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(54) **Title**: COMPACT USER-SIDE APPARATUS FOR A PERSONAL PROPULSION SYSTEM

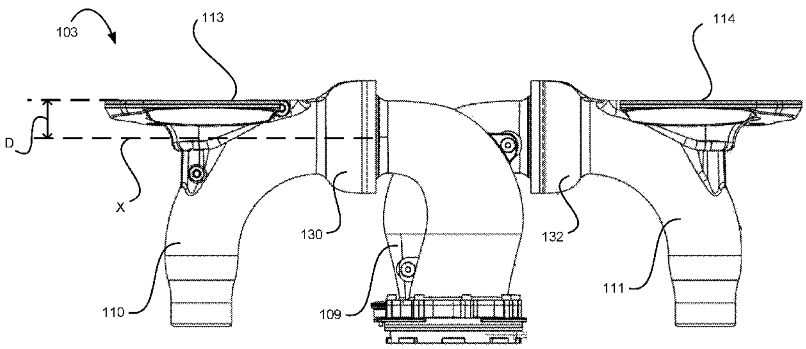

Fig. 5

(57) **Abstract**: A user side apparatus of a personal propulsion system, comprising a flow splitter, two nozzles, and two foot mounts. The flow splitter is configured for separating the first flow into two second flows. The nozzles are joined to outlets of the flow splitter, and are configured for receiving and ejecting the second flows. The foot mounts are mounted directly on the respective nozzle.

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Compact User-Side Apparatus for a Personal Propulsion System

Cross-References To Related Applications

[0001] The present application is a Continuation-in-Part of U.S. Patent application 14/941,660 filed on November 16, 2015, and claims priority to U.S. Provisional Application Serial Number 62/215,344 filed on September 8, 2015, both of which are hereby incorporated herein by reference in its entirety.

Technical Field

[0002] The present invention, in some embodiments thereof, relates to devices and systems based on fluid jet for propelling a user to fly above a surface.

Background of the Invention

[0003] Flight has always been a dream of mankind. In modern history, this dream has been achieved, and various flying vehicles have been produced to enable people to fly. Generally, these vehicles, such as airplanes or helicopters, enclose the user (pilot or passenger) and allow little freedom to the passenger's control of the flight.

[0004] Some personal propulsion systems have been designed to carry a single person while providing the user increased control of the user's flight via motion of the user's body.

[0005] US Patent 8,336,805 describes a propulsion device comprising a body arranged for receiving a passenger and engaging with a thrust unit supplied with a pressurized fluid from a compression station. The arrangement of such a device offers great freedom of movement through the air or under the surface of a fluid. US Patent 8,336,805 also discloses a propulsion system in which the compression station can be remote in the form of a motorized marine vehicle.

Brief Summary of Embodiments of the Invention

[0006] The aim of the present invention is to increase the user's freedom of movement while using a personal propulsion system.

[0007] Fig. 1 illustrate a personal propulsion system 100 as known in the prior art. A pump 102 pumps a fluid 122 (e.g., water) from a fluid reservoir (e.g., sea, lake, pool), and sends a fluid flow 124 through a flexible tube 106. The system 100 includes a user-side apparatus which includes a splitter 109, two nozzles 110 and 111, and two foot mounts 114 and 115. The tube 106 is connected to the splitter 109, which is attached to the two nozzles 110 and 111. The splitter 109 splits the flow 124 into two flows that enter the nozzles and are ejected as flows 126 and 128. The nozzles 110 and 111 are located below two foot mounts 113 and 114 which support the user, and face away from the user or they may be integrated into the nozzles themselves. The foot mounts may be connected to each other by a bridge 115 or may be physically separate. In this manner the nozzles 110 and 111 eject fluid flows 126 and 128 away from the user, and propel the user in a direction opposite to that of from the ejected fluid's flow. The user can change the orientation of the nozzles by changing the orientation of his or her body.

[0008] Figs. 2 and 3 are more detailed drawings showing the user-side apparatus of the system, which includes the splitter 109, the nozzles 110 and 111, and the foot mounts 113 and 114. In Fig. 2, it can be seen that the splitter is connected to the nozzles 110 and 111 by bearing units 130 and 132, respectively, to enable rotation of the nozzles with respect to the splitter 109. The foot mounts 113 and 114 are joined to the bearing units 130 and 132, respectively. In this manner, the user can change the orientation of the nozzles 110 and 111 by changing the orientation of the foot mounts 113 and 114, respectively.

[0009] The bearing units 130 and 132 surround the outlets of the splitter 109 and the inlets of the nozzles 110 and 111. Thus, joining the foot mounts to the bearings substantially increases the distance between the foot mounts and the rotation axis of the nozzles. The inventor has found that the larger the distance between the foot mounts and the rotation axis of the nozzle, the more difficult the control of the personal propulsion system becomes for the user. The inventor has called this phenomenon “stilt effect” or “high heel effect”, which will be explained below in the description of Fig. 4.

[0010] Fig. 4 is a diagram showing the forces acting on the foot mounts. When hose pulls back with a force T and user flies forward at a velocity V, a effect τ is created, causing the foot mount(s) to rotate forward and the toes to rotate downward. This is the “stilt effect” or “high heel effect”. The higher the foot mounts’ height above the rotation axis of the nozzles, the more prominent the effect. Thus, as the foot mounts are located farther and farther away from the nozzles’ axis of rotation, the lever arm of the torque grows, causing the foot to be subjected to stronger loads associated with flying. It should be noted that, in order to easily explain the stilt effect, Fig. 4 illustrate an extreme example in which the velocity V of the foot mounts forms an angle of 180 degrees with the hose’s pulling force T. However, the torque τ is created at almost any angle between the velocity V and the force T.

