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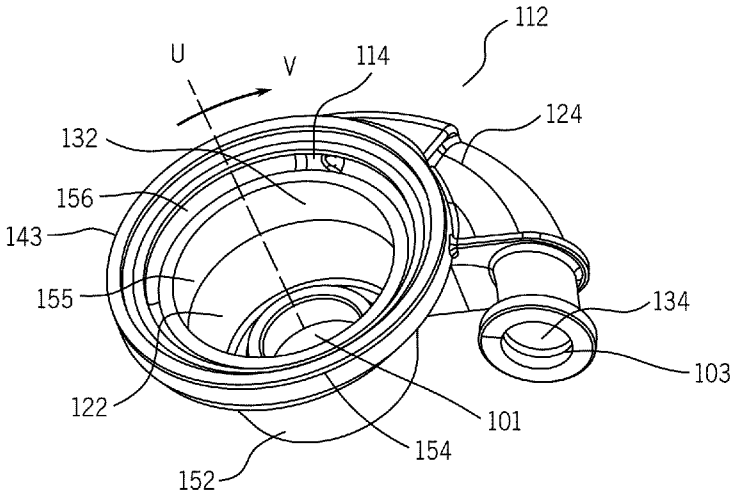

FIG. 1A

(57) Abstract: A volute assembly includes a volute (112), where the volute (112) includes a volute body (122) and a discharge tube (124), the volute body (122) defines an inner chamber (132), the discharge tube (124) defines a discharge flow channel (134), the volute body (122) and the discharge tube (124) are connected with each other, and the discharge flow channel (134) is in communication with the inner chamber (132). The volute assembly also includes a volute tongue (114), where the volute tongue (114) is detachably mounted to the volute (112), and is configured in such a manner that the inner chamber (132) and the discharge flow channel (134) are located on opposite sides of the volute tongue (114) when the volute tongue (114) is mounted to the volute (112).

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VOLUTE ASSEMBLY

TECHNICAL FIELD

The present application relates to the field of volutes, and in particular to a volute assembly.

BACKGROUND

In the prior art, a volute assembly comprises a volute and a volute tongue. The volute and the volute tongue are made by means of integral casting.

SUMMARY OF THE INVENTION

Exemplary embodiments of the present application can solve at least some of the above-described problems. The present application provides a volute assembly. The volute assembly comprises a volute and a volute tongue. The volute comprises a volute body defining an inner chamber and a discharge tube defining a discharge flow channel, the volute body and the discharge tube being connected with each other, and the discharge flow channel being in communication with the inner chamber. The volute tongue is detachably mounted to the volute, and is configured in such a manner that the inner chamber and the discharge flow channel are located on opposite sides of the volute tongue when the volute tongue is mounted to the volute.

According to the above-described volute assembly, the volute assembly further comprises at least one connecting member, wherein the volute tongue is configured to be mounted to the volute via the connecting member.

According to the above-described volute assembly, the volute is provided with at least one volute connecting hole thereon, and the volute tongue is provided with at least one volute tongue connecting hole thereon. The connecting member can be inserted into the volute connecting hole and the volute tongue connecting hole, thereby mounting the volute tongue to the volute.

According to the above-described volute assembly, the volute further comprises a volute connecting portion, and the volute connecting portion is connected with the volute body and the discharge tube. The at least one volute connecting hole is disposed on the volute connecting

portion.

According to the above-described volute assembly, the volute connecting portion comprises a volute connecting portion inner face and a volute connecting portion outer face that are arranged to oppose each other, wherein the volute connecting portion inner face faces the inner chamber, and the volute connecting portion outer face faces the discharge flow channel. The at least one volute connecting hole is formed by recessing from the volute connecting portion inner face to the volute connecting portion outer face.

According to the above-described volute assembly, the volute tongue comprises a volute tongue inner face and a volute tongue outer face that are arranged to oppose each other, the volute tongue inner face faces the inner chamber, and the volute tongue outer face faces the discharge flow channel.

According to the above-described volute assembly, on an inclined section, the volute tongue outer face and the volute tongue inner face have a first intersection point that is away from the discharge tube and a second intersection point that is close to the discharge tube, and a coordinate system is formed by using the first intersection point as the origin, the connection direction from the first intersection point to the second intersection point as the positive direction of the horizontal coordinate, and the direction pointing from the volute tongue inner face to the volute tongue outer face as the positive direction of the vertical coordinate. In the coordinate system, curves of the volute tongue inner face and the volute tongue outer face satisfy:

$$x_U = x - y_t \sin\theta \quad ; \quad y_U = y_c + y_t \cos\theta$$

$$x_L = x + y_t \sin\theta \quad ; \quad y_L = y_c - y_t \cos\theta$$

$$\frac{d_{yc}}{dx} = \begin{cases} \frac{2m}{p^2}(p - x) & 0 \le x \le p \\ \frac{2m}{(1-p)^2}(p - x) & p \le x \le 1 \end{cases}$$

$$y_t = 5t[0.2969\sqrt{x} - 0.1260x - 0.3156x^2 + 0.2843x^3 - 0.1015x^4]$$

$$\theta = \arctan\frac{d_{yc}}{dx}$$

wherein x_u, y_u are the horizontal coordinate and vertical coordinate of each point of the volute tongue outer face, X_l, Y_l are the horizontal coordinate and vertical coordinate of each point of the volute tongue inner face, the value range of t is $0.06 \leqslant t \leqslant 0.09$, the value range of m is: $0.05 \leqslant m \leqslant 0.09$, and the value range of p is: $0.4 \leqslant p \leqslant 0.5$.

According to the above-described volute assembly, the value range of the acute angle between the inclined section and the central axis of the volute is: equal to or greater than 40° and equal to or smaller than 50°.

According to the above-described volute assembly, the volute tongue comprises a volute tongue free end portion and a volute tongue connecting end portion that are arranged to oppose each other, as well as an abutting portion, and the abutting portion is formed by extending from the volute tongue connecting end portion and along the circumference of the volute assembly, and is used for abutting against the volute connecting portion, the at least one volute tongue connecting hole being provided on the abutting portion.

According to the above-described volute assembly, a guide structure is provided on the volute tongue connecting end portion and the volute connecting portion, so as to mount the volute tongue to the volute connecting portion.

According to the above-described volute assembly, the contact surface between the abutting portion and the volute connecting portion is a plane.

According to the above-described volute assembly, on the inclined section, the value range of the angle between the plane and the central axis of the volute assembly is: equal to or greater than 30° and equal to or smaller than 60°.

According to the above-described volute assembly, the volute tongue further comprises a volute tongue first face and a volute tongue second face that are arranged to oppose each other, and the volute tongue first face and the volute tongue second face are arranged between the volute tongue inner face and the volute tongue outer face. The volute tongue first face and the volute tongue second face respectively abut against the volute body.

According to the above-described volute assembly, the cross-section of the discharge flow channel is circular.

According to the above-described volute assembly, the volute is made through casting, and the volute tongue is made through machining.

