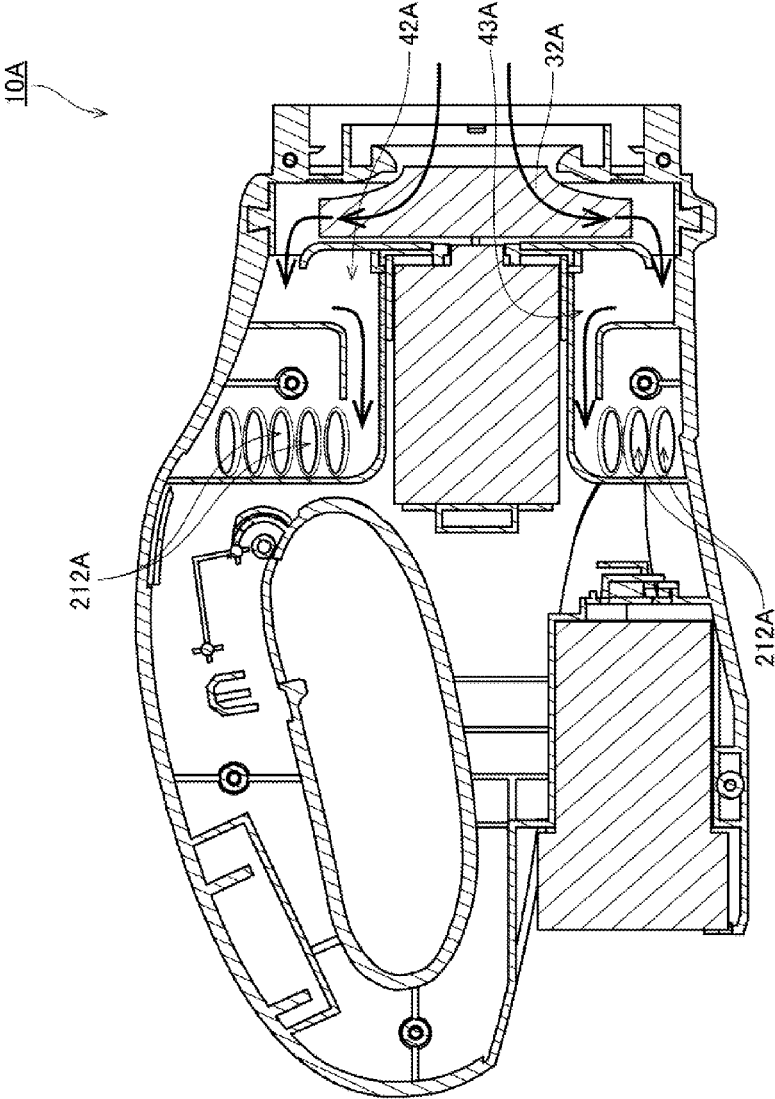


FIG. 6

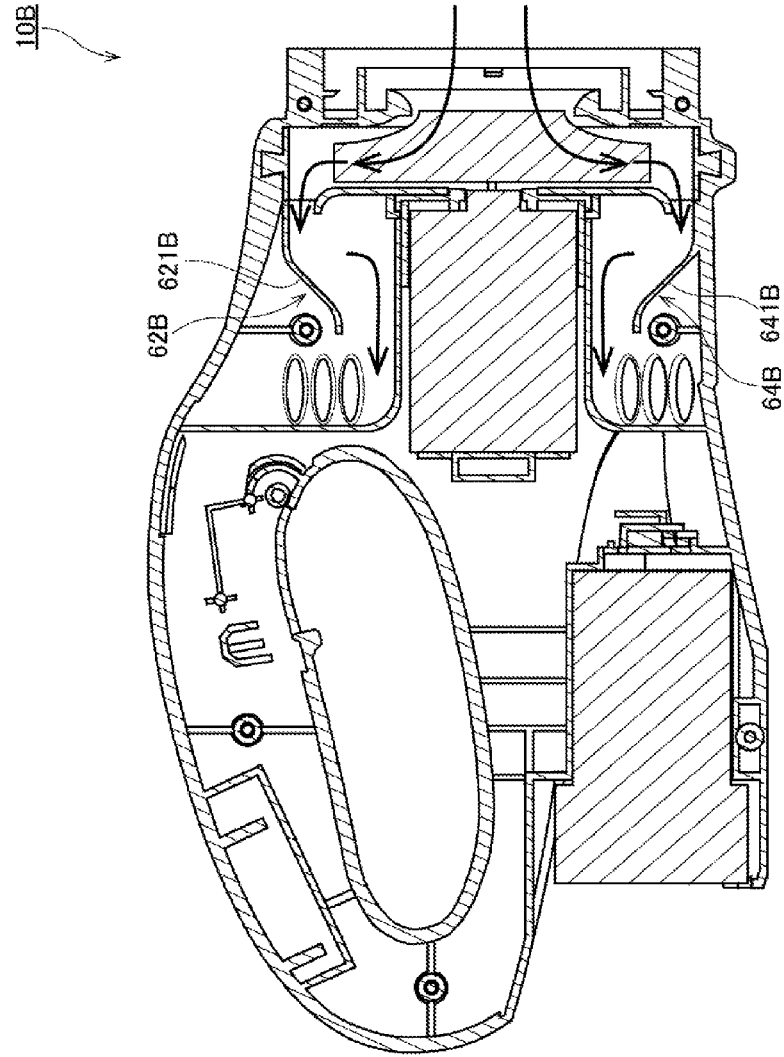
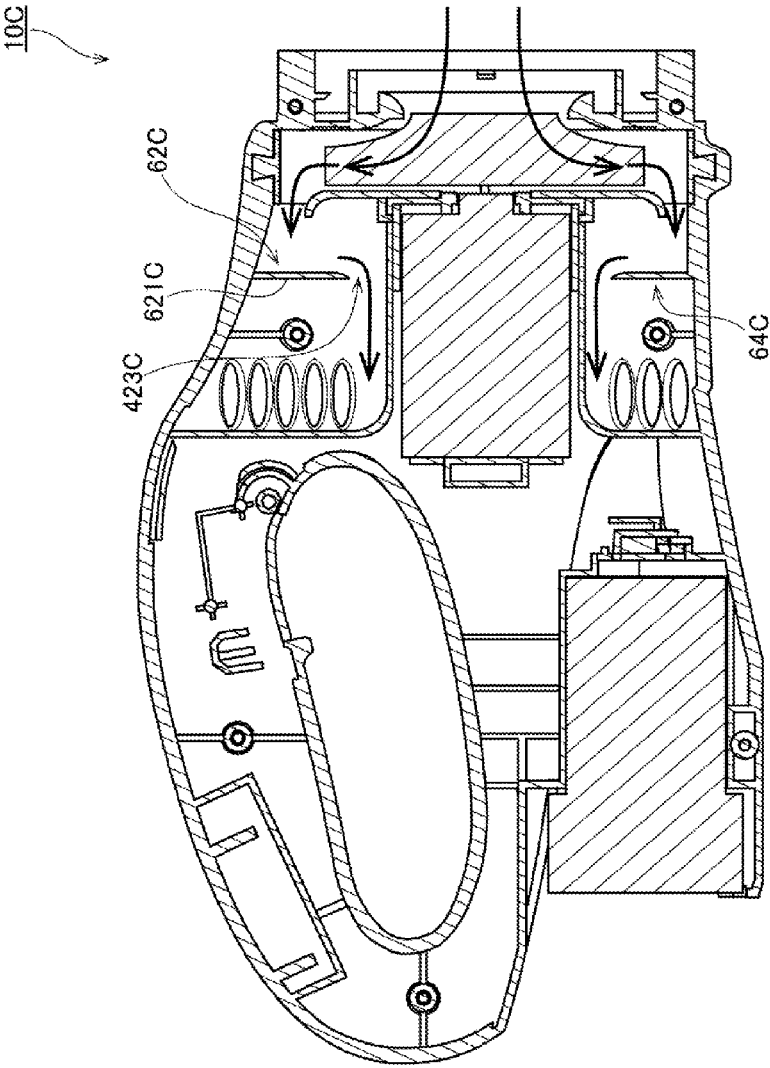


