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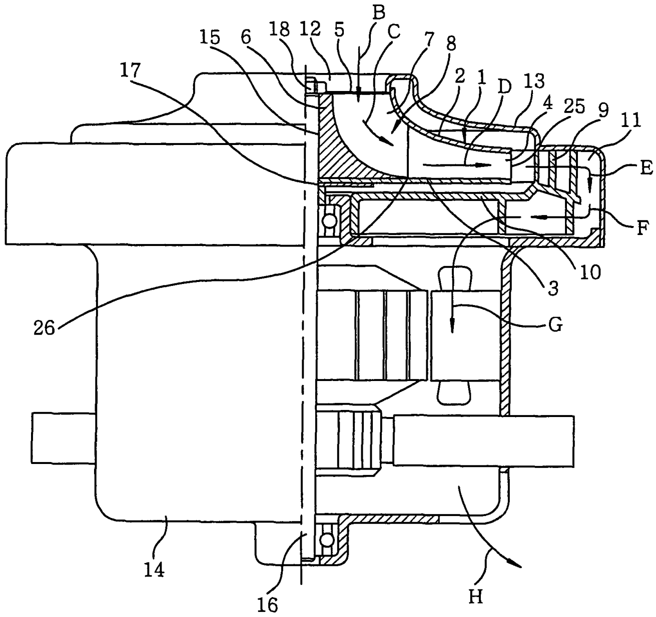
(54) **Electric blower and electric cleaner using the same**

(57) There is provided an electric blower capable of satisfactorily enhancing the blowing efficiency of an impeller and an electric cleaner having the electric blower. In the electric blower of the present invention, an area of a passage cross-section perpendicular to a center line of a passage, defined by front shroud 2, rear shroud 3 and hub 6 of inducer 8 from inlet 5 to outlet 25 of impeller 1, is monotonically increased from inlet 5 to outlet 25. Accordingly, air flow speed depending on the flow rate in impeller 1 is gradually decreased throughout the whole passage from inlet 5 to outlet 25, so that acceleration or rapid deceleration of the air flow speed is prevented, thereby satisfactorily enhancing the blowing efficiency.

FIG. 1



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Description

[0001] The present invention relates to an electric blower capable of enhancing the blowing efficiency of an impeller, and to an electric cleaner using the electric blower.

[0002] Conventionally, there have been proposed electric blowers enhancing blowing efficiencies of impellers thereof (see, e.g., Japanese Patent Laid-open Application No. 2006-9669).

[0003] As shown in Fig. 10, in a conventional electric blower, impeller 40 includes front shroud 41, rear shroud 42 and a plurality of blades 43 provided between front and rear shrouds 41 and 42. Front shroud 41 is inclined such that a distance between front shroud 41 and rear shroud (base plate) 42 is gradually decreased as it goes from the central portion of the impeller 40 to the outer edge thereof (a > b > c > d). Furthermore, front shroud 41 is of a curved shape in a radial cross-section thereof. In this way, as shown in Fig. 11A, from the inner periphery of impeller 40 to the outer periphery thereof (from an inlet to an outlet of a passage), the cylindrical cross-sectional area of the passage is linearly increased in a radial direction. Accordingly, as shown in Fig. 11B, the variation of current speed in the radial direction is linearly reduced from the passage inlet to the passage outlet.

[0004] However, in the above-described conventional configuration, the front shroud is opened at an inlet of impeller 40 and a direction of a flow of the air drawn therethrough is bent from a direction parallel to a rotating shaft of impeller 40 to a radial direction, and thus, the above-mentioned linear relationship from the inlet to the outlet of the impeller cannot be realized with only the variation in the distance between front and rear shrouds 41 and 42 and the curved shape of front shroud 41. Accordingly, it is impossible to design the passage to have a sufficient cross-sectional area to satisfactorily enhance the blowing efficiency of the impeller.

[0005] It is, therefore, an object of the present invention to provide an electric blower capable of satisfactorily enhancing the blowing efficiency of an impeller from an inlet to an outlet thereof, and to an electric cleaner using the electric blower.

[0006] In order to achieve the above object, an electric blower of the present invention includes an impeller having a front shroud, a rear shroud and a plurality of blades provided therebetween; and an inducer having a hub provided in the impeller, wherein an area of a passage cross-section perpendicular to the center line of a passage running from an inlet to an outlet of the impeller, defined by the front shroud, the rear shroud and the hub of the inducer, is monotonically increased from the inlet to the outlet.

[0007] With such arrangements, the air flow speed depending on the flow rate in the impeller is gradually decreased throughout the entire passage from the inlet to the outlet. Therefore, because acceleration or rapid deceleration of the air flow speed is not repeated, the blowing efficiency can be satisfactorily enhanced.

[0008] Furthermore, the electric cleaner using the electric blower has a high suction performance, thus achieving a satisfactory cleaning operation.

[0009] In accordance with a first aspect of the present invention, there is provided an electric blower, including: an impeller having a front shroud, a rear shroud, and a plurality of main blades provided between the front and rear shrouds; an inducer having a hub disposed in an inlet of the impeller; an air guide provided around the circumferential outer edge of the impeller; a casing enclosing the impeller and the air guide and having an intake opening at a central position thereof; and an electric motor rotating the impeller, wherein the area of a passage cross-section perpendicular to the center line of a passage extending from the inlet to an outlet of the impeller, defined by the front shroud, the rear shroud and the hub of the inducer, is monotonically increased from the inlet to the outlet. Accordingly, the air flow speed depending on the flow rate in the impeller is gradually decreased throughout the entire passage from the inlet to the outlet, and acceleration and rapid deceleration of the air flow speed is not repeated, so that the blowing efficiency of the electric blower can be satisfactorily enhanced.

[0010] Preferably, the monotonic increase in the passage cross-sectional area is substantially linear. In this way, the air flow speed depending on the flow rate in the impeller decreases at a constant rate with respect to the flow direction in the cross-section of the rotating shaft, thus preventing the air flow speed from abruptly decreasing.

[0011] Furthermore, a variation rate of the monotonic increase in the passage cross-sectional area from the inlet of the impeller to the outer edge of the hub preferably differs from that from the outer edge of the hub to the outlet. In this way, the portion from the inlet to the hub outer edge and the portion from the hub outer edge to the outlet can be separately designed. The portion adjacent to the inlet is configured such that the passage cross-sectional area is monotonically increased at a variation rate that makes it possible to reduce loss attributable to a secondary current or a vortex due to a separation of air flow occurring when the air flow drawn through the inlet is varied from the direction of the rotating shaft to the radial direction. Furthermore, the portion adjacent to the outlet is configured such that the passage cross-sectional area monotonically increases at a variation rate that makes it possible to reduce loss attributable to rotational friction (rotational friction loss) between air and the surface of the impeller or a vortex due to a separation of air flow occurring when the air is discharged in the radial direction. As a result, the blowing efficiency can be enhanced.

[0012] Preferably, the variation rate of the monotonic increase in the passage cross-sectional area from the inlet of the impeller to the outer edge of the hub is greater than that from the outer edge of the hub to the outlet. In this way, by compensating a reduction in an area through which air actually flows due to a secondary current or a vortex by a separation of air flow occurring when the flow direction of air drawn is varied from the direction of the rotating shaft to the radial direction, the monotonic increase in the passage cross-sectional area can be made to be substantially linear. As a result, the air flow speed depending on the flow rate in the impeller decreases at a constant rate with respect to the flow direction in the cross-section of the rotating shaft, thus preventing a rapid deceleration.

[0013] In addition, the variation rate of the monotonic increase in the passage cross-sectional area from the inlet of the impeller to a position at an upstream side of the outer edge of the hub may differ from that from a position at a downstream side of the outer edge of the hub to the outlet, each variation rate of the monotonic increases being substantially linear, and a curved variation section may be provided between the positions at the upstream and the downstream side of the outer edge of the hub to connect the monotonic increase sections of the passage cross-sectional area. Accordingly, the passage cross-sectional area can smoothly and monotonically increase from the inlet of the impeller to the hub outer edge and from the hub outer edge to the outlet, so that the flow speed of components depending on the flow rate in the impeller can be smoothly decreased.