According to the above-described volute assembly, the volute body comprises an opening portion, and the opening portion is ring shaped.

The volute tongue according to the present application can be detachably mounted to the volute, so that different processing modes may be adopted for the volute tongue and the volute, thereby achieving high flow channel smoothness.

Brief Description of the Accompanying Drawings

Features and advantages of the present application may be understood better by reading the detailed description below with reference to the accompanying drawings. In all the accompanying drawings, the same legends represent the same parts, wherein:

FIGS. 1A-1B are three-dimensional views of a volute assembly according to the present application;

FIG. 2A is an exploded view of the volute assembly shown in FIG. 1A;

FIG. 2B is a three-dimensional view of the volute shown in FIG. 1A;

FIG. 3 is a three-dimensional view of the volute tongue shown in FIG. 1A;

FIG. 4 is an axial cross-sectional view of the volute assembly shown in FIG. 1A;

FIG. 5 is a cross-sectional view of the volute assembly on an inclined section shown in FIG. 4;

FIG. 6 is a lines plan of the volute tongue shown in FIG. 5;

FIG. 7 is a cross-sectional view of a second embodiment of the volute tongue on an inclined section;

FIG. 8A is a graph of pneumatic efficiency comparison tests at a Mach number of 1.1 between an existing volute assembly and the volute assembly according to the present application; and

FIG. 8B is a graph of pneumatic efficiency comparison tests at a Mach number of 1.3 between an existing volute assembly and the volute assembly according to the present application.

Detailed Description

Various specific implementation manners of the present invention will be described below with reference to the accompanying drawings that constitute a part of this specification. It should be understood that terms indicating directions are used in the present invention, such as “front,” “back,” “up,” “down,” “left,” “right,” and the like, to describe various exemplary structural parts

and elements of the present invention in a directional or orientational manner, but the use of these terms herein is only for the purpose of easy description and determined based on the exemplary orientations shown in the accompanying drawings. Since the embodiments disclosed by the present invention may be arranged in different directions, these terms indicating directions are only used for description, not as limitations. In the accompanying drawings below, the same legends are used for the same parts.

FIG. 1A is a three-dimensional view of the volute assembly according to the present application when viewed from front to back and from bottom up, and FIG. 1B is a three-dimensional view of the volute assembly shown in FIG. 1A when viewed from back to front and from left up to right down, so as to illustrate the specific structure of the volute assembly. As shown in FIGS. 1A-1B, the volute assembly comprises a volute 112 and a volute tongue 114, wherein the volute 112 comprises a volute body 122 and a discharge tube 124. The volute assembly has a central axis U extending to front and back. The volute body 122 defines an inner chamber 132. The volute body 122 is formed by substantially surrounding the central axis U. A volute inlet 101 of the volute assembly is provided at the bottom (i.e., the back) of the volute body 122. The front of the volute body 122 has an opening portion 143. The opening portion 143 is substantially ring shaped and used to connect with an additional volute (not shown), such that the additional volute seals the opening portion 143.

Specifically, the volute body 122 comprises a cylindrical portion 152 and an arc portion 154. The cylindrical portion 152 is substantially a cylindrical portion that tapers towards the volute inlet 101. The arc portion 154 is provided in front of the cylindrical portion 152 and disposed to surround the external side of the cylindrical portion 152. More specifically, the starting end of the arc portion 154 is substantially located at the right side of the front of the cylindrical portion 152. After surrounding about ¾ circle of the cylindrical portion 152 in the clockwise direction (i.e., the V direction in FIG. 1A), the arc portion 154 is connected to the discharge tube 124 at the top of the cylindrical portion 152. The cylindrical portion 152 defines a cylindrical chamber 155. The arc portion 154 defines a communicating channel 156 that extends in an arc shape. The inner side of the communicating channel 156 is constantly in communication with the cylindrical chamber 155. The section of the communicating channel 156 is substantially circular, and the sectional area of

the communicating channel 156 gradually increases in the direction from the starting end to the place of connection with the discharge tube 124.

As shown in FIG. 1A, the discharge tube 124 is a substantially arc tub and defines a discharge flow channel 134. The starting end of the discharge tube 124 is substantially located above the volute body 122 and is connected to the arc portion 154. The discharge tube 124 extends from above to the right side of the volute body 122 in the clockwise direction. The discharge tube 124 and the arc portion 154 are integrally formed in a downward spiral shape. The discharge flow channel 134 has a circular cross-section, is in communication with the communicating channel 156, and forms a volute outlet 103 of the volute assembly at the free end. In this way, after entering the volute assembly via the volute inlet 101, a fluid can pass through the cylindrical chamber 155, the communicating channel 156, and the discharge flow channel 134, and flow out via the volute outlet 103. As an example, a fan may be provided in the cylindrical chamber 155 (not shown), so as to accelerate the fluid entering the volute assembly, and to cause the accelerated fluid to be discharged out of the volute assembly via the volute outlet 103.

In addition, the volute assembly further comprises a volute tongue 114. The volute tongue 114 is detachably mounted to the volute 112, and is configured in such a manner that the inner chamber 134 and the inner chamber 132 are located on opposite sides of the volute tongue 114 when the volute tongue 114 is mounted to the volute 112. As an example, the volute 112 is made through casting, and the volute tongue 114 is made through machining. As another example, the surface of the volute tongue 114 has a coating. For example, PTFE or epoxy resin is used for coating.

FIG. 2A is an exploded view of the volute assembly shown in FIG. 1A. As shown in FIG. 2A, the volute assembly further comprises two connecting members 216. The volute tongue 114 can be mounted to the volute 112 via the connecting members 216. Specifically, the volute 112 further comprises a volute connecting portion 252. The volute connecting portion 252 is connected with the volute body 122 and the discharge tube 124, and is substantially located at the place of connection between the arc portion 154 and the discharge tube 124. The volute connecting portion 252 is provided with two volute connecting holes 242 thereon. The volute tongue 114 is provided with two volute tongue connecting holes 244 thereon. The connecting members 216 can be inserted

into the volute tongue connecting holes 244 and the volute connecting holes 242, thereby connecting the volute tongue 114 and the volute 112. As an example, the connecting members 216 are screw bolts. The inner wall of the volute connecting holes 242 is formed with threads for cooperation with the screw bolts.

FIG. 2B is a three-dimensional view of the volute 112 shown in FIG. 2A. As shown in FIG. 2B, the volute connecting portion 252 comprises a volute connecting portion inner face 202 and a volute connecting portion outer face 204 that are arranged to oppose each other. The volute connecting portion inner face 202 faces the inner chamber 132, and the volute connecting portion outer face 204 faces the discharge flow channel 134. The volute connecting holes 242 are formed by recessing from the volute connecting portion inner face 202 to the volute connecting portion outer face 204. The volute connecting portion inner face 202 is farther away from the central axis U than the inner wall of the inner chamber 132, such that the volute connecting portion inner face 202 and the inner wall of the inner chamber 132 form a stair portion. When the volute tongue 114 is mounted to the volute 112, the volute tongue 114 just needs to abut against the volute connecting portion inner face 202. The volute connecting portion 252 is further provided with a dovetail groove 232. The dovetail groove 232 is formed by extending in an inclined manner along an inclined axis Z (see FIG. 3).