FIG. 7



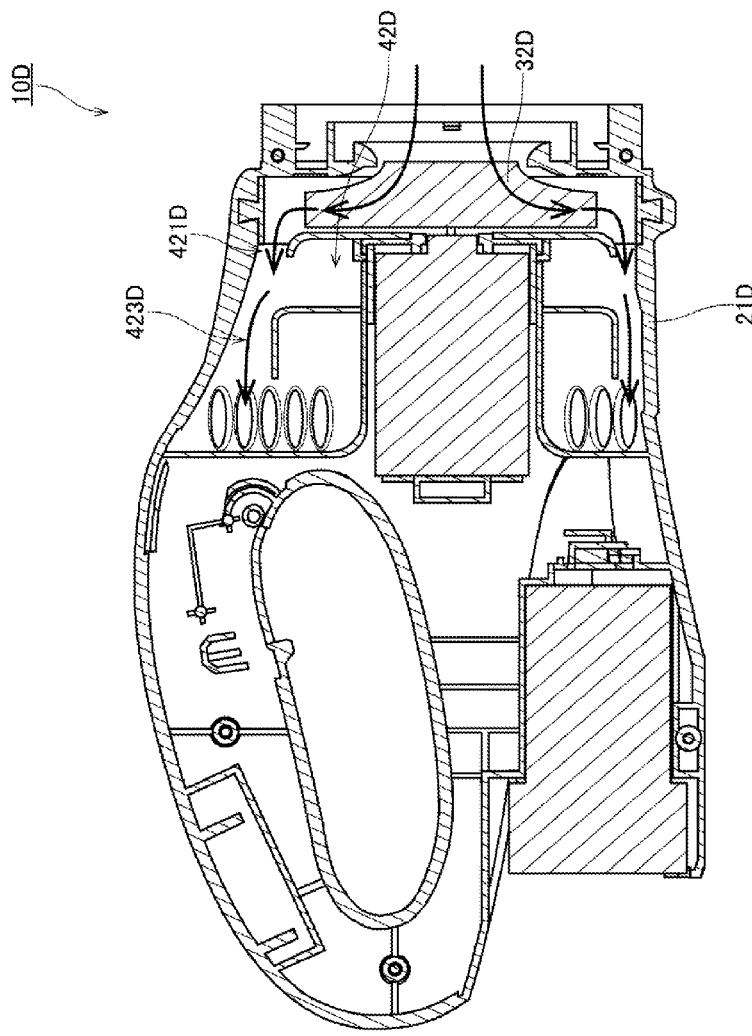


FIG. 8

MOTOR MODULE AND VACUUM CLEANER

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of priority to Japanese Patent Application No. 2016-206579 filed on Oct. 21, 2016. The entire contents of this application are hereby incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The present invention relates to a motor module and a vacuum cleaner including the motor module.

2. Description of the Related Art

[0003] Apparatuses, such as vacuum cleaners, which are required to create suction typically have a motor and a fan installed therein. In recent years, in addition to conventional canister-type vacuum cleaners, small-sized vacuum cleaners called handy-type, upright-type, or stick-type vacuum cleaners have become widespread. A known handy-type vacuum cleaner including a motor and a fan is described in, for example, JP-A 2016-67664.