[0011] The aim of the present invention is to increase the user’s control of the personal propulsion system by decreasing the stilt effect on the user’s feet. In the prior art, the distance D is dictated by the hardware underneath the foot mounts, which includes a water passageway having an inner diameter of approximately 2.75 inches, and generally includes a ball bearing pivot system. This leads to an average distance D of 3 inches between the foot mounts and the rotation axis. The apparatus of the present invention includes a nozzle and foot mount, in which the foot mount is not joined to the bearing unit, but is joined to the nozzle itself. In this manner, the distance between the nozzle and foot mount is decreased, to decrease the torque acting on the foot mount.

[0012] Therefore, an aspect of some embodiments of the present invention relates to a user side apparatus of a personal propulsion system, comprising a flow splitter, two nozzles, and two foot mounts. The flow splitter has an inlet and two outlets. The inlet is configured for being connected to a tube in which a fluid is driven from a pump and for receiving a first flow of the fluid, the flow splitter being configured for separating the first flow into two second flows, each second flow exiting the flow splitter through the respective outlet. Each nozzle is joined to a respective outlet of the flow splitter, and is configured for receiving the respective second flow and ejecting the respective second flow. Each foot mount is mounted directly on the respective nozzle.

[0013] Optionally, each foot mount conforms to a shape of the outer surface of the respective nozzle its connected to. In a variant, the foot mounts are integrated into the nozzle, rather than being separate.

[0014] In a variant, the user side apparatus includes two bearing units, each bearing unit being configured for connecting the respective outlet of the flow splitter with the respective nozzle, and for enabling rotation of the respective nozzle relative to the flow splitter around a respective rotation axis. The foot mounts are not mounted on the bearing units.

[0015] In another variant, a distance between the foot mount and the rotation axis of the respective bearing unit is lower than about 3 inches.

[0016] In yet another variant, a distance between the foot mount and the rotation axis of the respective bearing unit is equal to or lower than about 1.5 inches.

[0017] In a further variant, a distance between the foot mount and the rotation axis of the respective bearing unit is equal to about 0 inches, such that the foot mount is aligned with the rotation axis of the respective bearing unit.

[0018] In yet a further variant, the foot mount is aligned to an axis that is below the rotation axis of the respective bearing unit and above the inlet of the flow splitter.

[0019] Optionally, the flow splitter is configured for splitting the first flow into the two second flows and for changing a direction of each second flow with respect to a direction of the first flow. The flow splitter includes the inlet, a first pipe and a second pipe. The inlet, configured for receiving the first flow. The first pipe and the second pipe meet at an interface near the inlet and extending away from the inlet, such that the interface divides a first cross-sectional area of the inlet into two second cross-sectional areas. Portions of the first pipe and the second pipe proximal to the inlet are substantially helical and are intertwined with each other. The first pipe and the second pipe have a first outlet and a second outlet respectively at ends of the respective pipes, the first and second outlet facing away from each other.

[0020] In a variant, central axes of the first and second pipe at the outlets form substantially right angles with a central axis of the splitter at the inlet.

[0021] In another variant, a cross-sectional surface of the inlet is circular or oval, such that cross sectional surfaces of the pipes at the inlets are D-shaped. The cross-sectional surface of each pipe smoothly morphs from the D-shape into an oval shape at the respective outlet.

[0022] In yet another variant, a cross-sectional surface of the inlet is circular or oval, such that cross sectional surfaces of the pipes at the inlets are D-shaped. The cross-sectional surface of each pipe smoothly morphs from the D-shape into an oval shape along the pipe. The cross-sectional surface of each pipe smoothly morphs from the oval shape along the pipe to a circular shape at the respective outlet.

[0023] Optionally, the interface is a panel extends between two points of a circumference of the inlet.

[0024] In a variant, the interface has an aerodynamic shape, configured for maintaining low drag in the second flows.

[0025] Optionally, an edge of the interface proximal to the inlet has a frontal cross section perpendicular to the interface's larger surface having a parabola's shape, such that a vertex of the parabola is a point of the interface that is farthest from the outlets.

[0026] In a variant, a cross sectional area of each pipe is about constant along at least a portion of the respective pipe.

[0027] In some embodiments of the present invention, the flow splitter is configured for splitting the first flow into two second flows and for changing a direction of each second flow with respect to a direction of the first flow, and the flow splitter comprises an inlet, and a first pipe and a second pipe. The inlet is configured for receiving the first flow. The first pipe and the second pipe meet at an interface near the inlet and extend away from the inlet, such that the interface divides a first cross-sectional area of the inlet into two second cross-sectional area. The first and second pipes have first portions proximal to the inlet which extend vertically side by side away from the inlet, and second portions distal from the inlet which curve from each other at respective angles and end at the respective outlets. For each of the first portions, a width for any vertical point is the largest horizontal distance perpendicular to the interface between the interface and an inner surface of the pipe. For each of the first portions, a depth for any vertical point is the largest horizontal distance parallel to the interface between two points at an inner surface of the pipe. For each of the first portions, the width decreases and the depth increases as a vertical distance from the inlet increases.

[0028] In a variant, a cross-sectional area of each pipe is substantially constant along the respective pipe.

[0029] In another variant, central axes of the first and second pipe at the outlets form substantially right angles with a central axis of the splitter at the inlet.

[0030] In yet another variant, the interface is a panel extending between two points of a circumference of the inlet.

[0031] Optionally, the interface has an aerodynamic shape, configured for maintaining low drag in the second flows.

[0032] Other features and aspects of the invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawings, which illustrate, by way of example, the features in accordance with embodiments of the invention. The summary is not intended to limit the scope of the invention, which is defined solely by the claims attached hereto.

Brief Description of the Drawings

[0033] The present invention, in accordance with one or more various embodiments, is described in detail with reference to the following figures. The drawings are provided for purposes of illustration only and merely depict typical or example embodiments of the invention. These drawings are provided to facilitate the reader's understanding of the invention and shall not be considered limiting of the breadth, scope, or applicability of the invention. It should be noted that for clarity and ease of illustration these drawings are not necessarily made to scale.

[0034] Some of the figures included herein illustrate various embodiments of the invention from different viewing angles. Although the accompanying descriptive text may refer to such views as “top,” “bottom” or “side” views, such references are merely descriptive and do not imply or require that the invention be implemented or used in a particular spatial orientation unless explicitly stated otherwise.