FIG. 3 is a three-dimensional view of the volute tongue 114 shown in FIG. 2, so as to illustrate a first embodiment of the volute tongue 114. As shown in FIG. 3, the volute tongue 114 comprises a volute tongue inner face 302 and a volute tongue outer face 304 that are arranged to oppose each other, as well as a volute tongue first face 306 and a volute tongue second face 308 that are arranged to oppose each other. The volute tongue first face 306 and the volute tongue second face 308 are arranged between the volute tongue inner face 302 and the volute tongue outer face 304. When the volute tongue 114 is mounted to the volute 112, the volute tongue inner face 302 faces the inner chamber 132, the volute tongue outer face 304 faces the discharge flow channel 134 (see FIGS. 4-5), and the volute tongue first face 306 and the volute tongue second face 308 respectively abut against the volute body 122. The volute tongue 114 further comprises a volute tongue free end portion 312 and a volute tongue connecting end portion 314 that are arranged to oppose each other. The volute tongue free end portion 312 is located at one end formed by enclosure of the volute

tongue inner face 302, the volute tongue outer face 304, the volute tongue first face 306, and the volute tongue second face 308. An abutting portion 315 is provided on the volute tongue connecting end portion 314. The abutting portion 315 is formed by extending from the volute tongue connecting end portion 314 and along the circumference of the volute assembly, and is used for abutting against the volute connecting portion 252. The volute tongue connecting holes 244 are disposed on the abutting portion 315. Specifically, the abutting portion 315 comprises an abutting portion inner face 322 and an abutting portion outer face 324. The abutting portion inner face 322 is in connection with and transitions to, in a smooth manner, the volute tongue inner face 302. When the volute tongue 114 is mounted to the volute 112, the abutting portion outer face 324 is tightly attached to the volute connecting portion inner face 202, the abutting portion inner face 322 smoothly transitions to the wall of the inner chamber 132, and the volute tongue outer face 304 smoothly transitions to the inner wall of the discharge tube 124. In addition, the volute tongue connecting end portion 314 is further provided with a dovetail projection 332 thereon. The dovetail projection 332 is formed by extending from the abutting portion outer face 324 substantially along the inclined axis Z. In the process of mounting the volute tongue 114 to the volute 112, the dovetail projection 332 can extend into the dovetail groove 232 substantially along the inclined axis Z, thereby guiding the volute tongue 114 to move relative to the volute connecting portion 252, and facilitating the mounting of the volute tongue 114 to the volute connecting portion 252.

It should be noted that although the present application illustrates a guide structure comprising the dovetail groove 232 and the dovetail projection 332, a guide structure in any other form and disposed on the volute tongue connecting end portion 314 and the volute connecting portion 252 falls within the scope of protection of the present application.

FIG. 4 is an axial vertical cross-sectional view of the volute assembly shown in FIG. 1A, so as to describe the inclined axis Z. As shown in FIG. 4, the volute assembly has the central axis U and the inclined axis Z. The central axis of the discharge tube 124 has a central point K on the vertical section. The inclined axis Z runs through the central point K of the discharge tube 124, and the acute angle between the inclined axis Z and the central axis U is substantially 40°. The inclined section is a plane where the inclined axis Z is located, which has an acute angle of substantially 40° with respect to a plane where the central axis U is located. As an example, in

other embodiments, the value range of the acute angle between the inclined section and the central axis U is: equal to or greater than 40° and equal to or smaller than 50°. As shown in FIG. 4, on the section in the vertical direction, the cross-sections of the volute connecting portion inner face 202 and the volute connecting portion outer face 204 are arc shaped. As a result, when a fluid enters the discharge flow channel 134 from the inner chamber 132, the volute tongue 114 can better guide the fluid, thereby reducing the resistance.

FIG. 5 is a cross-sectional view of the volute assembly on an inclined section shown in FIG. 4, and FIG. 6 is a lines plan of the volute tongue 114 shown in FIG. 5. Specifically, on the inclined section, the volute tongue outer face 304 and the volute tongue inner face 302 have a first intersection point O that is away from the discharge tube 124 and a second intersection point N that is close to the discharge tube 124, and a coordinate system is formed by using the first intersection point O as the origin, the connection direction from the first intersection point O to the second intersection point N as the positive direction of the horizontal coordinate X, and the direction pointing from the volute tongue inner face 302 to the volute tongue outer face 304 as the positive direction of the vertical coordinate Y.

In the above-described coordinate system, curves of the volute tongue outer face 304 and the volute tongue inner face 302 satisfy the following equations:

$$x_U = x - y_t \sin\theta \quad ; \quad y_U = y_c + y_t \cos\theta$$

$$x_L = x + y_t \sin\theta \quad ; \quad y_L = y_c - y_t \cos\theta$$

$$\frac{d_{yc}}{dx} = \begin{cases} \frac{2m}{p^2}(p - x) & 0 \le x \le p \\ \frac{2m}{(1-p)^2}(p - x) & p \le x \le 1 \end{cases}$$

$$y_t = 5t[0.2969\sqrt{x} - 0.1260x - 0.3156x^2 + 0.2843x^3 - 0.1015x^4]$$

$$\theta = \arctan\frac{d_{yc}}{dx}$$

wherein x_U, y_U are the horizontal coordinate and vertical coordinate of each point of the volute tongue outer face 304, X_L, Y_L are the horizontal coordinate and vertical coordinate of each point of

the volute tongue inner face 302, t is a ratio of the thickness to chord length of the volute tongue, and the value range of t is $0.06 \leqslant t \leqslant 0.09$. m is the maximum degree of curvature, and the value range of m is: $0.05 \leqslant m \leqslant 0.09$. p is a ratio of the maximum curvature position to the chord length, and the value range of p is: $0.4 \leqslant p \leqslant 0.5$.

For the volute tongue 114 having the above-described shape, its volute tongue free end portion 312 facing an incoming flow is thinner and thus can reduce the impact loss when the an incoming flow impacts the volute tongue 114.

FIG. 7 is a cross-sectional view of a second embodiment of the volute tongue 114 on the inclined section shown. The part of the volute tongue 114 shown in FIG. 7 that is the same as the part of the volute tongue 114 shown in FIG. 3 will not be repeated, and the main difference thereof lies in that the contact surface between the abutting portion 315 and the volute connecting portion 252 is a plane 702. On the inclined section, the value range of the angle φ between the plane 702 and the central axis of the volute assembly is: equal to or greater than 30° and equal to or smaller than 60°, so as to enhance the connecting strength between the volute tongue 114 and the volute connecting portion 252.