[0014] Preferably, the passage has a parallel section, which is substantially parallel to a direction of a rotating shaft, at the inlet of the impeller. In this way, air is drawn into the inlet of the impeller in the direction parallel to the rotating shaft, and the air flow in the direction parallel to the rotating shaft can be smoothly changed in a radial direction.

[0015] Further, the inducer may be made of resin, and the front shroud, the rear shroud and the blades may be made of sheet metal. Accordingly, the passage in the inducer adjacent to the inlet of the impeller and the passage in the sheet metal part (defined by the front shroud and the rear shroud) adjacent to the outlet can be separately manufactured by using different methods, so that the impeller can be made with ease.

[0016] In accordance with a second aspect of the present invention, there is provided an electric cleaner including the electric blower, thus ensuring a high suction performance and a satisfactory cleaning operation.

[0017] The above and other objects and features of the present invention will become apparent from the following description of embodiments, given in conjunction with the accompanying drawings, in which:

Fig. 1 shows a half cross-sectional view of an electric blower in accordance with a first embodiment of the present invention;

Fig. 2 illustrates a partially cut-out top view of an impeller of the electric blower;

Fig. 3 depicts a cross-sectional view of the impeller of the electric blower;

Fig. 4A is a graph showing a passage cross-sectional area perpendicular to a center line of a passage in the impeller of the electric blower as a function of a distance from an inlet on the center line of the passage, and Fig. 4B is a graph showing an air flow speed along the center line of the passage as a function of a distance from the inlet on the center line of the passage;

Fig. 5A is a graph showing a passage cross-sectional area perpendicular to a center line of a passage of an impeller of an electric blower in accordance with a second embodiment of the present invention as a function of a distance from an inlet on the center line of the passage, and Fig. 5B is a graph showing an air flow speed along the center line of the passage as a function of a distance from the inlet on the center line of the passage;

Fig. 6A is a graph showing a passage cross-sectional area perpendicular to a center line of a passage of an impeller as a function of a distance from an inlet on the center line of the passage in accordance with a modification of the second embodiment of the present invention, and Fig. 6B is a graph showing an air flow speed along the center line of the passage as a function of a distance from the inlet on the center line of the passage in accordance with the modification of the second embodiment;

Fig. 7A is a sectional view of an impeller of an electric blower in accordance with a third embodiment of the present invention, and Fig. 7B is a graph showing a passage cross-sectional area perpendicular to a center line of a passage of the impeller as a function of a distance from an inlet on a center line of the passage in accordance with the third embodiment;

Fig. 8A and 8B show exploded sectional views of an impeller of an electric blower in accordance with a fourth embodiment of the present invention;

Fig. 9 illustrates a cross-sectional view of an electric cleaner in accordance with a fifth embodiment of the present invention;

Fig. 10 is a cross-sectional view of an impeller of a conventional electric blower; and

Fig. 11A is a graph showing a passage cross-sectional area as a function of a diameter of the impeller shown in Fig. 10, and Fig. 11B is a graph showing air flow speed in radial direction as a function of a diameter of the impeller shown in Fig. 10.

[0018] Hereinafter, embodiments of the present invention will be described in detail with reference to the accompanying drawings. The present invention is not limited to the embodiments.

(First Embodiment)

[0019] Figs. 1 to 4B illustrate an electric blower in accordance with a first embodiment of the present invention.

[0020] As shown in Figs. 1 and 2, the electric blower in accordance with the first embodiment includes impeller 1 having front shroud 2, rear shroud 3 and a plurality of blades 4 provided between front and rear shrouds 2 and 3; inducer 8 having hub 6 of a conical shape disposed in inlet 5 of impeller 1 and inlet guide vanes 7 coupled to respective blades 4, inlet guide vanes 7 having a three-dimensionally curved surface; air guide 11 having a plurality of stationary vanes 9 provided around the circumferential outer edge of impeller 1 and base plate 10; casing 13 enclosing impeller 1 and air guide 11 and having at its central portion intake opening 12 corresponding to inlet 5 of impeller 1; and electric motor 14 for rotating impeller 1.

[0021] In a passage extending from inlet 5 to outlet 25 defined by front and rear shrouds 2 and 3 of impeller 1 and hub 6 of inducer 8, cross-sectional area of the passage, taken perpendicular to the center line of the passage, continuously increases without decreasing, that is, monotonically increases in a general sense.

[0022] In this embodiment, front shroud 2, rear shroud 3 and blades 4 of impeller 1 are made of metal sheets. These three elements are coupled to each other through, e.g., a caulking. Inducer 8 is made of resin. At a time when the three elements (front shroud 2, rear shroud 3 and blades 4) are assembled, inducer 8 is inserted therein to be fastened together. Inducer 8 is connected to the impeller 1 at outer edge 26 of hub 6, and inlet guide vanes 7 are connected to respective blades 4.

[0023] In impeller 1, rear shroud 3 and shaft insertion part 15 of hub 6 are fitted on rotating shaft 16 of electric motor 14 through washer 17 and nut 18.

[0024] Furthermore, a configuration of a cross-section (a meridian cross-section) of the passage from inlet 5 to outlet 25, which is defined by front and rear shrouds 2 and 3 and hub 6 of inducer 8, taken in the direction of rotating shaft 16, is shown in Fig. 3.

[0025] Specifically, when taking a cross-section of impeller 1 in the direction of rotating shaft 16, there are defined front curved line 19 of front shroud 2 and rear curved line 20 continuously formed of hub 6 and rear shroud 3 that is further extended beyond hub 6. A plurality of passage cross-section defining lines 22, each of which is perpendicular to passage center curved line 21, which extends along the approximate center between the two curved lines (front curved line 19 and rear curved line 20), is also defined. The area of an annular surface, formed by rotating each passage cross-section defining line 22 around the rotating shaft 16, defines the passage cross-sectional area at each corresponding position.

[0026] The passage cross-sectional areas at the respective corresponding positions from inlet 5 to outlet 25 along passage center curved line 21 monotonically increase such that the variation in the passage cross-sectional areas becomes substantially linear as illustrated in the graph of Fig. 4A. Accordingly, air flow speed from inlet 5 to outlet 25 is linearly decreased as illustrated in the graph of Fig. 4B.

[0027] In this embodiment, passage center curved line 21 is obtained by dividing each of front curved line 19 and rear curved line 20 into a same number of sections at regular intervals, connecting each pair of corresponding section points 23 by section lines 24, and drawing a curved line passing through the middle points of respective section lines 24.

[0028] The operations and functions of the electric blower constructed as set forth above will now be described.

[0029] Referring to Figs. 1 and 2, when impeller 1 coupled to electric motor 14 is rotated at a high speed (in the direction indicated by arrow A) to thereby draw air therein through intake opening 12 of casing 13 and inlet 5 of impeller 1 (in the direction of arrow B). The air flow direction is changed (along the direction of arrow C) from the direction of the rotating shaft 16 to the radial direction in a portion of each passage which is defined by front shroud 2, hub 6 and two adjacent inlet guide vanes 7. Subsequently, the air flows (in the direction of arrow D) through a portion of each passage which is defined by front shroud 2, rear shroud 3 and two adjacent blades 4. Thereafter, the air is discharged from the outer periphery of impeller 1.

[0030] The air discharged from impeller 1 flows between the stationary vanes 9 of the air guide 11 and strikes the circumferential sidewall of casing 13 (as designated by the arrow E). Then, the air flows along the rear surface of air guide 11 (designated by arrow F) and passes through electric motor 14 while cooling the interior of electric motor 14 (designated by arrow G). Subsequently, the air is discharged outside electric motor 14 through a discharge hole formed in electric motor 14 (as indicated by arrow H).