[0004] In recent years, there has been a demand for a reduction in noise of vacuum cleaners because of, for example, an increased number of apartment houses. In addition, the small-sized vacuum cleaners can be used in various places and situations. Accordingly, a reduction in noise is more strongly demanded of the small-sized vacuum cleaners than of larger vacuum cleaners. That is, there is a demand for a reduction in noise of a motor module including a motor and a fan.

SUMMARY OF THE INVENTION

[0005] A motor module according to a preferred embodiment of the present invention includes a motor including a rotating portion arranged to rotate about a rotation axis; a fan arranged on a first axial side of the motor to rotate together with the rotating portion; and a casing arranged to house the motor and the fan therein. The casing includes a tubular body portion arranged to extend in an axial direction; an air inlet arranged on the first axial side of the fan; an air outlet arranged on a second axial side of the fan and radially outside of the motor; a flow passage being a space arranged to join the air inlet and the air outlet to each other between the body portion and the motor; and at least one partitioning portion arranged in the flow passage to partition the flow passage. The flow passage includes a fan accommodating portion arranged to have the fan accommodated therein, and arranged to be in direct communication with the air inlet; a first silencing chamber arranged to be in communication with the fan accommodating portion through a first communicating passage; and a second silencing chamber arranged to be in communication with the first silencing chamber through a second communicating passage, and arranged to be in direct or indirect communication with the air outlet. The first silencing chamber is arranged to have a flow passage cross-sectional area greater than a flow passage cross-sectional area of the first communicating passage. The second silencing chamber is arranged to have a flow passage cross-sectional area greater than a flow passage cross-sectional area of the second communicating passage.

[0006] According to the above preferred embodiment of the present invention, the first communicating passage and the first silencing chamber together define an expansion-type silencer. In addition, the second communicating passage and the second silencing chamber together define another expansion-type silencer. With the two expansion-type silencers being arranged between the fan and the air outlet, noise generated in the fan can be reduced with high efficiency.

[0007] The above and other elements, features, steps, characteristics and advantages of the present invention will become more apparent from the following detailed description of the preferred embodiments with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. 1 is a side view of a vacuum cleaner according to a first preferred embodiment of the present invention.

[0009] FIG. 2 is a sectional view of a motor module according to the first preferred embodiment.

[0010] FIG. 3 is a sectional view of the motor module according to the first preferred embodiment taken along line A-A in FIG. 2.

[0011] FIG. 4 is a perspective view of a first casing of the motor module according to the first preferred embodiment.

[0012] FIG. 5 is a sectional view of a motor module according to a modification of the first preferred embodiment.

[0013] FIG. 6 is a sectional view of a motor module according to another modification of the first preferred embodiment.

[0014] FIG. 7 is a sectional view of a motor module according to yet another modification of the first preferred embodiment.

[0015] FIG. 8 is a sectional view of a motor module according to yet another modification of the first preferred embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0016] Hereinafter, vacuum cleaners including a motor module according to preferred embodiments of the present invention will be described. It is assumed herein that a direction parallel to a rotation axis of a motor is referred to by the term “axial direction”, “axial”, or “axially”, that directions perpendicular to the rotation axis of the motor are each referred to by the term “radial direction”, “radial”, or “radially”, and that a direction along a circle centered on the rotation axis of the motor is referred to by the term “circumferential direction”, “circumferential”, or “circumferentially”. It is also assumed herein that a vertical direction in FIG. 2 is a vertical direction, and that a side on which a handle portion is arranged with respect to a rechargeable battery is an upper side. The shape of each member or portion and relative positions of different members or portions will be described based on the above assumptions. It should be noted, however, that the above definition of the vertical direction and the upper and lower sides is not meant to restrict in any way the orientation of a motor module according to any preferred embodiment of the present invention at the time of manufacture or when in use.

1-1. Structure of Vacuum Cleaner

[0017] FIG. 1 is a side view of a vacuum cleaner 1 according to a first preferred embodiment of the present invention. The vacuum cleaner 1 includes a motor module 10, a dust separation portion 11, and a nozzle 12. The vacuum cleaner 1 is a so-called handy-type vacuum cleaner.

[0018] FIG. 2 is a sectional view of the motor module 10. Referring to FIG. 2, the motor module 10 includes a casing 20, a motor 31, a fan 32, and a rechargeable battery 33.

[0019] The casing 20 is arranged to house the motor 31, the fan 32, and the rechargeable battery 33 therein. The casing 20 includes an air inlet 211, which is arranged on one axial side (this side will be hereinafter referred to as a first axial side) of the fan 32 and is arranged to bring an interior of the dust separation portion 11 into communication with a space inside of the casing 20 in which the fan 32 is housed, and air outlets 212 defined in a side surface of the casing 20. In addition, the casing 20 has a flow passage 40, which is a space arranged to join the air inlet 211 to the air outlets 212, defined inside thereof. The structure of the casing 20 will be described in detail below.

[0020] The motor 31 is a brushless motor. The motor 31 includes a rotating portion arranged to rotate about a rotation axis 9. The fan 32 is arranged on the first axial side of the motor 31. In addition, the fan 32 is arranged to rotate together with the rotating portion of the motor 31. The fan 32 is a so-called centrifugal fan, and is arranged to generate air flows traveling radially outward through the rotation thereof. Thus, the fan 32 is arranged to generate air flows traveling from the air inlet 211 toward the air outlets 212 in the flow passage 40 of the casing 20. The rechargeable battery 33 is arranged to supply driving power to the motor 31.