FIG. 8A is a graph of pneumatic efficiency comparison tests at a Mach number of 1.1 between an existing volute assembly and the volute assembly according to the present application, wherein the horizontal coordinate represents flow coefficient, i.e., a dimensionless number of inspiratory volume. The vertical coordinate represents pneumatic efficiency, i.e., the pneumatic efficiency at the standard Reynolds number. Here, the curve of the existing volute assembly is plotted in a solid line, and the curve of the volute assembly according to the present application is plotted in a dotted line. As shown in FIG. 8A, when the flow coefficient is in a range of 0.038-0.07, the pneumatic efficiency of the volute assembly according to the present application is higher than the pneumatic efficiency of the existing volute assembly, and in the vicinity of the pneumatic efficiency peak point (i.e., the flow coefficient is 0.045-0.055), the pneumatic efficiency of the volute assembly according to the present application is about 1% higher than the pneumatic efficiency of the existing volute assembly.

FIG. 8B is a graph of pneumatic efficiency comparison tests at a Mach number of 1.3 between an existing volute assembly and the volute assembly according to the present application, wherein the horizontal coordinate represents flow coefficient, i.e., a dimensionless number of inspiratory volume. The vertical coordinate represents pneumatic efficiency, i.e., the pneumatic efficiency at the standard Reynolds number. Here, the curve of the existing volute assembly is plotted in a solid line, and the curve of the volute assembly according to the present application is plotted in a dotted line. As shown in FIG. 8B, when the flow coefficient is in a range of 0.055-0.085, the pneumatic efficiency of the volute assembly according to the present application is consistently higher than the pneumatic efficiency of the existing volute assembly, and in the vicinity of the pneumatic efficiency peak point (i.e., the flow coefficient is 0.0625-0.0775), the pneumatic efficiency of the volute assembly according to the present application is about 1% higher than the pneumatic efficiency of the existing volute assembly.

It should be noted that although the present application illustrates two connecting members 216, two volute connecting holes 242, and two volute tongue connecting holes 244, any number of the connecting members 216 and corresponding numbers of the volute connecting holes 242 and the volute tongue connecting holes 244 fall within the scope of protection of the present application.

It should be further noted that although the connecting members 216 being screw bolts are used as an example in the present application for description, those skilled in the art should understand that other types of connecting members also fall within the scope of protection of the present application. For example, the connecting members 216 are screw rods, which connect the volute tongue 114 to the volute 112 by means of interference fit.

Most of existing volute assemblies are integrally molded through casting. However, the inventors of the present application found that integrally molded volute assemblies have relatively rough surfaces, and as a result, the volute assemblies have poor pneumatic performance.

The volute tongue in the volute assembly according to the present application can be

detachably mounted to the volute, so that different processing modes may be adopted for the volute tongue and the volute. For example, the volute tongue can be machined. Thus, the surface roughness of the volute tongue can reach Ra5 to Ra10, thereby achieving high flow channel smoothness. In addition, the volute tongue is mounted to the volute through positioning by the connecting members, which can simplify the position operation and mounting operation of the volute tongue.

Although the present disclosure has been described in combination with examples of the embodiments described briefly above, various alternative solutions, modifications, variations, improvements, and/or substantially equivalent solutions, regardless of known or foreseeable now or in the near future, may all be obvious to those of at least ordinary skills in the art. In addition, the technical effects and/or technical problems described herein are exemplary, rather than limiting, and therefore, the disclosure herein may be used to solve other technical problems and has other technical effects and/or can solve other technical problems. Therefore, the examples of the embodiments of the present disclosure as described above are intended to be illustrative, rather than limiting. Without departing from the spirit or scope of the present disclosure, various changes may be made. As a result, the present disclosure is intended to encompass all alternative solutions, modifications, variations, improvements, and/or substantially equivalent solutions that are known or developed earlier.

CLAIMS

1. A volute assembly, characterized in that the volute assembly comprises:

a volute (112), wherein the volute (112) comprises a volute body (122) and a discharge tube (124), the volute body (122) defines an inner chamber (132), the discharge tube (124) defines a discharge flow channel (134), the volute body (122) and the discharge tube (124) are connected with each other, and the discharge flow channel (134) is in communication with the inner chamber (132); and

a volute tongue (114), wherein the volute tongue (114) is detachably mounted to the volute (112), and is configured in such a manner that the inner chamber (132) and the discharge flow channel (134) are located on opposite sides of the volute tongue (114) when the volute tongue (114) is mounted to the volute (112).

2. The volute assembly according to claim 1, characterized in that the volute assembly further comprises:

at least one connecting member (216);

wherein the volute tongue (114) is configured to be mounted to the volute (112) via the connecting member (216).

3. The volute assembly according to claim 2, characterized in that

the volute (112) is provided with at least one volute connecting hole (242) thereon, and the volute tongue (114) is provided with at least one volute tongue connecting hole (244) thereon; and

the connecting member (216) can be inserted into the volute connecting hole (242) and the volute tongue connecting hole (244), thereby mounting the volute tongue (114) to the volute (112).

4. The volute assembly according to claim 3, characterized in that

the volute (112) further comprises a volute connecting portion (252), and the volute connecting portion (252) is connected with the volute body (122) and the discharge tube (124); and

the at least one volute connecting hole (242) is disposed on the volute connecting portion (252).

5. The volute assembly according to claim 4, characterized in that

the volute connecting portion (252) comprises a volute connecting portion inner face (202) and a volute connecting portion outer face (204) that are arranged to oppose each other, the volute connecting portion inner face (202) faces the inner chamber (132), and the volute connecting portion outer face (204) faces the discharge flow channel (134); and

the at least one volute connecting hole (242) is formed by recessing from the volute connecting portion inner face (202) to the volute connecting portion outer face (204).

6. The volute assembly according to claim 5, characterized in that

the volute tongue (114) comprises a volute tongue inner face (302) and a volute tongue outer face (304) that are arranged to oppose each other, the volute tongue inner face (302) faces the inner chamber (132), and the volute tongue outer face (304) faces the discharge flow channel (134).

7. The volute assembly according to claim 6, characterized in that

on an inclined section, the volute tongue outer face (304) and the volute tongue inner face (302) have a first intersection point that is away from the discharge tube (124) and a second intersection point that is close to the discharge tube (124), and a coordinate system is formed by using the first intersection point as the origin, the connection direction from the first intersection point to the second intersection point as the positive direction of the horizontal coordinate, and the direction pointing from the volute tongue inner face (302) to the volute tongue outer face (304) as the positive direction of the vertical coordinate;

in the coordinate system, curves of the volute tongue inner face (302) and the volute tongue outer face (304) satisfy:

$$x_U = x - y_t \sin\theta \quad ; \quad y_U = y_c + y_t \cos\theta$$

$$x_L = x + y_t \sin\theta \quad ; \quad y_L = y_c - y_t \cos\theta$$

$$\frac{d_{yc}}{dx} = \begin{cases} \frac{2m}{p^2}(p - x) & 0 \le x \le p \\ \frac{2m}{(1-p)^2}(p - x) & p \le x \le 1 \end{cases}$$

$$y_t = 5t[0.2969\sqrt{x} - 0.1260x - 0.3156x^2 + 0.2843x^3 - 0.1015x^4]$$

$$\theta = \arctan\frac{d_{yc}}{dx}$$

wherein x_U, y_U are the horizontal coordinate and vertical coordinate of each point of the volute tongue outer face (304), X_L, Y_L are the horizontal coordinate and vertical coordinate of each point of the volute tongue inner face (302), the value range of t is $0.06 \leqslant t \leqslant 0.09$, the value range of m is: $0.05 \leqslant m \leqslant 0.09$, and the value range of p is: $0.4 \leqslant p \leqslant 0.5$.