[0031] Here, in the passage from inlet 5 to outlet 25 defined by front and rear shrouds 2, 3 and hub 6 of inducer 8, because the area of the passage cross-section perpendicular to the passage increases monotonically, the flow speed of components depending on the flow rate in impeller 1 (components in the cross-section direction of rotating shaft 16) gradually decreases monotonically throughout the entire passage from inlet 5 to outlet 25 (Fig. 4B) without any abrupt decrease.

[0032] As described above, in this embodiment, in the passage cross-sections perpendicular to the passage from inlet 5 to outlet 25 defined by front and rear shrouds 2, 3 and hub 6 of inducer 8, the area of the passage cross-section monotonically increases in such a manner that the flow speed of components depending on the flow rate in impeller 1 (components in the cross-section direction of rotating shaft 16) gradually decreases throughout the whole passage from inlet 5 to outlet 25 without any abrupt decrease, which results in a significant increase of the blowing efficiency.

[0033] Furthermore, the monotonic increase in the passage cross-sectional area is made to be substantially linear as shown in Fig. 4A, and thus the flow speed of components depending on the flow rate in impeller 1 (components in the cross-section direction of rotating shaft 16) decreases at a constant rate with respect to the flow direction in the cross-section of rotating shaft 16, which prevents the air flow speed from abruptly decreasing.

(Second Embodiment)

[0034] Hereinafter, a second embodiment of the present invention will be described with reference to Figs. 5A to 6B. The basic configurations of the second embodiment are the same as those of the first embodiment, and redundant descriptions thereof will be omitted.

[0035] In this embodiment, as shown in Fig. 5A, the variation in the passage cross-sectional area of impeller 1 between inlet 5 and hub outer edge 26 differs from that between hub outer edge 26 and outlet 25, which in turn makes the air flow speed from inlet 5 to outlet 25 along passage center curved line 21 of impeller 1 vary as illustrated in the graph of Fig. 5B.

[0036] Accordingly, in this embodiment, the section from inlet 5 to hub outer edge 26 and the section from hub outer edge 26 to outlet 25 may be separately designed. At the side of inlet 5, the passage cross-sectional area is monotonically increased in such a way that it reduces the loss attributable to, e.g., a secondary current or a vortex due to a separation of air flow occurring when the flow direction of the air drawn through inlet 5 is changed from the direction along the rotating shaft 16 to the radial direction. Furthermore, at the side of outlet 25, the passage cross-sectional area is monotonically increased in such a manner that it reduces the loss attributable to, e.g., rotational friction (rotational friction loss) between air and the surface of impeller 1 or a vortex due to a separation of air flow occurring until the air is discharged in the radial direction. In this way, the blowing efficiency can be enhanced.

[0037] Furthermore, in this embodiment, the variation rate of the monotonic increase in the passage cross-sectional area of impeller 1 from inlet 5 to hub outer edge 26 is set to be greater than that of the passage cross-sectional area from hub outer edge 26 to outlet 25.

[0038] Accordingly, it is possible to compensate a reduction in an area through which the air actually flows due to a secondary current or a vortex by a separation of air flow occurring when the flow direction of the air drawn is changed from the direction along rotating shaft 16 to the radial direction, thereby making the monotonic increase in the passage cross-sectional area through which the air actually flows substantially linear. As a result, the flow speed of components depending on the flow rate in impeller 1 (components in the cross-section direction of rotating shaft 16) gradually decreases at a constant rate in the flow direction in the cross-section of rotating shaft 16, thus preventing rapid deceleration.

[0039] In addition, in this embodiment, as shown in Figs. 6A and 6B, the monotonic increase in the passage cross-sectional area of impeller 1 from inlet 5 of impeller 1 to a position A1 at upstream side of hub outer edge 26 differs from that in the passage cross-sectional area from a position A2 at downstream side of hub outer edge 26 to outlet 25, each monotonic increase being substantially linear. In addition, curved variation section 27 is provided between positions A1 and A2, which connects the substantially linear monotonic increase sections at the sides of inlet 5 and outlet 25.

[0040] In this way, the passage cross-sectional area can smoothly and monotonically increase from inlet 5 of impeller 1 to hub outer edge 26 and from hub outer edge 26 to outlet 25, so that the flow speed of components depending on the flow rate in impeller 1 (components in the cross-section of rotating shaft 16) can be smoothly decreased.

(Third Embodiment)

[0041] Next, a third embodiment of the present invention will be described with reference to Figs. 7A and 7B. The general configurations of the electric blower in accordance with the third embodiment are the same as those of the first embodiment, and redundant descriptions thereof will be omitted.

[0042] In this embodiment, as shown in Figs. 7A and 7B, impeller 1 has parallel section 28 of the passage, which is substantially parallel to the direction of rotating shaft 16, near the ends of front shroud 2 and hub 6 around inlet 5 of impeller 1, thus forming a ring-shaped intake passage which is parallel to rotating shaft 16.

[0043] With such an arrangement, air is drawn into inlet 5 of impeller 1 in a direction parallel to rotating shaft 16. Accordingly, it is possible to reduce the turbulence upon the air suction and then to smoothly change the whole air flow in the direction parallel to rotating shaft 16 to a flow in the radial direction.

(Fourth Embodiment)

[0044] Hereinafter, a fourth embodiment of the present invention will be described with reference to Figs. 8A and 8B. The general configurations of the electric blower in accordance with the fourth embodiment are the same as those of the first embodiment, and redundant descriptions thereof will be omitted.

[0045] Fig. 8A illustrates an inducer, and Fig. 8B shows the impeller from which the inducer has been removed.

[0046] In this embodiment, inducer 8 included in impeller 1 is made of resin, and front shroud 2, rear shroud 3 and blades 4 are made of sheet metal. Thus, in this embodiment, a passage cross-sectional area at hub outer edge 26 is made to be parallel to the direction of rotating shaft 16. In other words, in a case where rear shroud 3 is provided perpendicular to the rotating shaft 16, passage cross-section defining line 22 at hub outer edge 26 (the border between inlet guide vane 7 and blade 4) is perpendicular to rear shroud 3.

[0047] In this way, it is possible to separately manufacture the passage in inducer 8 at the side of inlet 5 of impeller 1 and that in the sheet metal part (defined between front shroud 2 and rear shroud 3) at the side of outlet 25, inducer 8 and the sheet metal part being made of different materials and through different methods. Therefore, impeller 1 can be manufactured with ease.

(Fifth Embodiment)

[0048] Fig. 9 illustrates an electric cleaner in accordance with a fifth embodiment of the present invention.

[0049] As shown in Fig. 9, electric blower 30 is installed in cleaner body 29, so that dust along with air is drawn into cleaner body 29 through intake nozzle 31. The drawn dust is collected in dust collection chamber 32.

[0050] Here, any one of the electric blowers in accordance with the first through fourth embodiments can be used as electric blower 30, thus increasing the suction performance of the electric cleaner and reducing the energy consumption thereof.

[0051] As described above, an electric blower in accordance with the present invention can satisfactorily increase blowing efficiency and, therefore, can be widely applied to other household electrification appliances, industrial apparatuses and the like as well as the electric cleaner. Furthermore, the electric blower of the present invention can be also applied to a compressor, a turbine and a hydraulic pump.

Claims

1. An electric blower, comprising:

> an impeller having a front shroud, a rear shroud, and a plurality of blades provided between the front and rear shrouds;
> an inducer having a hub disposed in an inlet of the impeller;
> an air guide provided around an outer periphery of the impeller;
> a casing enclosing the impeller and the air guide and having an intake opening at a central position thereof; and
> an electric motor for rotating the impeller,

wherein an area of a passage cross-section perpendicular to a center line of a passage from the inlet to an outlet of the impeller, defined by the front shroud, the rear shroud and the hub of the inducer, is monotonically increased from the inlet to the outlet.

2. The electric blower of claim 1, wherein the monotonic increase in the passage cross-sectional area is substantially linear.

3. The electric blower of claim 1 or 2, wherein a variation rate of the monotonic increase in the passage cross-sectional area from the inlet of the impeller to an outer edge of the hub differs from that from the outer edge of the hub to the outlet.