[0035] Fig. 1 is a schematic drawing illustrating a personal propulsion system, as known in the prior art;

[0036] Figs. 2-3 are drawings illustrating a user–side apparatus of a personal propulsion system, as known in the prior art;

[0037] Fig. 4 is a schematic drawing illustrating the inventor’s analysis of forces acting on the foot mount, according to some embodiments of the present invention;

[0038] Fig. 5 is a schematic drawing illustrating a foot mount joined directly to the nozzle, according to some embodiments of the present invention;

[0039] Fig. 5A is an exploded illustrating a foot mount joined directly to the nozzle, via a riser, according to some embodiments of the present invention;

[0040] Fig. 6 is a schematic drawing illustrating different positions of the foot mount on the nozzle, according to some embodiments of the present invention;

[0041] Figs. 7-9 are drawings illustrating a two-way helical splitter, according to some embodiments of the present invention;

[0042] Figs. 10-12 are drawings illustrating a flat splitter, according to some embodiments of the present invention; and

[0043] Figs. 13-15 are schematic drawings illustrating user-side apparatuses of a personal propulsion system, each having a respective different configuration of the platforms joined to the user's feet in.

[0044] The figures are not intended to be exhaustive or to limit the invention to the precise form disclosed. It should be understood that the invention can be practiced with modification and alteration, and that the invention be limited only by the claims and the equivalents thereof.

Detailed Description of the Embodiments of the Invention

[0045] Unless defined otherwise, all technical and scientific terms used herein have the same meaning as is commonly understood by one of ordinary skill in the art to which this invention belongs. All patents, applications, published applications and other publications referred to herein are incorporated by reference in their entirety. If a definition set forth in this section is contrary to or otherwise inconsistent with a definition set forth in applications, published applications and other publications that are herein incorporated by reference, the definition set forth in this document prevails over the definition that is incorporated herein by reference.

[0046] Fig. 5 is a schematic drawing illustrating a system in which the foot mounts are joined directly to the respective nozzles, according to some embodiments of the present invention. While in the prior art, the foot mounts are joined to the bearing units, in the present invention, the foot mounts 113 and 114 are joined directly to the nozzles 110 and 111, respectively. In this manner, the thickness of the bearing units does not contribute to the distance D between the axis X of rotation of the nozzles and the foot mounts. In this manner the distance D is diminished, compared to the prior art, decreasing the stilt effect. Optionally, the foot mounts conform to the shape of outer surface of the nozzles each is connected to, to create a strong connection and reduce the distance D between the axis and the foot mount location. Optionally, the foot mounts are integral with the nozzles, and do require additional foot mount plates.

[0047] Referring to Fig. 5A, a riser 116 is attached to an outsider surface of the nozzle, and connects the nozzle to a foot mount 114. The riser 116 is shaped to conform to the outside surface contour of the nozzle 111 on a first side, and is planar on a second side for mating or connecting with a planar underside of a foot mounting plate 114. Thus, the riser 116 provides a flat support for the foot mount to attached to the curved nozzle 114.

[0048] Moreover, joining the foot mounts directly to the nozzles does not confine the manufacturer/designer to use only certain types of bearing units which have a small outer radius. Since the size of the bearing unit does not contribute to the value of the distance D, the manufacturer/designer has the added freedom of using bearing units which may have a large outer radius, but have other properties (e.g. desirable friction values, longer life, etc.) that are suitable the manufacture/design of specific personal propulsion systems.

[0049] In some embodiments of the present invention, the nozzles and foot mounts may be made from metal, machined or gravity cast, or injection molded reinforced plastic. The bearing unit may include 10mm POM balls. It should be noted that the size and material of the balls in the bearing unit may be chosen according to the needs of the designer/manufacturer, and that the scope of the present invention extends to any system with any kind of bearing unit, based on balls or on any other mode of operation.

[0050] Fig. 6 is a schematic drawing illustrating different positions of the foot mount on the nozzle, according to some embodiments of the present invention.

[0051] Different designs of the user-side section of the personal propulsion system may be made, in which the foot mount 114 may be joined to different sections of the nozzle 111. In this manner, the distance D between the foot mount 114 and the rotation axis of the nozzle can be chosen to have a desired value.

[0052] It can be seen that in the prior art, the distance D is about 3 inches. By using the structure of the present invention, the distance D may be set to be lower than 3 inches, for example, 1.5 inches, 0 inches (the foot mount is aligned with the nozzle rotation axis), or have a negative value (the foot mount is below the nozzle rotation axis). By decreasing D to a positive value, the instability of the user side apparatus of the propulsion system is decreased. In this manner, the user has to put less effort into stabilizing the rotation of the nozzles. By decreasing D to zero, the user side apparatus of the propulsion system is neutrally stable, and the user does not need to put effort into stabilizing the rotation of the nozzles, and can use his/her abilities to perform desired maneuvers. By decreasing D to a negative value, the user side apparatus of the propulsion system becomes positively stable, and would resist any rotation, by trying to return to its neutral point. This last configuration makes the system less maneuverable but more stable. The added stability is an advantage for first time riders and beginners who often times have a difficult time finding their balance while using the personal propulsion system.

[0053] In some embodiments of the present invention, the splitter 109 of Fig. 1 is a narrow-outlet splitter, which is constructed in a manner that allows a decrease in the distance between the outlets of the splitter. Such a splitter allows the foot mounts to be mounted directly on the nozzles, while keeping the distance between the user's feet to be at a comfortable gap. In this manner, the user can keep a comfortable stance while using the personal propulsion system.

[0054] Referring now to Figs. 7-9, drawings are provided illustrating a two-way helical splitter 200, according to some embodiments of the present invention. Fig. 7 is a top view of the splitter 200. Fig. 8 is a side view of the splitter 200. Fig. 9 is a perspective view of the splitter 200.