[0021] The dust separation portion 11 is arranged on the first axial side of the motor module 10. The nozzle 12 is arranged on the first axial side of the dust separation portion 11. The dust separation portion 11 is arranged to separate dust and trash included in an air flow sucked through the nozzle 12 from the air flow. The dust separation portion 11 may be arranged to separate the dust and the trash using a paper bag, or may alternatively be arranged to separate the dust and the trash using a cyclone separator.

[0022] Once the vacuum cleaner 1 is driven, the motor 31 is driven to generate air flows which travel from the nozzle 12 toward the air outlets 212 through the interior of the dust separation portion 11, the air inlet 211, and an interior of the motor module 10. Thus, dust and trash are sucked through the nozzle 12 together with the air flows. In the dust separation portion 11, the dust and the trash are removed from the air flows sucked through the nozzle 12. Then, the air flows, from which the dust and the trash have been removed, pass through the interior of the motor module 10, and are discharged through the air outlets 212.

1-2. Structure of Casing

[0023] Next, the specific structure of the casing 20 will now be described below with reference to FIGS. 2, 3, and 4. FIG. 3 is a sectional view of the motor module 10 taken along line A-A in FIG. 2. FIG. 4 is a perspective view of a first casing 71, which will be described below.

[0024] The casing 20 has a body portion 21, a handle portion 22, and a rechargeable battery accommodating portion 23.

[0025] The body portion 21 is a tubular portion arranged to extend in an axial direction. The air inlet 211, which is arranged to pass through in the axial direction, is defined in the body portion 21 on the first axial side. The air inlet 211 is arranged on the first axial side of the fan 32.

[0026] In addition, the air outlets 212, each of which is a through hole, are defined in a side surface of the body portion 21. Each air outlet 212 is arranged on a second axial side (i.e., a side opposite to the first axial side) of the fan 32 and radially outside of the motor 31.

[0027] Each of the handle portion 22 and the rechargeable battery accommodating portion 23 is arranged on the second axial side of the air outlets 212. The handle portion 22 is arranged on the upper side of the rechargeable battery accommodating portion 23. Here, the handle portion 22 is formed by a handle hole 221 arranged to pass through in a left-right direction, which is perpendicular to both the axial direction and the vertical direction, and a graspable portion 222 arranged to extend in the axial direction on the upper side of the handle hole 221. The rechargeable battery 33 is accommodated in the rechargeable battery accommodating portion 23.

[0028] Referring to FIGS. 2 and 4, the casing 20 includes an upper-side wall portion 51, a lower-side wall portion 52, and a middle wall portion 53, which are arranged to partition the space inside of the casing 20.

[0029] The upper-side wall portion 51, the lower-side wall portion 52, and the middle wall portion 53 are arranged to partition the space inside of the casing 20 into the flow passage 40 and a portion outside of the flow passage 40. In the present preferred embodiment, the flow passage 40 includes a fan accommodating portion 41 arranged to have the fan 32 accommodated therein, and an upper-side flow passage 42 and a lower-side flow passage 43 each of which is arranged to extend from the fan accommodating portion 41 to the second axial side. That is, the flow passage 40 according to the present preferred embodiment is arranged to branch out into the upper-side flow passage 42 and the lower-side flow passage 43 on a downstream side of the fan 32.

[0030] The upper-side flow passage 42 is arranged above the motor 31. The lower-side flow passage 43 is arranged below the motor 31. The upper-side wall portion 51 is arranged to divide the upper-side flow passage 42 and the portion outside of the flow passage 40 from each other above the motor 31. The lower-side wall portion 52 is arranged to divide the lower-side flow passage 43 and the portion outside of the flow passage 40 below the motor 31. In addition, the middle wall portion 53 is arranged to extend in the vertical direction to join an end portion of the upper-side wall portion 51 on the first axial side and an end portion of the lower-side wall portion 52 on the first axial side to each other. As a result, the fan accommodating portion 41 and a space in which the motor 31 is accommodated are divided from each other.

[0031] The upper-side wall portion 51 includes an upper-side motor covering portion 511 and an upper-side partition wall portion 512. The lower-side wall portion 52 includes a lower-side motor covering portion 521 and a lower-side partition wall portion 522. Each of the upper-side motor covering portion 511 and the lower-side motor covering portion 521 is arranged to extend in the axial direction and the left-right direction to assume the shape of a plate. The upper-side motor covering portion 511 is arranged between

the motor 31 and the upper-side flow passage 42. The lower-side motor covering portion 521 is arranged between the motor 31 and the lower-side flow passage 43.

[0032] Accordingly, the upper-side flow passage 42 is surrounded by the upper-side motor covering portion 511 and the body portion 21 at a position radially overlapping with the upper-side motor covering portion 511. In addition, the lower-side flow passage 43 is surrounded by the lower-side motor covering portion 521 and the body portion 21 at a position radially overlapping with the lower-side motor covering portion 521.

[0033] Because the upper-side motor covering portion 511 is arranged between the motor 31 and the upper-side flow passage 42, and the lower-side motor covering portion 521 is arranged between the motor 31 and the lower-side flow passage 43 as described above, the shape of each of the upper-side and lower-side flow passages 42 and 43 can be defined regardless of the shape of the motor 31. Thus, flow passage resistance in each of the upper-side and lower-side flow passages 42 and 43 and silencing effects, which will be described below, can remain the same even if the motor 31 is replaced with a motor having a different shape.