8. The volute assembly according to claim 7, characterized in that

the value range of the acute angle between the inclined section and the central axis of the volute (112) is: equal to or greater than 40° and equal to or smaller than 50°.

9. The volute assembly according to claim 6, characterized in that

the volute tongue (114) comprises a volute tongue free end portion (312) and a volute tongue connecting end portion (314) that are arranged to oppose each other, as well as an abutting portion (315), and the abutting portion (315) is formed by extending from the volute tongue connecting end portion (314) and along the circumference of the volute assembly, and is used for abutting against the volute connecting portion (252); and

the at least one volute tongue connecting hole (244) is provided on the abutting portion (315).

10. The volute assembly according to claim 9, characterized in that

a guide structure is provided on the volute tongue connecting end portion (314) and the volute connecting portion (252), so as to mount the volute tongue (114) to the volute connecting portion

(252).

11. The volute assembly according to claim 9, characterized in that

the contact surface between the abutting portion (315) and the volute connecting portion (252) is a plane (702).

12. The volute assembly according to claim 11, characterized in that

on the inclined section, the value range of the angle between the plane (702) and the central axis of the volute assembly is: equal to or greater than 30° and equal to or smaller than 60°.

13. The volute assembly according to claim 6, characterized in that

the volute tongue (114) further comprises a volute tongue first face (306) and a volute tongue second face (308) that are arranged to oppose each other, and the volute tongue first face (306) and the volute tongue second face (308) are arranged between the volute tongue inner face (302) and the volute tongue outer face (304); and

the volute tongue first face (306) and the volute tongue second face (308) respectively abut against the volute body (122).

14. The volute assembly according to claim 4, characterized in that

the cross-section of the discharge flow channel (134) is circular.

15. The volute assembly according to claim 1, characterized in that

the volute (112) is made through casting, and the volute tongue (114) is made through machining.

16. The volute assembly according to claim 1, characterized in that

the volute body (122) comprises an opening portion (143), and the opening portion (143) is ring shaped.

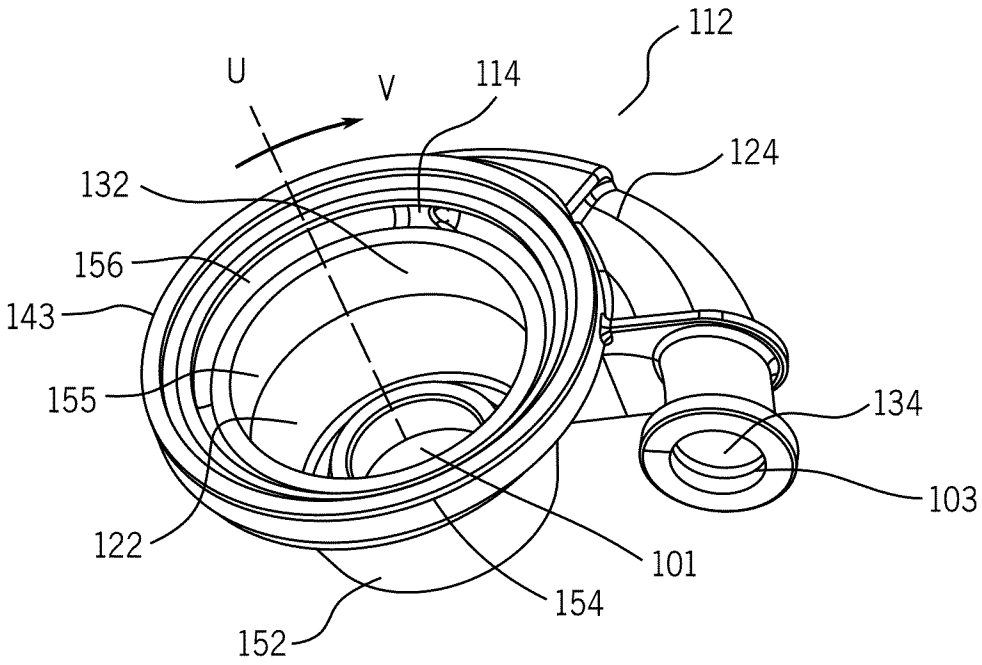
112
U
V
114
124
132
156
143
155
134
103
122
101
154
152