4. The electric blower of claim 3, wherein the variation rate of the monotonic increase in the passage cross-sectional area from the inlet of the impeller to the outer edge of the hub is greater than that from the outer edge of the hub to the outlet.

5. The electric blower of claim 1, wherein a variation rate of the monotonic increase in the passage cross-sectional area from the inlet of the impeller to a position at an upstream side of an outer edge of the hub differs from that from a position at a downstream side of the outer edge of the hub to the outlet, each variation rate of the monotonic increases being substantially linear, and a curved variation section is provided between the positions at the upstream and the downstream side of the outer edge of the hub to connect the monotonic increase sections of the passage cross-sectional area.

6. The electric blower of any one of claims 1 to 5, wherein the passage has a parallel section, which is substantially parallel to a direction of a rotating shaft, at the inlet of the impeller.

7. The electric blower of any one of claims 1 to 6, wherein the inducer is made of resin, and the front shroud, the rear shroud and the blades are made of sheet metal.

8. An electric cleaner comprising the electric blower described in any one of claims 1 to 7.

FIG. 1

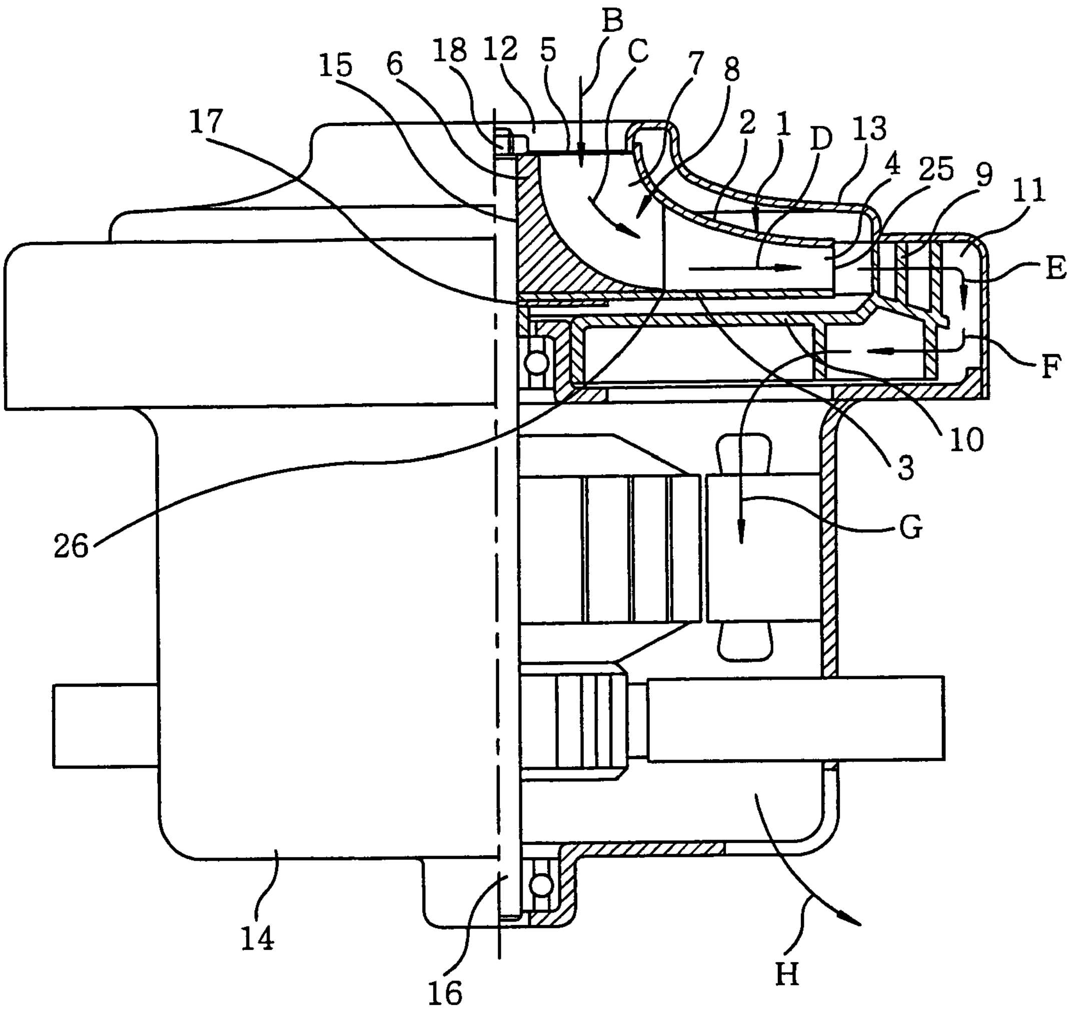


FIG.2

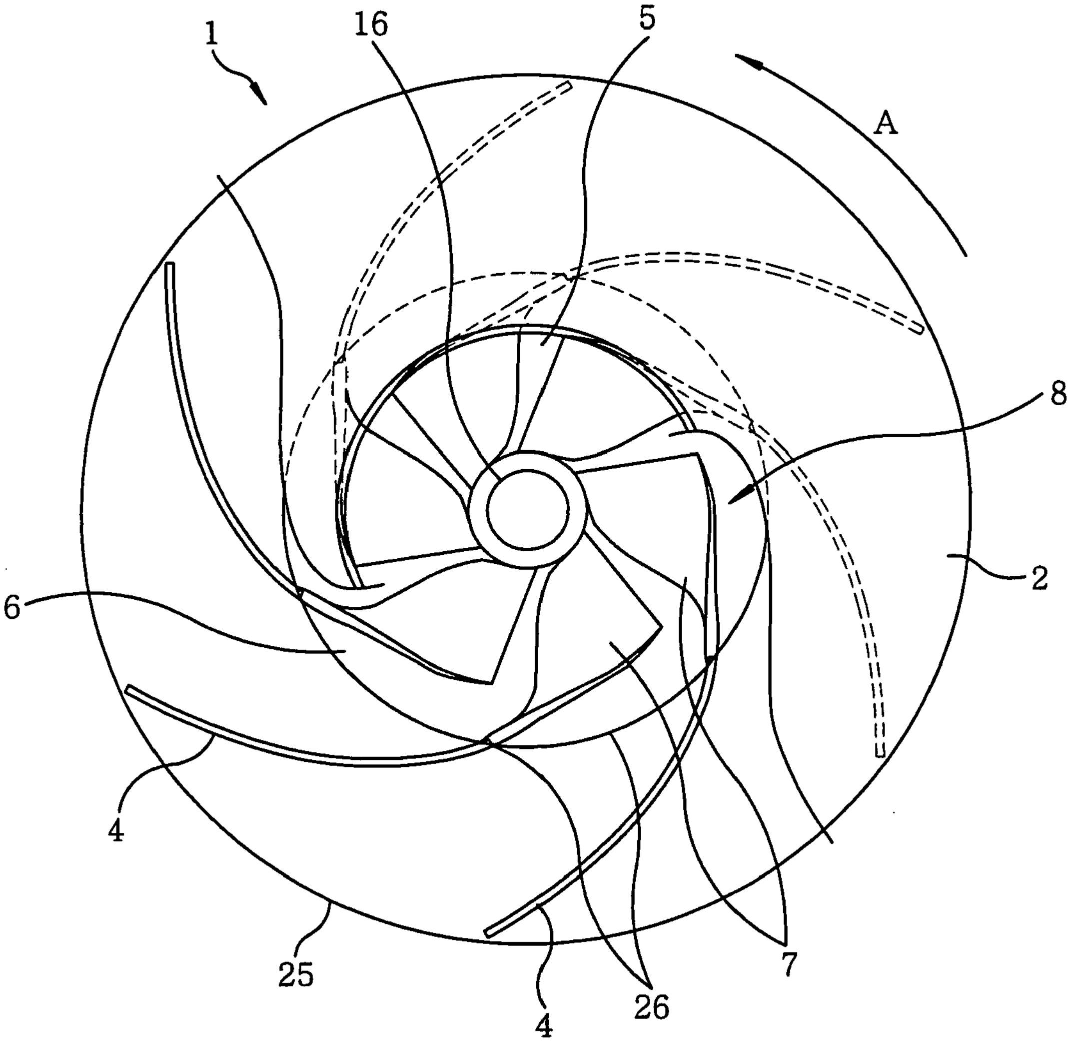


FIG.3

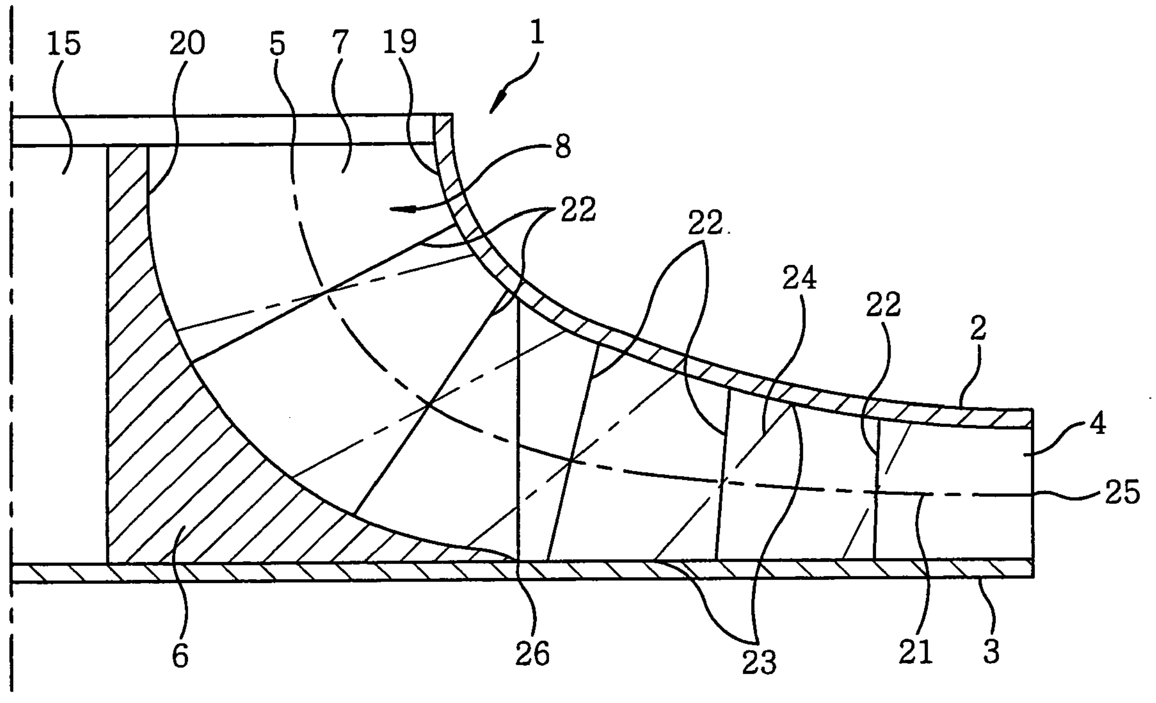


FIG. 4A

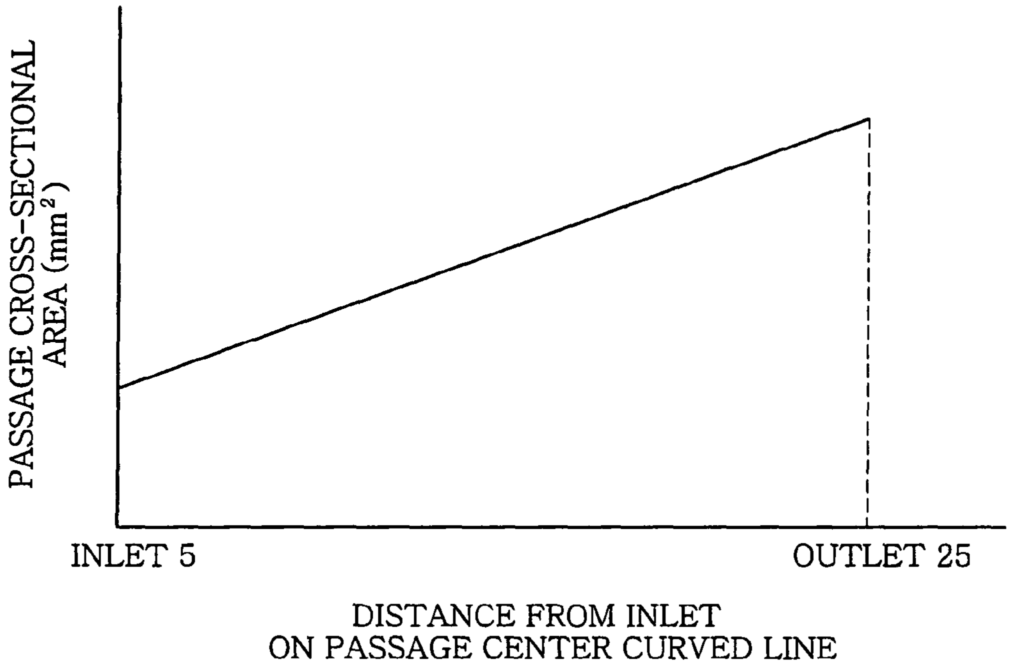