[0055] The splitter is a tube which includes an inlet 201 and two outlets 202 and 204. The flow is separated at the inlet by a panel 206 at the inlet. The panel 206 divides the cross-sectional surface of the inlet in two surfaces. Optionally, the inlet is circular or oval, and the panel divides the surface of the inlet into two D-shaped surfaces. The panel 206 is the interface at which two pipes 212 and 214 connect to form the intake 201. The first flow passes through the first pipe 212 to reach the first outlet 202. The second flow passes through the second pipe 214 to reach the second outlet 204.

[0056] Portions of the pipes 212 and 214 that are near the inlet are substantially helical, and the outlets 202 and 204 face away from each other at opposite directions. The helical portions of the pipes are intertwined with each other. In some embodiments of the present invention, central axes of the outlets form angles of about 90 degrees with the central axis of the inlet. In this manner, the flows are bent by about 90 degrees from the inlet to the respective outlets. Optionally, central axes of the pipes form an angle of about 180 degrees. The helical shape of the pipes 212 and 214 bends each fluid flow to soften the bend angle over a smooth, wide radius curve. The helical path enables maintaining a low curvature along the pipes 212 and 214, while reducing the spacing between outlets. Therefore, on the one hand, lower curvature improves the flow efficiency, decreases turbulence, and thus decreases the energy spent by the pump to pump the fluid from the fluid reservoir to the outlets. On the other hand, the reduced distance between outlets improves performance and handling of the personal propulsion system.

[0057] The panel 206 optionally has an aerodynamic shape, to reduce drag in the flow and to maintain a smooth flow through the splitter 200. In a non-limiting example, the lower edge of the panel 206 is shaped like a parabola where the vertex of the parabola is the lowest point of the panel (i.e., a point of the interface that is farthest from the outlets).

[0058] In some embodiments of the present invention, the outlets have oval shape. In a variant, each pipe smoothly morphs the D-shape at the entry into oval-like shape at the respective outlet. According to some embodiments of the present invention, the outlets have circular shapes. To achieve this shape, each pipe smoothly morphs the D-shape at the entry into an oval-like shape along the pipe, and then morphs the oval-like shape into a circular shape at the respective outlet.

[0059] In some embodiments of the present invention the cross sectional area in the pipes is maintained substantially constant in at least a portion of each pipe. This feature decreases turbulence and increases the efficiency of the fluid flows.

[0060] It should be noted that in some embodiments of the present invention, the inlet's cross-sectional area is split into two substantially equal portions by the panel. In a variant, the inlet's cross-sectional area is split by the panel into two unequal portions.

[0061] Reference is now made to Figs. 10-12, which are drawings illustrating a flat splitter 300, according to some embodiments of the present invention. Fig. 10 is a perspective view of the splitter 300. Fig. 11 is a front view of the splitter 300. Fig. 12 is a side view of the splitter 300.

[0062] The flat splitter 300 is a tube which has an inlet 301 and two outlets 302 and 304. The flow entering the flat splitter is split at or just after the inlet, by a panel/interface 306 which divides the cross-sectional surface of the inlet into two parts. Optionally, the inlet is circular or oval, and the panel divides the surface of the inlet into two D-shaped surfaces. The panel 306 extends parallel to normal axis of the cross-sectional surface of the intake, and divides the tube into two pipes 312 and 314 having outlets 302 and 304, respectively. The pipes 312 and 314 extend side by side vertically away from the inlet and then curve away from each other and from the panel to release the respective fluid flows from the respective outlets 302 and 304 facing away from each other. Optionally the outlets' normal axes are at about 180 degrees from each other.

[0063] As it can be clearly seen in Figs. 11 and 12, along the straight portions of each pipe, the width of the each pipe decreases while the depth of each pipe increases as the distance from the inlet grows. The width at any vertical point may be defined as the largest horizontal distance perpendicular to the interface/panel between the interface/panel and the inner surface of the pipe. A depth for any vertical point is the largest horizontal distance parallel to the interface/panel between two points at an inner surface of the pipe. For example, the width w1 near the base of the pipe 314 is larger than the width w2 located farther than the base of the pipe 314. The depth d1 (at the same point as the width w1) is larger than the depth d2 (at the same point as the width w1).

[0064] Because the width of the pipes narrows, the curvature of each pipe is gentler (i.e. having a larger radius of curvature) than the curvature of a pipe known in the art. As shown in Fig. 11, the shape of a pipe which is part of a two-way splitter known in the art having a decreased distance between outlets has a first straight portion a, a second curved portion b, and a third straight portion c. The curved portion b has a tight curvature (i.e., as a small radius of curvature), which compromises the flow efficiency of the fluid through the pipe. In contrast, the shapes of the pipes 312 and 314 describe gentler curves from the inlet to the respective outlets 302 and 314, without compromising flow efficiency, and enabling a narrow distance between the outlets.

[0065] As the width of each pipe decreases, the depth of each pipe increases, as can be seen on Fig. 12. The increase in depth ensures that the cross-sectional area of each pipe is maintained substantially constant along the pipe's length. As mentioned above, this feature helps reduce turbulence in the flow through the pipes.

[0066] Optionally, the panel 306 has an aerodynamic shape, to reduce drag in the flow and to maintain a smooth flow through the splitter 300. In a non-limiting example, the lower edge of the panel 306 is shaped like a parabola the vertex of which is the lowest part of the parabola.

[0067] In some embodiments of the present invention, the outlets have an oval shape. In a variant, each pipe smoothly morphs the flat shape near along the substantially straight section of the pipe to an oval-like shape at the respective outlet. According to some embodiments of the present invention, the outlets have circular shapes. To achieve this shape, each pipe smoothly morphs the flat shape near along the substantially straight section of the pipe to an oval-like shape before the outlets, and then morphs the oval-like shape into a circular shape at the respective outlet.

[0068] The shapes of the splitters 200 and 300 enable a decreased distance between the outlets, and therefore a decreased distance between the nozzles joined to the outlets. By using the splitters 200 and 300, the inventors have constructed a splitter having a diameter of about 4 inches at the inlet and a distance between outlets of about 6 inches. Using dual row 10mm ball bearings to connect each outlet to a respective nozzle, the distance between the exits of the nozzles is below 27 inches.