FIG. 1A

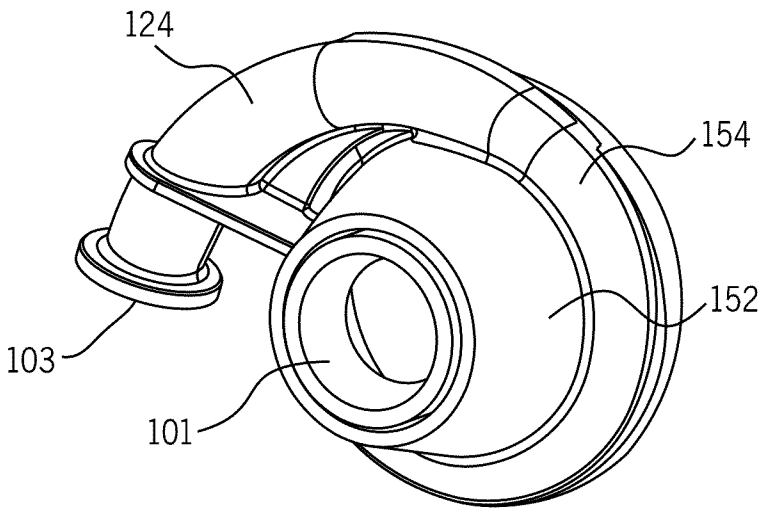
124
154
152
103
101

FIG. 1B

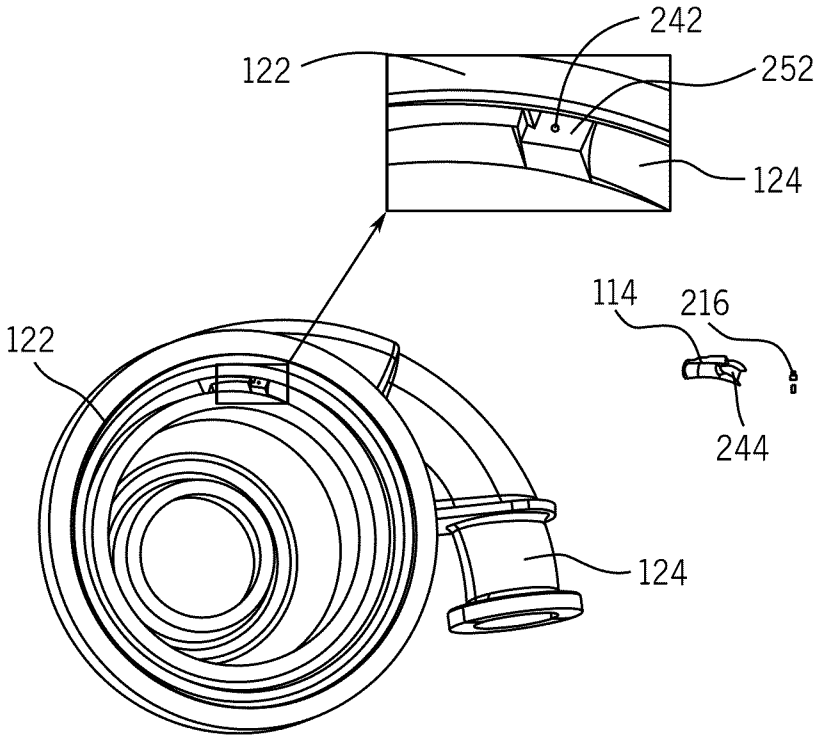

FIG. 2A

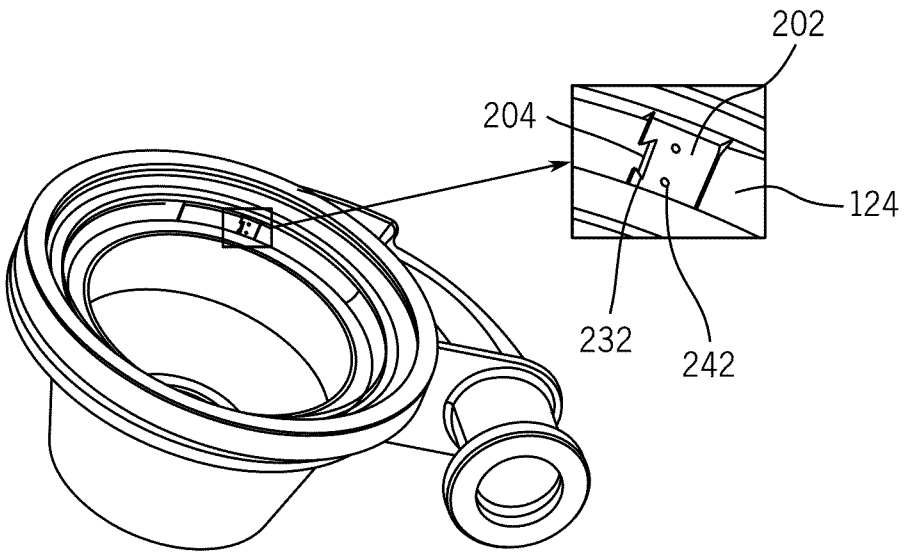

FIG. 2B

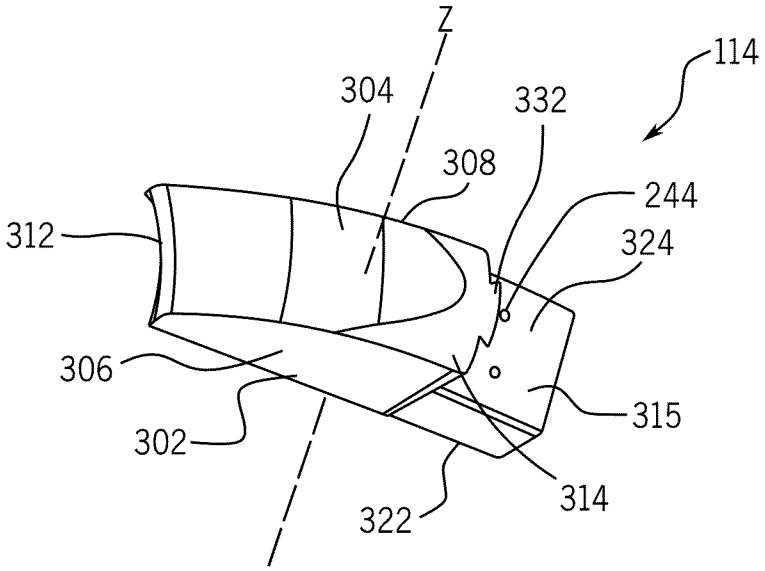
Z
114
304
332
308
244
312
324
306
315
302
314
322