PASSAGE CROSS-SECTIONAL AREA (mm²)
INLET 5
OUTLET 25
DISTANCE FROM INLET ON PASSAGE CENTER CURVED LINE

FIG. 4B

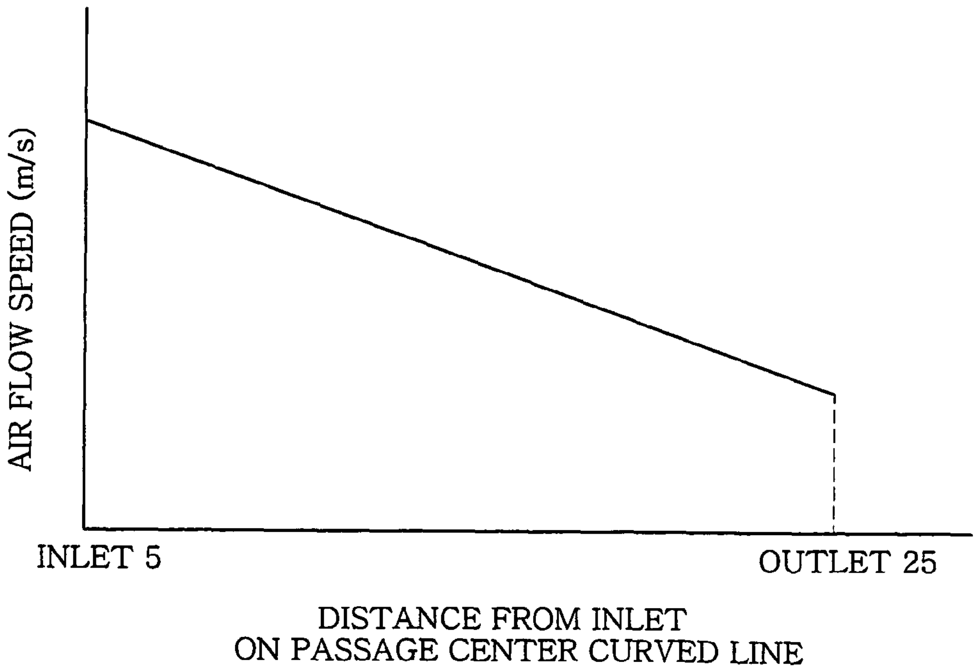

AIR FLOW SPEED (m/s)
INLET 5
OUTLET 25
DISTANCE FROM INLET ON PASSAGE CENTER CURVED LINE

FIG. 5A

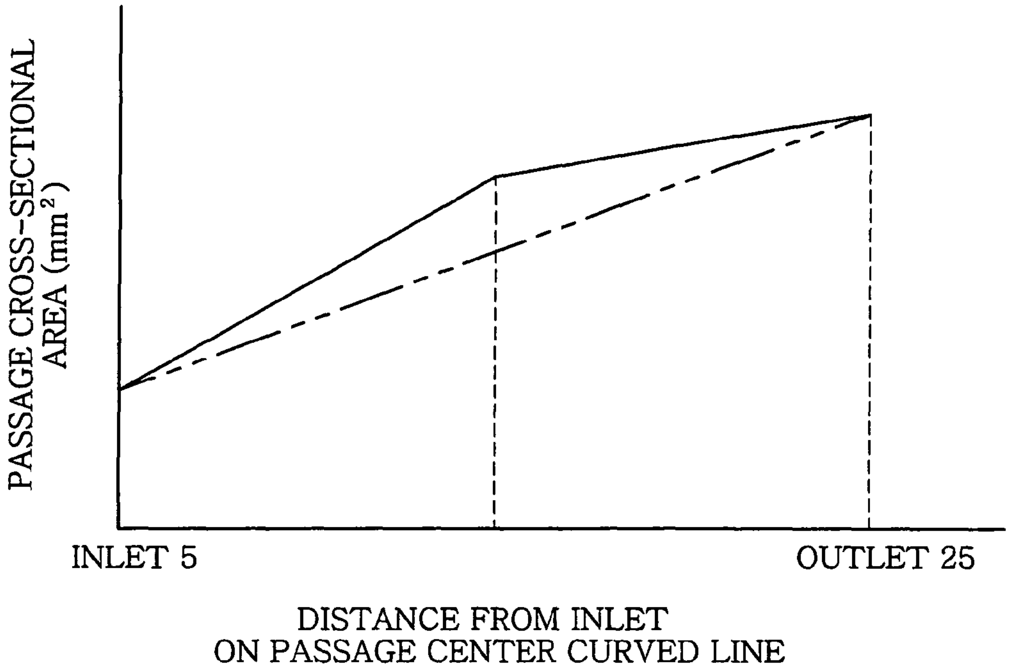

PASSAGE CROSS-SECTIONAL AREA (mm²)
INLET 5
OUTLET 25
DISTANCE FROM INLET ON PASSAGE CENTER CURVED LINE

FIG. 5B

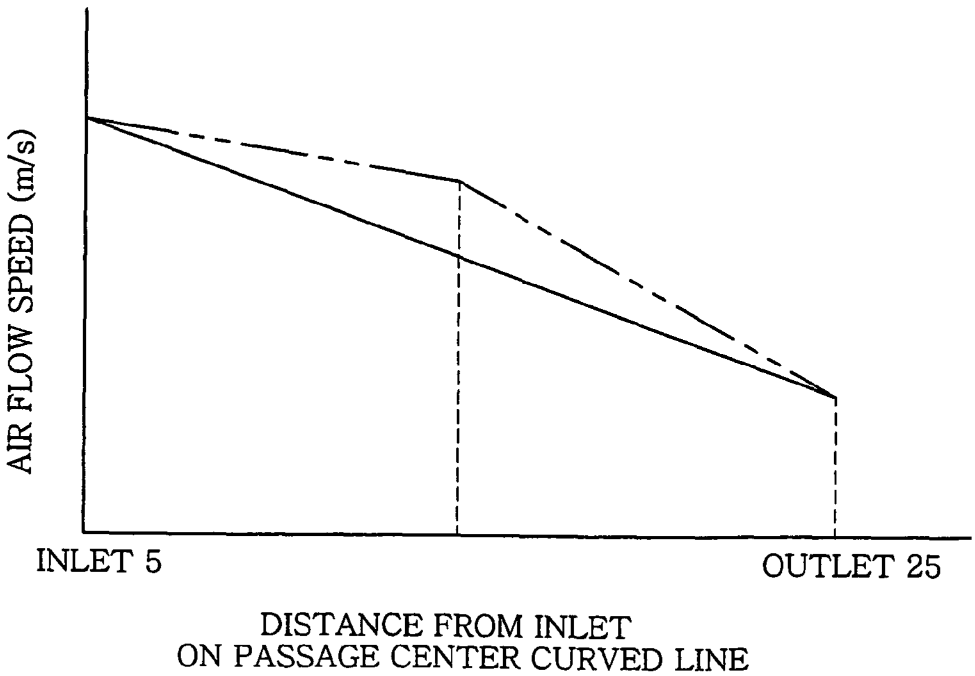

AIR FLOW SPEED (m/s)
INLET 5
OUTLET 25
DISTANCE FROM INLET ON PASSAGE CENTER CURVED LINE

FIG. 6A

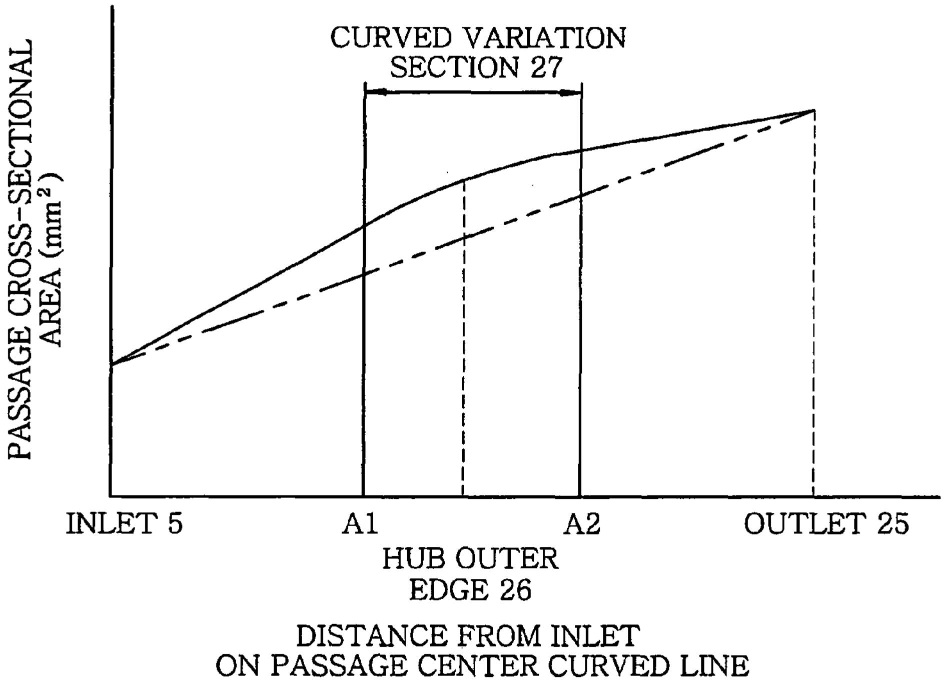

CURVED VARIATION
SECTION 27
PASSAGE CROSS-SECTIONAL
AREA (mm²)
INLET 5
A1
A2
OUTLET 25
HUB OUTER
EDGE 26
DISTANCE FROM INLET
ON PASSAGE CENTER CURVED LINE