[0069] Referring now to Figs. 13-15, schematic drawings are provided illustrating user-side apparatuses of a personal propulsion system, each having a respective different configuration of the foot mounts joined to the user's feet in. Fig. 13 illustrates an example in which the distance between the foot mounts is larger than the distance between the exits of the nozzles. Fig. 14 illustrates an example in which the distance between the foot mounts is about equal to the distance between the exits of the nozzles. Fig. 15 illustrates an example in which the distance between the foot mounts is smaller than the distance between the exits of the nozzles.

[0070] Thanks to the decreased distance between the outlets splitters 200 and 300, the inventors have constructed and tested a personal propulsion apparatus in which the foot positions on the platform 113 of Fig. 1 are located right above the exits of the nozzles, without increasing the distance between the user's feet. The foot mounts 113 and 114 are joined to respective nozzles 110 and 111. Each foot mount is located above a respective nozzle, such that the foot position on each foot mount is right above the exit of the respective nozzle. Using a narrow outlet splitter 200/300 of the present invention, having an inlet diameter of about 4 inches and an outlet distance of about 6 inches, as well as dual row 10mm ball bearings attached to respective outlets, the inventors have designed a user side apparatus of a personal propulsion system in which the jets emitted by the nozzles are under the user's feet, and the user has a comfortable stance in which the distance between the user's feet and the distance between the jets are around 21.6 inches. In contrast, in the prior art, because of the large distance between the outlets of the splitter, aligning the foot with the exits of the nozzles, would require the user to spread the user's legs and maintain an uncomfortable stance while using the personal propulsion system. It should be noted that the distance between jets can further be decreased by either connecting the nozzles to the splitter without bearings, or by improving bearing design to decrease the size of the bearings.

[0071] The narrow-outlet splitters 200 and 300 enable the foot mounts 113 and 114 to be mounted on the nozzles rather than on the bearings, while allowing the user to keep a comfortable stance which does not require the user to spread the user's feet.

[0072] Furthermore, aligning the nozzles' exits (and therefore the source of thrust) with the user's feet causes a more predictable response to the user's control inputs. The user feels more "connected" to the personal propulsion system, and this makes the user feel more in control and stable.

[0073] As mentioned above, in some embodiments of the present invention, each nozzle is joined to the respective outlet of the splitter via a respective bearing. This bearing is configured for enabling a rotation of the nozzle with respect to the splitter. In this manner, the user is able to use his/her body stance to control the direction of the jets (i.e., the direction of thrust). Since the feet of the user are right above the exits of the nozzles, the weight of the rider is placed directly above the line of thrust. In this manner the load on the bearings is decreased, and the friction of the bearings' movement during use is decreased, thereby prolonging the lifetime if the bearings.

[0074] In some embodiments of the present invention, the decreased distance between the outlets of the splitter, enables the distance between exists of the nozzles to be smaller than the distance between the user's feet. For example, a splitter having an inlet having a diameter of about 4 inches and a distance between outlets between 4 and 6 inches, can be connected to two nozzles via respective dual row 10mm ball bearings, in which the distance between the exits of the nozzles is below 20 inches. A jet span narrower than the user's stance can increase responsiveness and maneuverability of the personal propulsion system.

Claims

What is claimed is:

1. A user side apparatus of a personal propulsion system, comprising:

a flow splitter, having an inlet and two outlets, the inlet being configured for being connected to a tube in which a fluid is driven from a pump and for receiving a first flow of the fluid, the flow splitter being configured for separating the first flow into two second flows, each second flow exiting the flow splitter through the respective outlet

two nozzles, each nozzle being joined to a respective outlet of the flow splitter, and being configured for receiving the respective second flow and ejecting the respective second flow;

two foot mounts, each foot mount being mounted directly on the respective nozzle.

2. The user side apparatus of claim 1, wherein each foot mount conforms to a shape of an outer surface of the respective nozzle it is mounted to.

3. The user side apparatus of claim 1, comprising two bearing units, each bearing unit connecting a respective outlet of the flow splitter with the respective nozzle, and for enabling rotation of the respective nozzle relative to the flow splitter around a respective rotation axis, wherein the foot mounts do are not mounted on the bearing units.

4. The user side apparatus of claim 3, wherein a distance between the foot mount and the rotation axis of the respective bearing unit is lower than about 3 inches.

5. The user side apparatus of claim 3 wherein a distance between the foot mount and the rotation axis of the respective bearing unit is equal to or lower than about 1.5 inches.

6. The user side apparatus of claim 3, wherein a distance between the foot mount and the rotation axis of the respective bearing unit is equal to about 0 inches, such that the foot mount is on the rotation axis of the respective bearing unit.

7. The user side apparatus of claim 3, wherein the foot mount is positioned below the rotation axis of the respective bearing unit and above the inlet of the flow splitter.

8. The apparatus of claim 1, wherein the flow splitter is configured for splitting the first flow into the two second flows and for changing a direction of each second flow with respect to a direction of the first flow, the flow splitter comprising:

the inlet, configured for receiving the first flow;

a first pipe and a second pipe meeting at an interface near the inlet and extending away from the inlet, such that the interface divides a first cross-sectional area of the inlet into two second cross-sectional areas;

wherein:

portions of the first pipe and the second pipe proximal to the inlet are substantially helical and are intertwined with each other;

the first pipe and the second pipe have a first outlet and a second outlet respectively at ends of the respective pipes, the first and second outlet facing away from each other.

9. The flow splitter of claim 8, wherein central axes of the first and second pipe at the outlets form substantially right angles with a central axis of the splitter at the inlet.

10. The flow splitter of claim 8, wherein:

a cross-sectional surface of the inlet is circular or oval, such that cross sectional surfaces of the pipes at the inlets are D-shaped;

the cross-sectional surface of each pipe smoothly morphs from the D-shape into an oval shape at the respective outlet.