FIG. 3

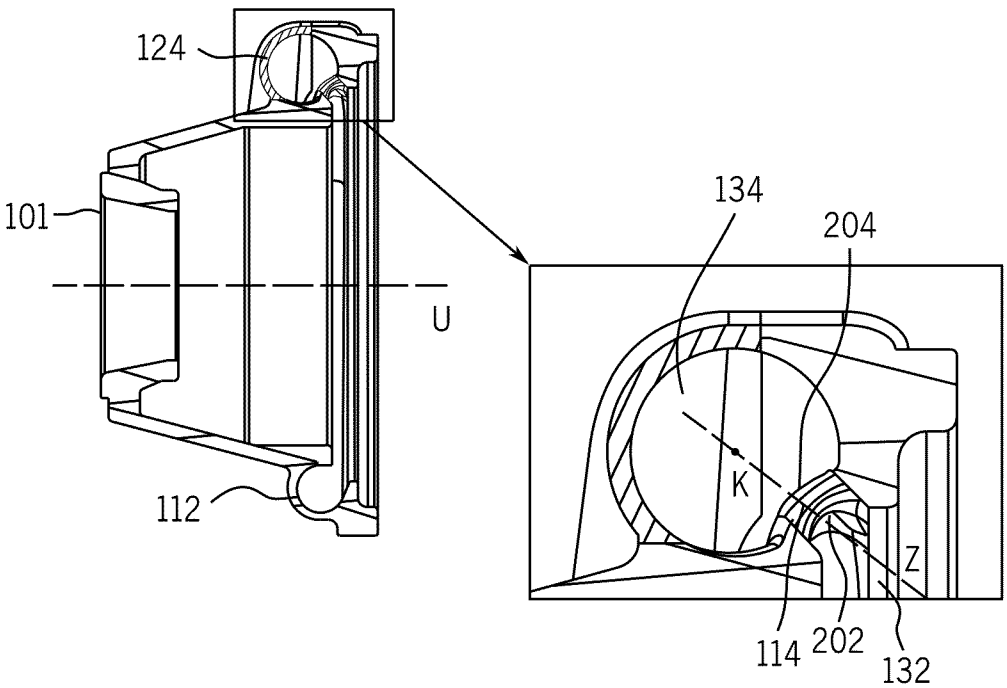
124
101
U
112
134
204
K
Z
114
202
132

FIG. 4

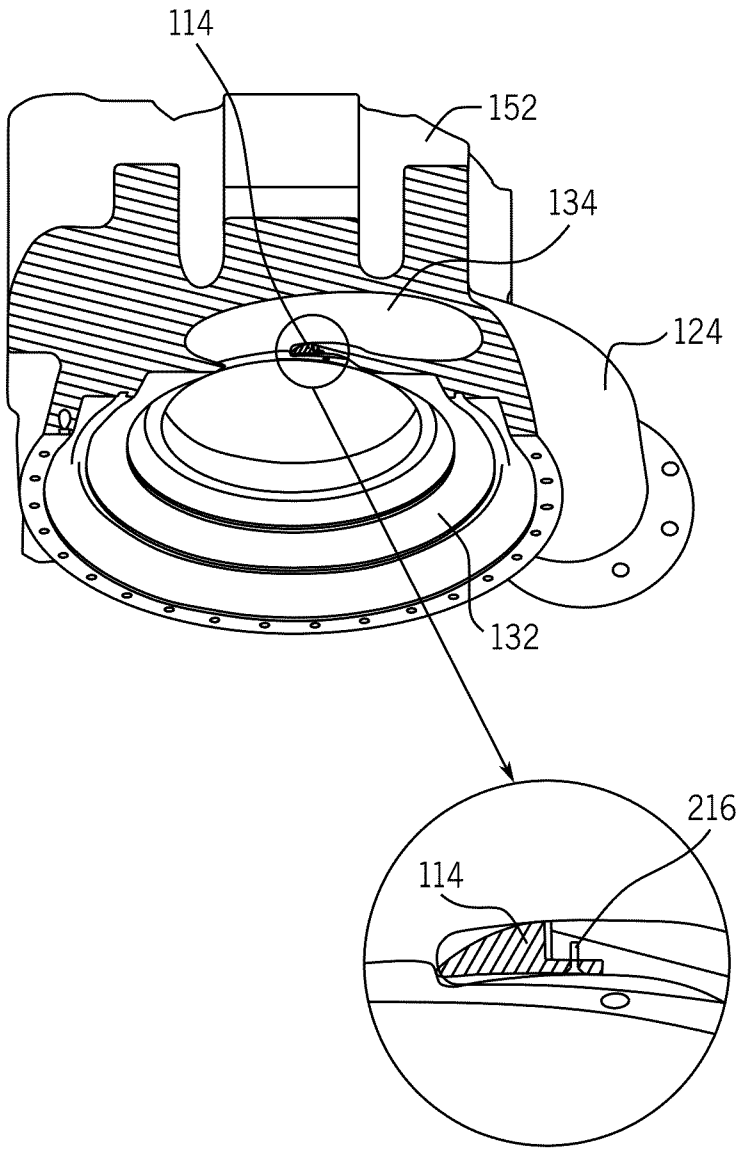

FIG. 5

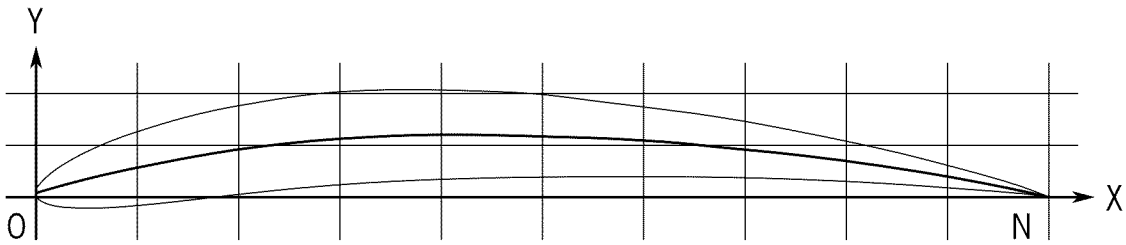

FIG. 6

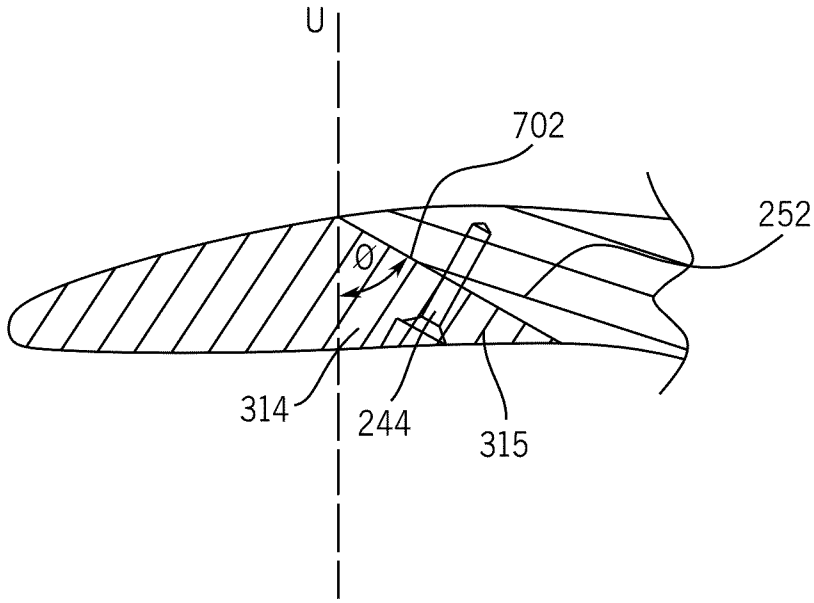

FIG. 7

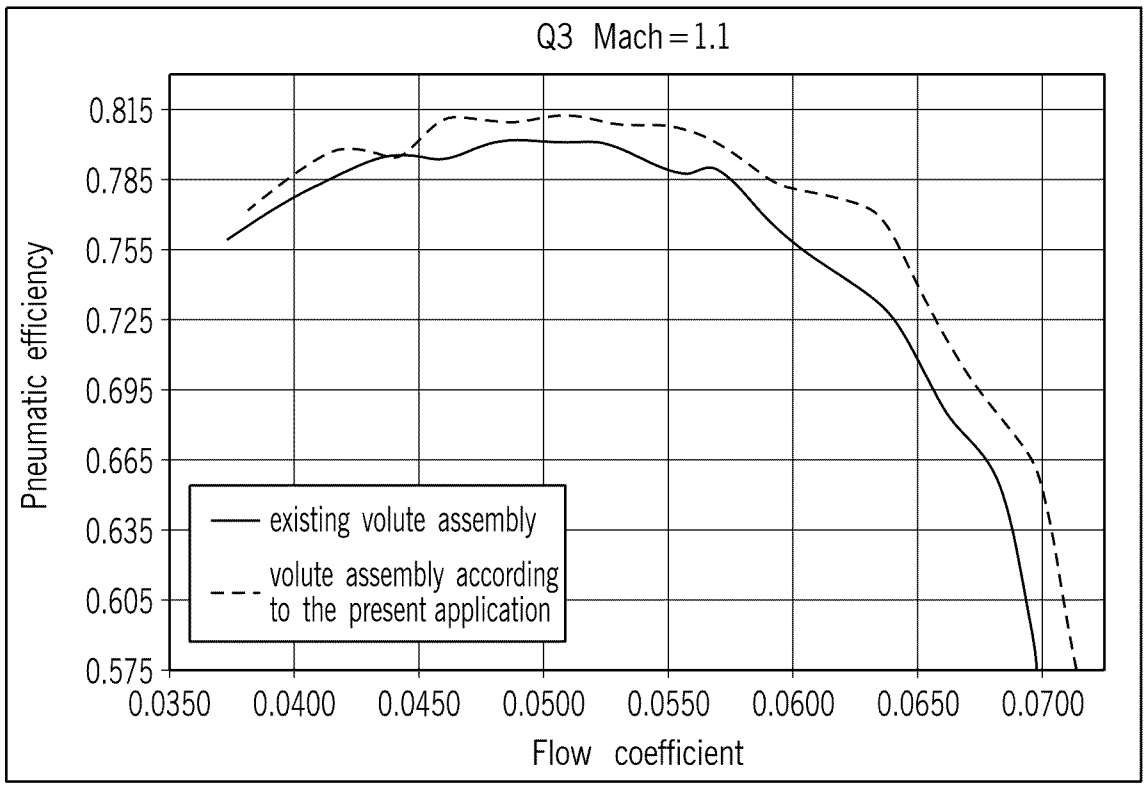
Q3 Mach = 1.1
Pneumatic efficiency
0.815
0.785
0.755
0.725
0.695
0.665
0.635
0.605
0.575
0.0350
0.0400
0.0450
0.0500
0.0550
0.0600
0.0650
0.0700
Flow coefficient
existing volute assembly
volute assembly according to the present application

FIG. 8A

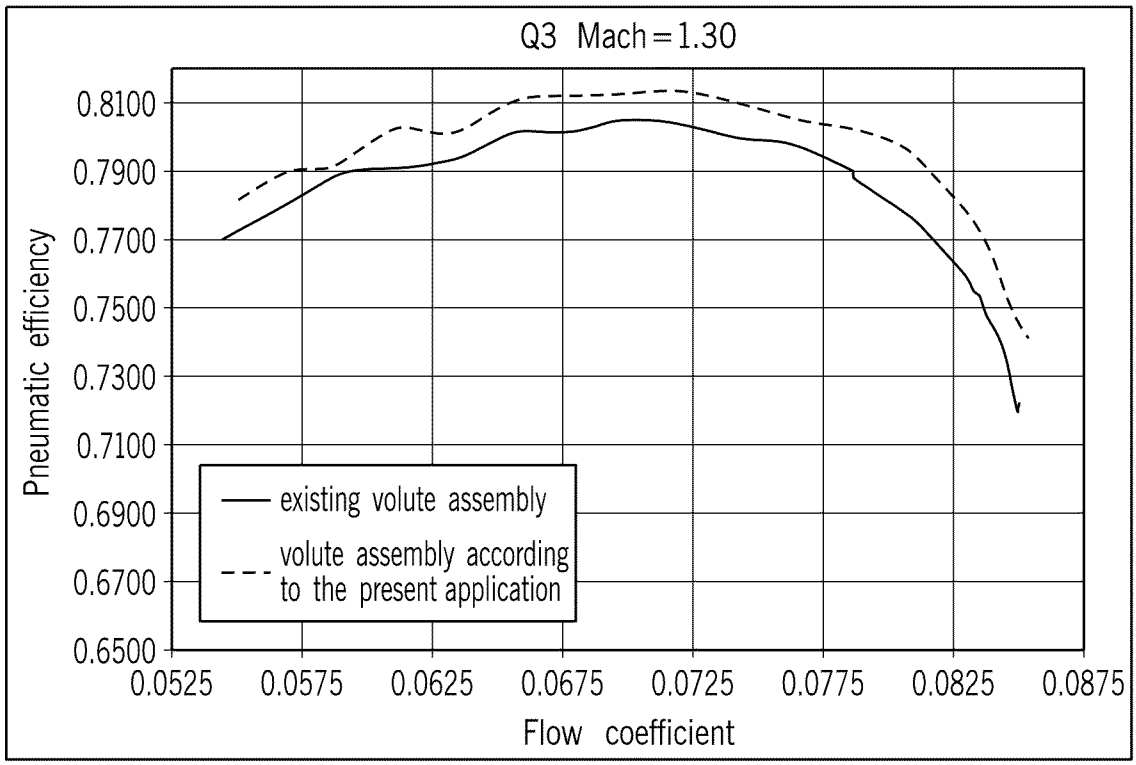
Q3 Mach = 1.30
Pneumatic efficiency
0.8100
0.7900
0.7700
0.7500
0.7300
0.7100
0.6900
0.6700
0.6500
0.0525
0.0575
0.0625
0.0675
0.0725
0.0775
0.0825
0.0875
Flow coefficient
existing volute assembly
volute assembly according to the present application

FIG. 8B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2023/084279

A. CLASSIFICATION OF SUBJECT MATTER

F04D 29/42(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F04D 29/42(2006.01); F02C 7/04(2006.01); F04D 1/00(2006.01); F04D 29/44(2006.01); F04D 29/66(2006.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: volute, tongue, detach, mount, connection, hole, insert, casting, machining

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2018-0355886 A1 (IHI CORPORATION) 13 December 2018 (2018-12-13) paragraphs [0027]-[0030] and figures 1-5A	1-4,14-16
A		5-13