FIG. 6B

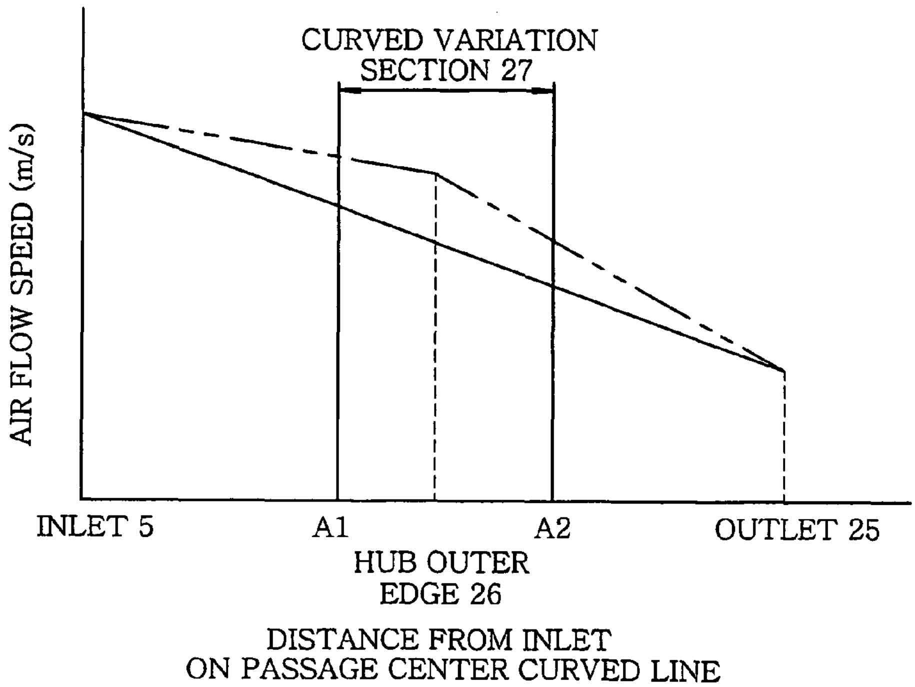

CURVED VARIATION
SECTION 27
AIR FLOW SPEED (m/s)
INLET 5
A1
A2
OUTLET 25
HUB OUTER
EDGE 26
DISTANCE FROM INLET
ON PASSAGE CENTER CURVED LINE

FIG. 7A

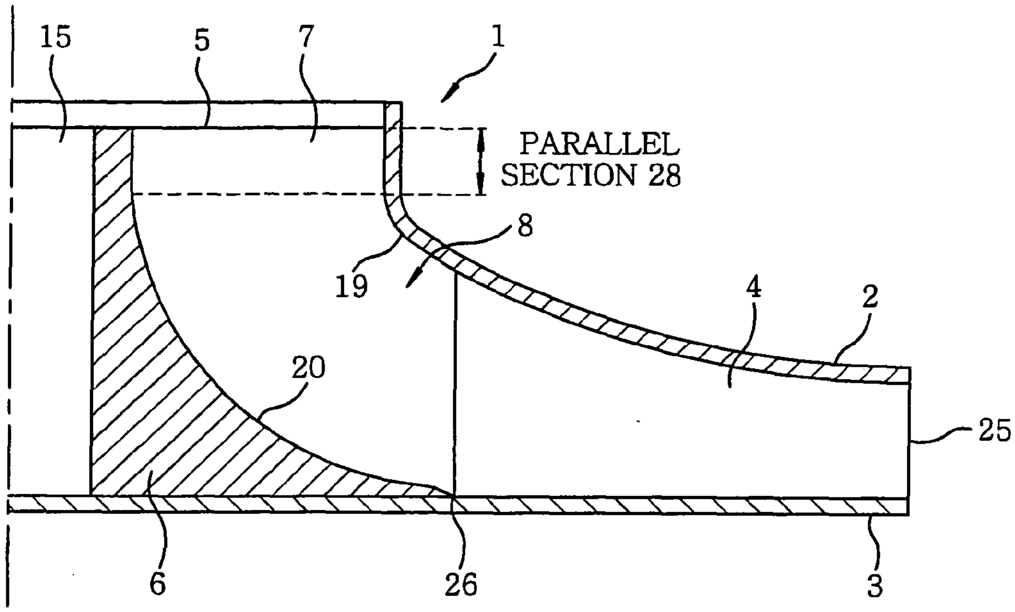

15
5
7
1
PARALLEL
SECTION 28
8
19
4
2
20
25
6
26
3

FIG. 7B

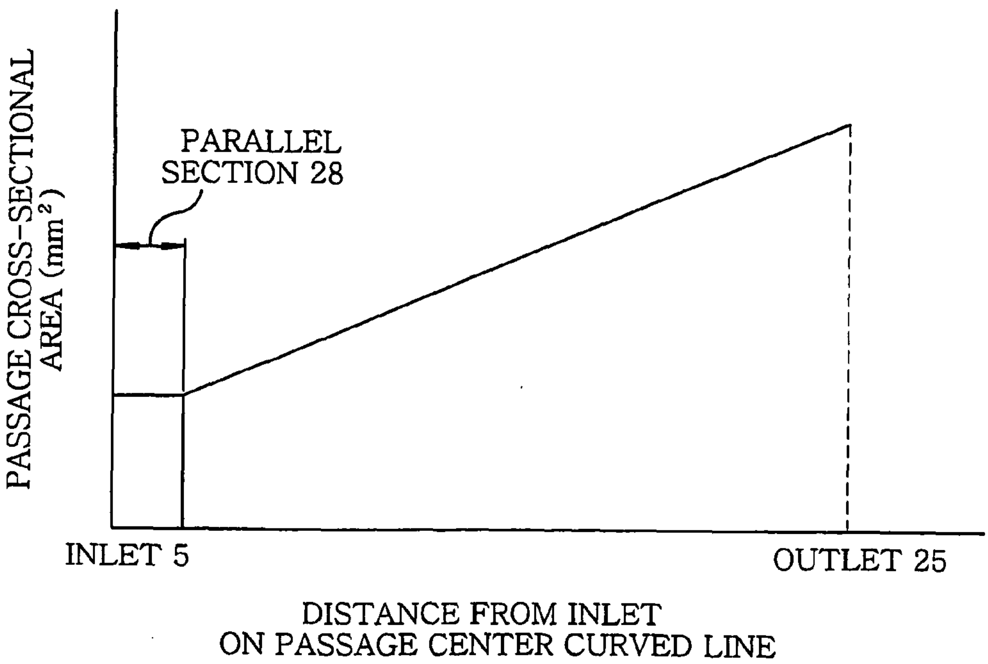

PASSAGE CROSS-SECTIONAL
AREA (mm²)
PARALLEL
SECTION 28
INLET 5
OUTLET 25
DISTANCE FROM INLET
ON PASSAGE CENTER CURVED LINE