11. The flow splitter of claim 8, wherein:

a cross-sectional surface of the inlet is circular or oval, such that cross sectional surfaces of the pipes at the inlets are D-shaped;

the cross-sectional surface of each pipe smoothly morphs from the D-shape into an oval shape along the pipe;

the cross-sectional surface of each pipe smoothly morphs from the oval shape along the pipe to a circular shape at the respective outlet.

12. The flow splitter of claim 8, wherein the interface is a panel extending between two points of a circumference of the inlet.

13. The flow splitter of claim 12, wherein the interface has an aerodynamic shape, configured for maintaining low drag in the second flows.

14. The flow splitter of claim 13, wherein an edge of the interface proximal to the inlet has a frontal cross section perpendicular to the interface's larger surface having a parabola's shape, such that a vertex of the parabola is a point of the interface that is farthest from the outlets.

15. The flow splitter of claim 8, wherein a cross sectional of each pipe is about constant along at least a portion of the respective pipe.

16. The apparatus of claim 1, wherein the flow splitter is configured for splitting the first flow into two second flows and for changing a direction of each second flow with respect to a direction of the first flow, the flow splitter comprising:

the inlet, configured for receiving the first flow;

a first pipe and a second pipe meeting at an interface near the inlet and extending away from the inlet, such that the interface divides a first cross-sectional area of the inlet into two second cross-sectional areas;

wherein:

the first and second pipes have first portions proximal to the inlet which extend vertically side by side away from the inlet, and second portions distal from the inlet which curve from each other at respective angles and end at the respective outlets;

for each of the first portions, a width for any vertical point is the largest horizontal distance perpendicular to the interface between the interface and an inner surface of the pipe;

for each of the first portions, a depth for any vertical point is the largest horizontal distance parallel to the interface between two points at an inner surface of the pipe;

for each of the first portions, the width decreases and the depth increases as a vertical distance from the inlet increases.

17. The flow splitter of claim 16, wherein a cross-sectional area of the each pipe is substantially constant along the respective pipe.

18. The flow splitter of claim 16, wherein central axes of the first and second pipe at the outlets form substantially right angles with a central axis of the splitter at the inlet.

19. The flow splitter of claim 16, wherein the interface is a panel extending between two points of a circumference of the inlet.

20. A user side apparatus of a personal propulsion system, comprising:

a flow splitter, having an inlet and two outlets, the inlet being configured for being connected to a tube in which a fluid is driven from a pump and for receiving a first flow of the fluid, the flow splitter being configured for separating the first flow into two second flows, each second flow exiting the flow splitter through the respective outlet

two nozzles, each nozzle being joined to a respective outlet of the flow splitter, and being configured for receiving the respective second flow and ejecting the respective second flow;

two foot mounts having planar top and undersides;

two risers, having a first side and a second side, the first side conforming an outside contour of the nozzles, and the second side being planar and connected to a planar underside of each foot mount.

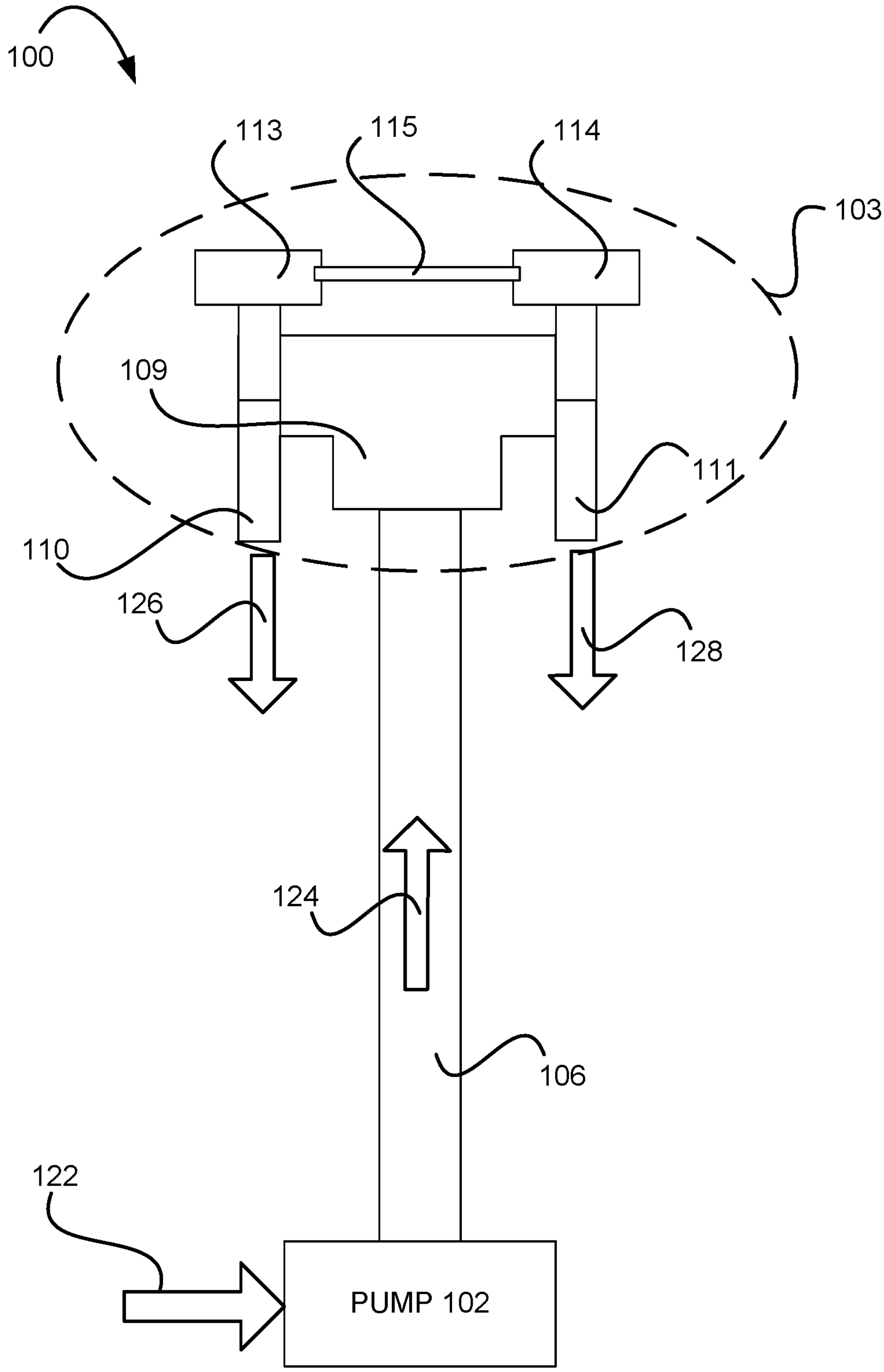


Fig. 1 (Prior Art)