[0034] Each of the upper-side partition wall portion 512 and the lower-side partition wall portion 522 is arranged to extend in the vertical direction and the left-right direction to assume the shape of a plate. The upper-side partition wall portion 512 is arranged to extend from an end portion of the upper-side motor covering portion 511 on the second axial side to an inner wall of the body portion 21. The upper-side partition wall portion 512 is thus arranged to divide the upper-side flow passage 42 and a space which is not a flow passage and which is on the second axial side of the upper-side flow passage 42 from each other on the second axial side of the upper-side flow passage 42. In other words, the upper-side partition wall portion 512 is arranged to divide a second silencing chamber 424, which will be described below, and the space which is not a flow passage and which is on the second axial side of the second silencing chamber 424 from each other on the second axial side of the air outlets 212.

[0035] The lower-side partition wall portion 522 is arranged to extend from an end portion of the lower-side motor covering portion 521 on the second axial side to the inner wall of the body portion 21. The lower-side partition wall portion 522 is thus arranged to divide the lower-side flow passage 43 and a space which is not a flow passage and which is on the second axial side of the lower-side flow passage 43 from each other on the second axial side of the lower-side flow passage 43. In other words, the lower-side partition wall portion 522 is arranged to divide a second silencing chamber 434, which will be described below, and the space which is not a flow passage and which is on the second axial side of the second silencing chamber 434 from each other on the second axial side of the air outlets 212.

[0036] As described above, the upper-side wall portion 51 is arranged to partition a space inside of the casing 20 into the upper-side flow passage 42 and a space outside of the flow passage 40, while the lower-side wall portion 52 is arranged to partition a space inside of the casing 20 into the lower-side flow passage 43 and a space outside of the flow passage 40. Thus, the shape of each of the upper-side and lower-side flow passages 42 and 43 can be defined without being affected by a space outside of the flow passage 40. Accordingly, an air flow is prevented from striking against

a portion such as, for example, the handle portion 22, the rechargeable battery accommodating portion 23, or the rechargeable battery 33 to cause noise. In addition, the flow passage resistance in each of the upper-side and lower-side flow passages 42 and 43 and the silencing effects, which will be described below, can remain the same regardless of the shapes of the handle portion 22, the rechargeable battery accommodating portion 23, and the rechargeable battery 33.

[0037] The casing 20 includes plate-shaped partitioning portions 61, 62, 63, and 64 each of which is arranged in the flow passage 40 to partition the flow passage 40. Specifically, the four partitioning portions 61 to 64 include an upper-side first partitioning portion 61 arranged to divide the fan accommodating portion 41 and the upper-side flow passage 42 from each other, an upper-side second partitioning portion 62 arranged to partition the upper-side flow passage 42, a lower-side first partitioning portion 63 arranged to divide the fan accommodating portion 41 and the lower-side flow passage 43 from each other, and a lower-side second partitioning portion 64 arranged to partition the lower-side flow passage 43.

[0038] The upper-side first partitioning portion 61 includes a first plate portion 611 and a first bend portion 612. The first plate portion 611 is arranged to extend substantially perpendicularly to the axial direction on the first axial side of the motor 31 and on the second axial side of the fan 32. The first bend portion 612 is arranged to extend from the first plate portion 611 to the second axial side. The upper-side second partitioning portion 62 includes a second plate portion 621 and a second bend portion 622. The second plate portion 621 is arranged to extend substantially perpendicularly to the axial direction on the second axial side of the upper-side first partitioning portion 61 and on the first axial side of the upper-side partition wall portion 512. The second bend portion 622 is arranged to extend from the second plate portion 621 to the second axial side.

[0039] Thus, the upper-side flow passage 42 includes a first communicating passage 421, a first silencing chamber 422, a second communicating passage 423, and the second silencing chamber 424.

[0040] The first communicating passage 421 is a space arranged to extend in the axial direction between the upper-side first partitioning portion 61 and an inner wall of an upper portion of the body portion 21. Specifically, the first communicating passage 421 is arranged to bring the fan accommodating portion 41 and the first silencing chamber 422 into communication with each other between the first bend portion 612 and the inner wall of the upper portion of the body portion 21. The first silencing chamber 422 is a space defined on the second axial side of the upper-side first partitioning portion 61 and the first communicating passage 421, on the upper side of the upper-side motor covering portion 511, on a radially inner side of the inner wall of the body portion 21, and on the first axial side of the upper-side second partitioning portion 62 and the second communicating passage 423.

[0041] The second communicating passage 423 is a space arranged to extend in the axial direction between the upper-side second partitioning portion 62 and the upper-side motor covering portion 511. Specifically, the second communicating passage 423 is arranged to bring the first and second silencing chambers 422 and 424 into communication with each other between the second bend portion 622 and the upper-side motor covering portion 511. The second silencing

chamber 424 is a space defined on the second axial side of the upper-side second partitioning portion 62 and the second communicating passage 423, on the upper side of the upper-side motor covering portion 511, on the radially inner side of the inner wall of the body portion 21, and on the first axial side of the upper-side partition wall portion 512. A portion of the body portion 21 which contributes to defining the second silencing chamber 424 includes three of the air outlets 212, each of which is a through hole, on a left-hand side and other three of the air outlets 212 on a right-hand side. That is, each of these air outlets 212 is in direct communication with the second silencing chamber 424. Note that each of these air outlets 212 may alternatively be in indirect communication with the second silencing chamber 424.