FIG. 8A

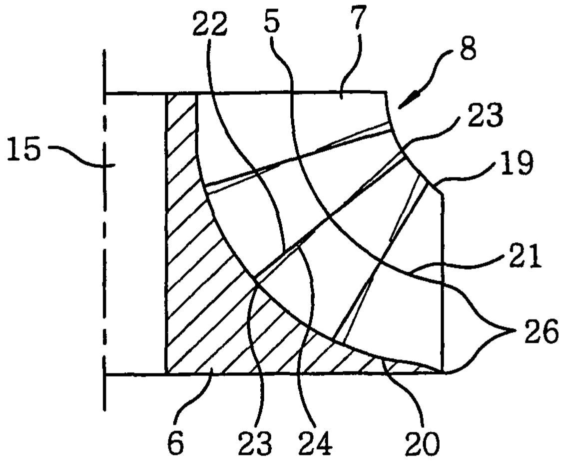


FIG. 8B

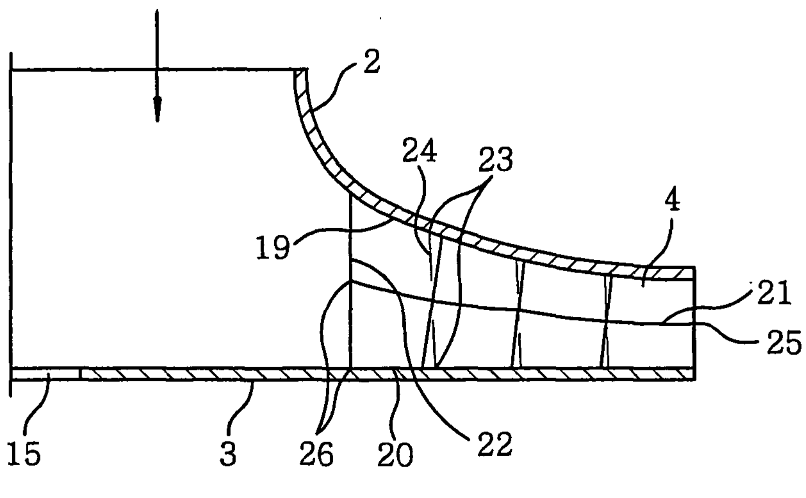


FIG. 9

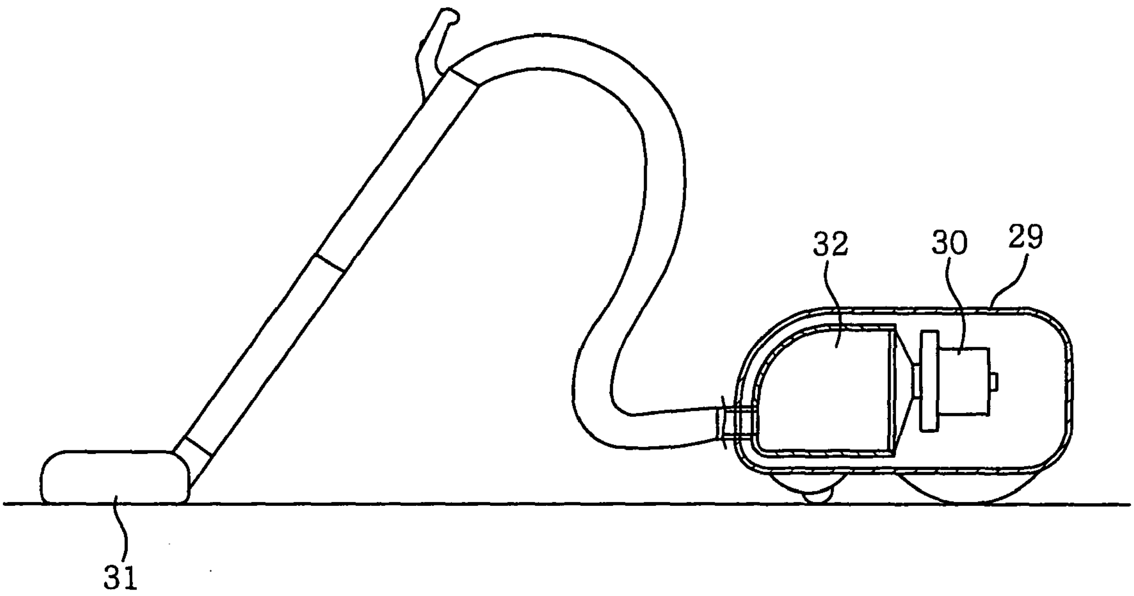


FIG. 10

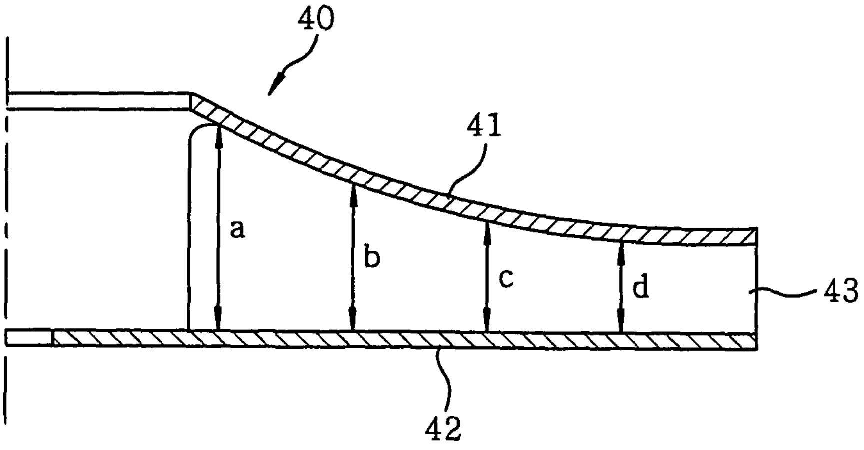


FIG. 11A

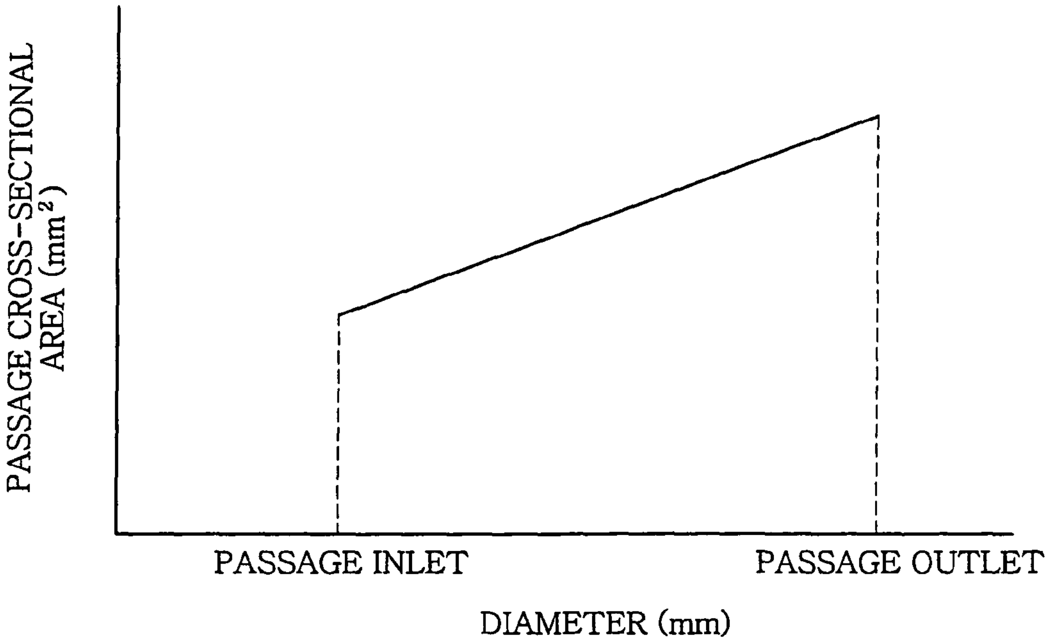
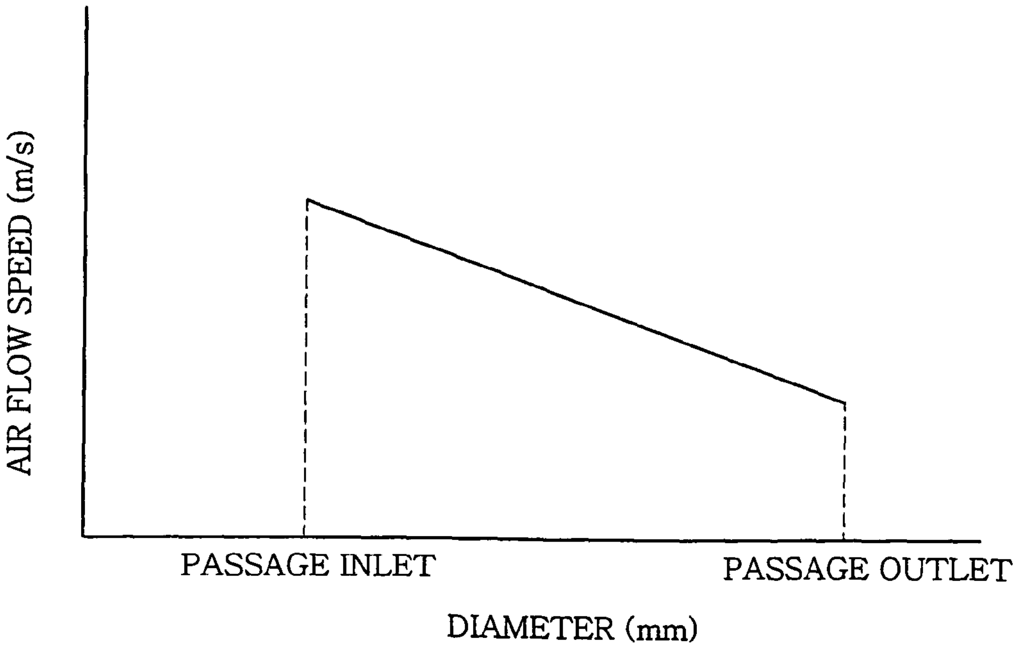


FIG. 11B



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2006009669 A **[0002]**