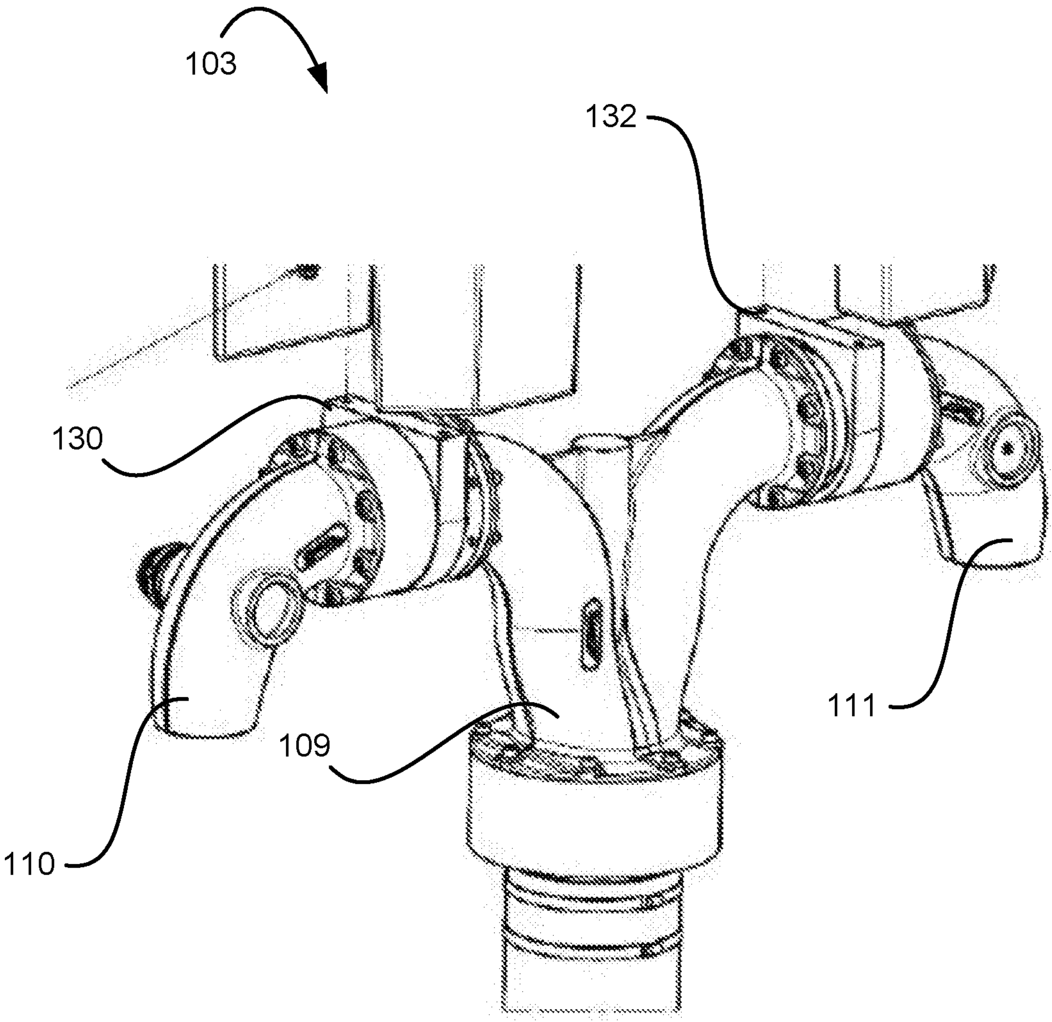


Fig. 2 (Prior Art)