[0042] The lower-side flow passage 43 is similar in structure to the upper-side flow passage 42 turned upside down. Accordingly, the lower-side first partitioning portion 63 and the lower-side second partitioning portion 64 are similar in shape to the upper-side first partitioning portion 61 and the upper-side second partitioning portion 62, respectively, turned upside down. Accordingly, similarly to the upper-side flow passage 42, the lower-side flow passage 43 includes a first communicating passage 431, a first silencing chamber 432, a second communicating passage 433, and the second silencing chamber 434. The first communicating passage 431, the first silencing chamber 432, the second communicating passage 433, and the second silencing chamber 434 of the lower-side flow passage 43 are similar in structure to the first communicating passage 421, the first silencing chamber 422, the second communicating passage 423, and the second silencing chamber 424, respectively, of the upper-side flow passage 42.

[0043] The upper-side flow passage 42 and the lower-side flow passage 43 are arranged to have different dimensions as measured in the vertical direction. The dimension of each portion of the upper-side flow passage 42 as measured in the vertical direction is greater than the dimension of a corresponding portion of the lower-side flow passage 43 as measured in the vertical direction. Thus, the dimension of the upper-side second partitioning portion as measured in the vertical direction is greater than the dimension of the lower-side second partitioning portion 64 as measured in the vertical direction. In the case where the flow passage 40 is arranged to branch out into the upper-side flow passage 42 and the lower-side flow passage 43 on the downstream side of the fan 32, the upper-side flow passage 42 and the lower-side flow passage 43 may be arranged to have different flow passage cross-sectional areas as described above. Descriptions of features of the lower-side flow passage 43 which are shared by the upper-side flow passage 42 are omitted.

[0044] Once the motor 31 is driven to cause the fan 32 to start rotating, the fan 32 generates air flows traveling from above the fan 32 radially outwardly of the fan 32. Thus, air flows which travel from the air inlet 211 into the upper-side flow passage 42 and the lower-side flow passage 43 through the first communicating passages 421 and 431 are generated in the fan accommodating portion 41. The air flows then pass through the first silencing chambers 422 and 432, the second communicating passages 423 and 433, and the second silencing chambers 424 and 434, and are discharged out of the motor module 10 through the air outlets 212.

[0045] The first silencing chamber 422 is arranged to have a flow passage cross-sectional area greater than that of the first communicating passage 421. Thus, the first communicating passage 421 and the first silencing chamber 422 together define a first expansion-type silencer 401. In addition, the second silencing chamber 424 is arranged to have a flow passage cross-sectional area greater than that of the second communicating passage 423. Thus, the second communicating passage 423 and the second silencing chamber 424 together define a second expansion-type silencer 402. With the two expansion-type silencers 401 and 402 being arranged between the fan 32 and the air outlets 212 in the upper-side flow passage 42 as described above, noise generated in the fan 32 can be reduced with high efficiency.

[0046] In the present preferred embodiment, the first bend portion 612 of the upper-side first partitioning portion 61 contributes to increasing the axial dimension of the first communicating passage 421. An increase in a duct length of the first communicating passage 421 contributes to an improved silencing effect of the first expansion-type silencer 401 defined by the first communicating passage 421 and the first silencing chamber 422. In addition, the length of the first communicating passage 421 can be adjusted by appropriately adjusting the length of the first bend portion 612. It is therefore possible to fine-tune the silencing effect of the first expansion-type silencer 401 to achieve improved silencing performance.

[0047] In addition, a portion of the first communicating passage 421 is arranged in the first silencing chamber 422, so that the first expansion-type silencer 401 serves as a silencer with an inner duct. Specifically, a space over the upper-side motor covering portion 511 and under the first bend portion 612 performs a function as an inner duct. Accordingly, this space functions as a side branch silencer (i.e., an interference/resonance silencer). It is therefore possible to fine-tune the silencing effect of the first expansion-type silencer 401 to achieve improved silencing performance.

[0048] Meanwhile, the second bend portion 622 of the upper-side second partitioning portion 62 contributes to increasing the axial dimension of the second communicating passage 423. An increase in a duct length of the second communicating passage 423 contributes to an improved silencing effect of the second expansion-type silencer 402 defined by the second communicating passage 423 and the second silencing chamber 424. In addition, the length of the second communicating passage 423 can be adjusted by appropriately adjusting the length of the second bend portion 622. It is therefore possible to fine-tune the silencing effect of the second expansion-type silencer 402 to achieve improved silencing performance.

[0049] In addition, a portion of the second communicating passage 423 is arranged in the second silencing chamber 424, so that the second expansion-type silencer 402 serves as a silencer with an inner duct. Specifically, a space under the inner wall of the upper portion of the body portion 21 and over the second bend portion 622 performs a function as an inner duct. Accordingly, this space functions as a side branch silencer. It is therefore possible to fine-tune the silencing effect of the second expansion-type silencer 402 to achieve improved silencing performance.

[0050] In the lower-side flow passage 43, which is similar to the upper-side flow passage 42, the first communicating passage 431 and the first silencing chamber 432 together

define an expansion-type silencer, and the second communicating passage 433 and the second silencing chamber 434 together define another expansion-type silencer. With the two expansion-type silencers being arranged between the fan 32 and the air outlets 212 on the lower side in the lower-side flow passage 43 as described above, noise generated in the fan 32 can be reduced with high efficiency.

[0051] In the present preferred embodiment, the first communicating passage 421 is arranged along the inner wall of the upper portion of the body portion 21. This allows an air flow generated in the fan accommodating portion 41 by the fan 32 and traveling radially outward to easily enter into the first communicating passage 421. In addition, the second communicating passage 423 is arranged along the motor 31. Thus, the first and second communicating passages 421 and 423 are arranged at different positions when viewed in the axial direction. Arranging the first and second communicating passages 421 and 423 at different positions when viewed in the axial direction contributes to an improved silencing effect of the first expansion-type silencer 401 defined by the first communicating passage 421 and the first silencing chamber 422. That is, the motor module 10 as a whole is designed with a high priority placed on the silencing performance.