Y	US 2015-0050131 A1 (WESCAST INDUSTRIES, INC.) 19 February 2015 (2015-02-19) paragraphs [0047], [0049] and figures 7-10	1-4,14-16
Y	JP 2021-195887 A (EBARA CORP.) 27 December 2021 (2021-12-27) paragraphs [0018]-[0019] and figures 2, 5	2-4,14
A	CN 201560984 U (HISENSE (SHANDONG) AIR-CONDITIONING CO., LTD.) 25 August 2010 (2010-08-25) paragraphs [0028]-[0030] and figures 1-3	1-16
A	JP 2020-204281 A (EBARA CORP.) 24 December 2020 (2020-12-24) paragraphs [0025]-[0030] and figure 4	1-16

☑ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 April 2024	**16 April 2024**

Name and mailing address of the ISA/KR	Authorized officer
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Facsimile No. **+82-42-481-8578**	Telephone No. **+82-42-481-3405**

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 116221181 A (JOHNSON CONTROLS AIR CONDITIONING AND REFRIGERATION (WUXI) CO., LTD. et al.) 06 June 2023 (2023-06-06) claims 1-16 and figures 1A-8B The above document is a publication of the earlier application whose priority has been claimed in this international application.	1-16

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/US2023/084279

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		EP 3033504 B1	20 December 2017
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CN 201560984 U	25 August 2010	None	
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CN 116221181 A	06 June 2023	None	