[0052] Referring to FIG. 3, in the present preferred embodiment, the casing 20 includes the first casing 71, which is defined by a single monolithic member, and a second casing 72 defined by a single monolithic member. The first and second casings 71 and 72 include contact surfaces 710 and 720, respectively, which are arranged to be in contact with each other on a plane 90 passing through the rotation axis 9. The casing 20 is arranged to be substantially symmetrical with respect to the plane 90. Accordingly, the handle portion 22 is also substantially symmetrical with respect to the plane 90.

[0053] As described above, the casing 20 includes two members each of which forms a half of the casing 20, and this contributes to improving efficiency with which parts of the motor module 10 are fitted together in a process of manufacturing the motor module 10. In addition, in the first and second casings 71 and 72, each of which forms the half of the casing 20, each of the partitioning portions 61 to 64 is arranged to be perpendicular to the plane 90. This contributes to reducing the number of mold parts which are used when the first and second casings 71 and 72 are defined by injection molding processes. This in turn leads to a reduced production cost.

[0054] In the present preferred embodiment, each of the upper-side first partitioning portion 61 and the lower-side first partitioning portion 63 is defined by a member defined separately from the first and second casings 71 and 72. When the motor module 10 is assembled, the upper-side first partitioning portion 61 and the lower-side first partitioning portion 63 are inserted into the middle wall portion 53 of each of the first and second casings 71 and 72.

[0055] The first casing 71 includes first projecting portions 711 each of which is arranged to project from the plane 90 toward the second casing 72. The second casing 72 includes first recessed portions 721 each of which is recessed from the plane 90. Each first projecting portion 711 is fitted into a corresponding one of the first recessed portions 721. The first and second casings 71 and 72 are thus securely fixed to each other. The first projecting portions 711 and the first

recessed portions 721 are arranged in the vicinity of an outer surface of the casing 20 and around the handle hole 221.

[0056] In addition, referring to FIG. 4, the first casing 71 includes second recessed portions 712 each of which is recessed from the plane 90. The second casing 72 includes second projecting portions (not shown) each of which is arranged to project from the plane 90 toward the first casing 71. Each second projecting portion is fitted into a corresponding one of the second recessed portions 712. The first and second casings 71 and 72 are thus more securely fixed to each other.

[0057] FIG. 5 is a sectional view of a motor module 10A according to a modification of the first preferred embodiment. In the motor module 10A according to the modification illustrated in FIG. 5, the number of air outlets 212A provided for an upper-side flow passage 42A is different from the number of air outlets 212A provided for a lower-side flow passage 43A. As described above, in the case where a flow passage 40A is arranged to branch out into the upper-side flow passage 42A and the lower-side flow passage 43A on the downstream side of a fan 32A, a different number of air outlets 212A may be provided for each of the upper-side flow passage 42A and the lower-side flow passage 43A.

[0058] FIG. 6 is a sectional view of a motor module 10B according to another modification of the first preferred embodiment. In the motor module 10B according to the modification illustrated in FIG. 6, a second plate portion 621B of an upper-side second partitioning portion 62B is arranged to slant with respect to the axial direction. Similarly, a second plate portion 641B of a lower-side second partitioning portion 64B is also arranged to slant with respect to the axial direction.

[0059] As illustrated in FIG. 6, each partitioning portion may be modified in angle and length as desired. This allows silencing effects of a first expansion-type silencer and a second expansion-type silencer arranged in each flow passage to be adjusted to achieve improved silencing performance.

[0060] FIG. 7 is a sectional view of a motor module 10C according to yet another modification of the first preferred embodiment. In the motor module 10C according to the modification illustrated in FIG. 7, an upper-side second partitioning portion 62C includes only a second plate portion 621C arranged to extend substantially perpendicularly to the axial direction. In other words, the upper-side second partitioning portion 62C includes no second bend portion extending from the second plate portion 621C to the second axial side. Thus, a duct length of a second communicating passage 423C is equal to a thickness of the upper-side second partitioning portion 62C. In addition, a lower-side second partitioning portion 64C is arranged to have a shape similar to that of the upper-side second partitioning portion 62C.

[0061] As illustrated in FIG. 7, each partitioning portion may not include a bend portion to increase the duct length of a corresponding communicating passage. The first and second expansion-type silencers can exhibit silencing performance even when each of the first and second communicating passages has a short duct length as described above.

[0062] FIG. 8 is a sectional view of a motor module 10D according to yet another modification of the first preferred embodiment. In the motor module 10D according to the modification illustrated in FIG. 8, each of a first communi-

cating passage 421D and a second communicating passage 423D is arranged along an inner wall of a body portion 21D. In addition, the first and second communicating passages 421D and 423D are arranged to overlap at least in part with each other when viewed in the axial direction.

[0063] This allows an air flow generated by a fan 32D and traveling to the second axial side along the inner wall of the body portion 21D to easily enter into the first communicating passage 421D and the second communicating passage 423D. That is, a reduction in flow passage resistance in an upper-side flow passage 42D can be achieved. This leads to improved air blowing efficiency of the motor module 10D as a whole.

[0064] Note that, although the fan is a centrifugal fan in each of the above-described preferred embodiment and the modifications thereof, this is not essential to the present invention. Fans used in motor modules and vacuum cleaners according to other preferred embodiments of the present invention may be mixed flow fans.

[0065] Note that, although the flow passage is arranged to branch out into two flow passages on the downstream side of the fan in each of the above-described preferred embodiment and the modifications thereof, this is not essential to the present invention. Alternatively, only one flow passage may be provided on the downstream side of the fan. In this case, this sole flow passage may be an annular flow passage extending all the way around the motor in the circumferential direction. Also note that the flow passage may alternatively be arranged to branch out into three or more flow passages on the downstream side of the fan.

[0066] Note that, although the vacuum cleaner according to the above-described preferred embodiment is a handy-type vacuum cleaner, this is not essential to the present invention. Motor modules according to other preferred embodiments of the present invention may be installed in an upright-type or stick-type vacuum cleaner which is arranged to cause gas to be sucked into an air inlet through a suction head and a dust separation portion and be discharged through an air outlet, as is the case with the handy-type vacuum cleaner.

[0067] Also note that a motor module according to a preferred embodiment of the present invention may be installed in a so-called canister-type vacuum cleaner. The canister-type vacuum cleaner includes, in addition to a suction head and a dust separation portion, a hose portion arranged to join the suction head and the dust separation portion to each other. The motor module is arranged to cause gas to be sucked into an air inlet through the suction head, the hose portion, and the dust separation portion and be discharged through an air outlet.

[0068] Also note that the detailed shape of any member may be different from the shape thereof as illustrated in the accompanying drawings of the present application. For example, the shape of any of the air inlet, the air outlets, and the wall portions may be different from that according to each of the above-described preferred embodiment and the modifications thereof. Also note that features of the above-described preferred embodiment and the modifications thereof may be combined appropriately as long as no conflict arises.

[0069] Preferred embodiments of the present invention are applicable to, for example, motor modules and vacuum cleaners.

[0070] 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 from 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 motor module comprising:

a motor including a rotating portion arranged to rotate about a rotation axis;
a fan arranged on a first axial side of the motor to rotate together with the rotating portion; and
a casing arranged to house the motor and the fan therein; wherein

the casing includes:

a tubular body portion arranged to extend in an axial direction;
an air inlet arranged on the first axial side of the fan;
an air outlet arranged on a second axial side of the fan and radially outside of the motor;
a flow passage being a space arranged to join the air inlet and the air outlet to each other between the body portion and the motor; and
at least one partitioning portion arranged in the flow passage to partition the flow passage;

the flow passage includes:

a fan accommodating portion arranged to have the fan accommodated therein, and arranged to be in direct communication with the air inlet;
a first silencing chamber arranged to be in communication with the fan accommodating portion through a first communicating passage; and
a second silencing chamber arranged to be in communication with the first silencing chamber through a second communicating passage, and arranged to be in direct or indirect communication with the air outlet;

the first silencing chamber is arranged to have a flow passage cross-sectional area greater than a flow passage cross-sectional area of the first communicating passage; and

the second silencing chamber is arranged to have a flow passage cross-sectional area greater than a flow passage cross-sectional area of the second communicating passage.

2. The motor module according to claim 1, wherein the at least one partitioning portion includes:

a plate-shaped first partitioning portion arranged between the fan accommodating portion and the first silencing chamber; and
a plate-shaped second partitioning portion arranged between the first and second silencing chambers.

3. The motor module according to claim 2, wherein the first partitioning portion includes:

a first plate portion arranged to extend substantially perpendicularly to the axial direction; and
a first bend portion arranged to extend from the first plate portion to the second axial side.

4. The motor module according to claim 2, wherein the second partitioning portion includes:

a second plate portion arranged to extend substantially perpendicularly to the axial direction; and
a second bend portion arranged to extend from the second plate portion to the second axial side.

5. The motor module according to claim 1, wherein each of the first and second communicating passages is arranged along an inner wall of the body portion; and the first and second communicating passages are arranged to overlap at least in part with each other when viewed in the axial direction.
6. The motor module according to claim 1, wherein the first communicating passage is arranged along an inner wall of the body portion; the second communicating passage is arranged along the motor; and the first and second communicating passages are arranged at different positions when viewed in the axial direction.
7. The motor module according to claim 1, wherein the casing further includes a motor covering portion arranged between the motor and the flow passage; and at least a portion of the flow passage is surrounded by the motor covering portion and the body portion.
8. The motor module according to claim 1, wherein the air outlet is a through hole defined in the body portion, and is arranged to be in direct communication with the second silencing chamber.
9. The motor module according to claim 8, wherein the casing further includes a partition wall portion arranged to divide the second silencing chamber and a space on the second axial side of the second silencing chamber from each other on the second axial side of the air outlet.
10. The motor module according to claim 1, wherein the casing includes:
 - a first casing defined by a single monolithic member; and
 - a second casing defined by a single monolithic member; and
 the first and second casings include contact surfaces arranged to be in contact with each other on a plane passing through the rotation axis.
11. The motor module according to claim 10, wherein the first casing includes a projecting portion arranged to project from the plane toward the second casing; the second casing includes a recessed portion recessed from the plane; and the projecting portion is fitted into the recessed portion.
12. A handy-type, upright-type, or stick-type vacuum cleaner comprising:
 - a suction head;
 - a dust separation portion arranged to separate dust included in an air flow from the air flow; and
 the motor module of claim 10; wherein the casing includes a handle portion arranged to be substantially symmetrical with respect to the plane; and the motor module is arranged to cause gas to be sucked into the air inlet through the suction head and the dust separation portion and be discharged through the air outlet.
13. A canister-type vacuum cleaner comprising:
 - a suction head;
 - a dust separation portion arranged to separate dust included in an air flow from the air flow;
 - a hose portion arranged to join the suction head and the dust separation portion to each other; and
 the motor module of claim 1; wherein the motor module is arranged to cause gas to be sucked into the air inlet through the suction head, the hose portion, and the dust separation portion and be discharged through the air outlet.

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