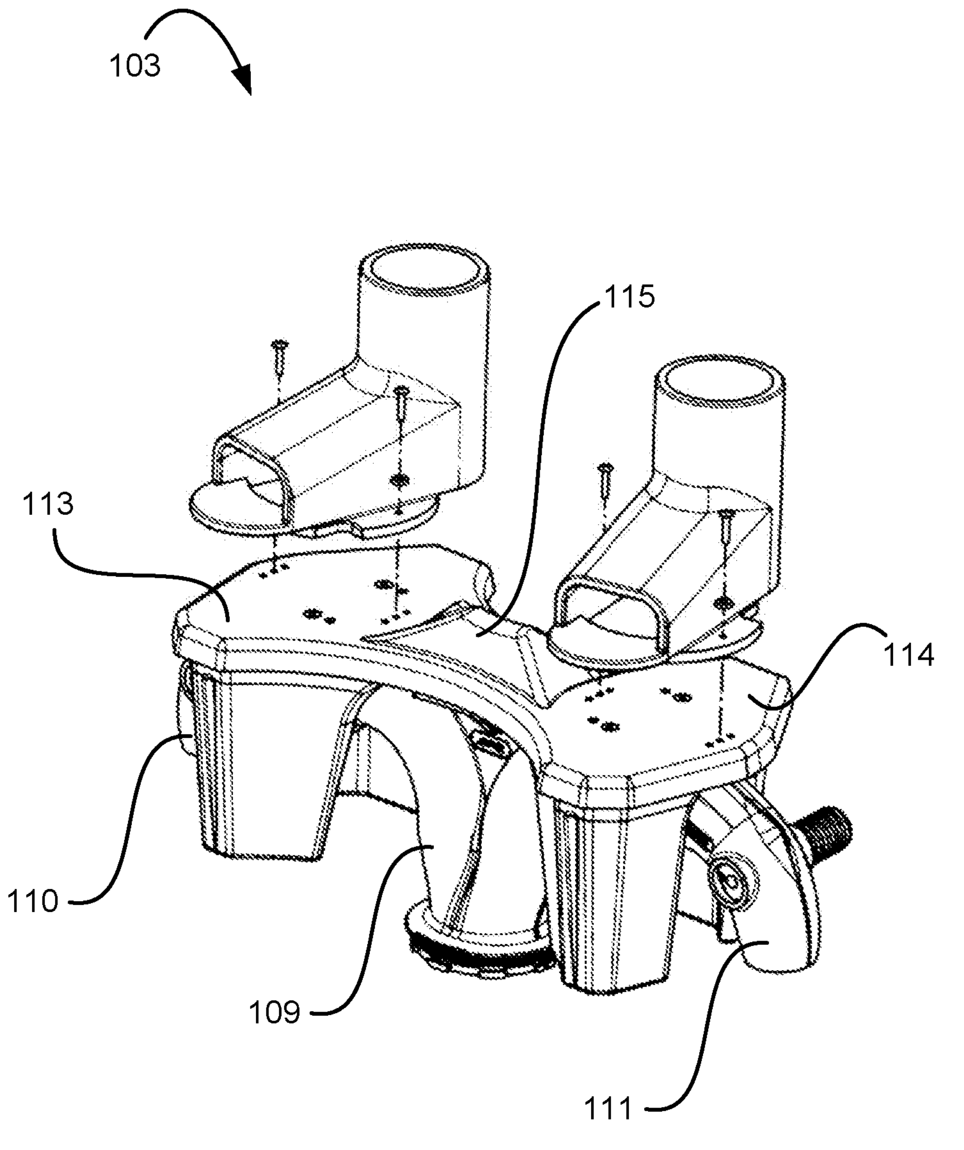


Fig. 3 (Prior Art)

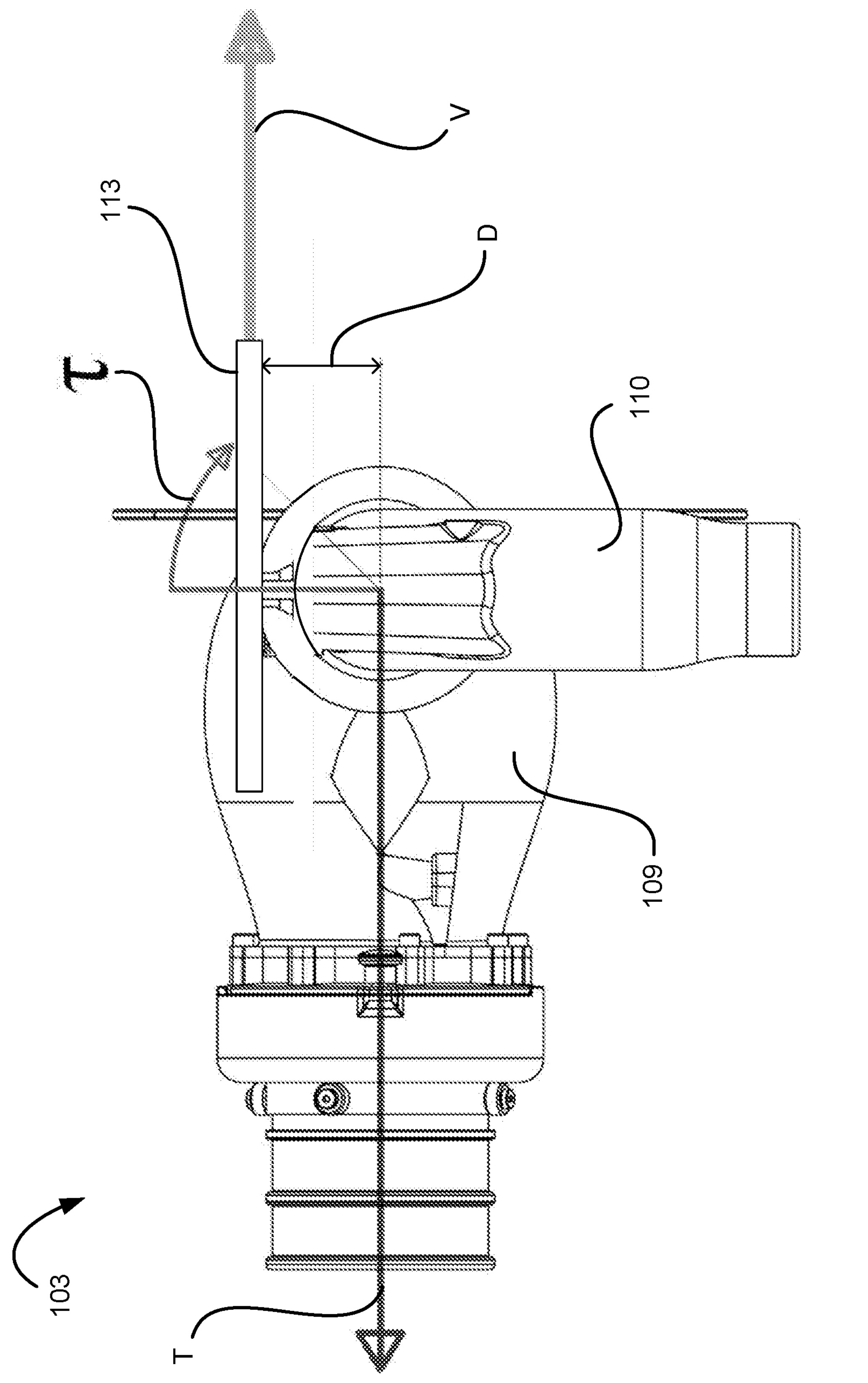


Fig. 4

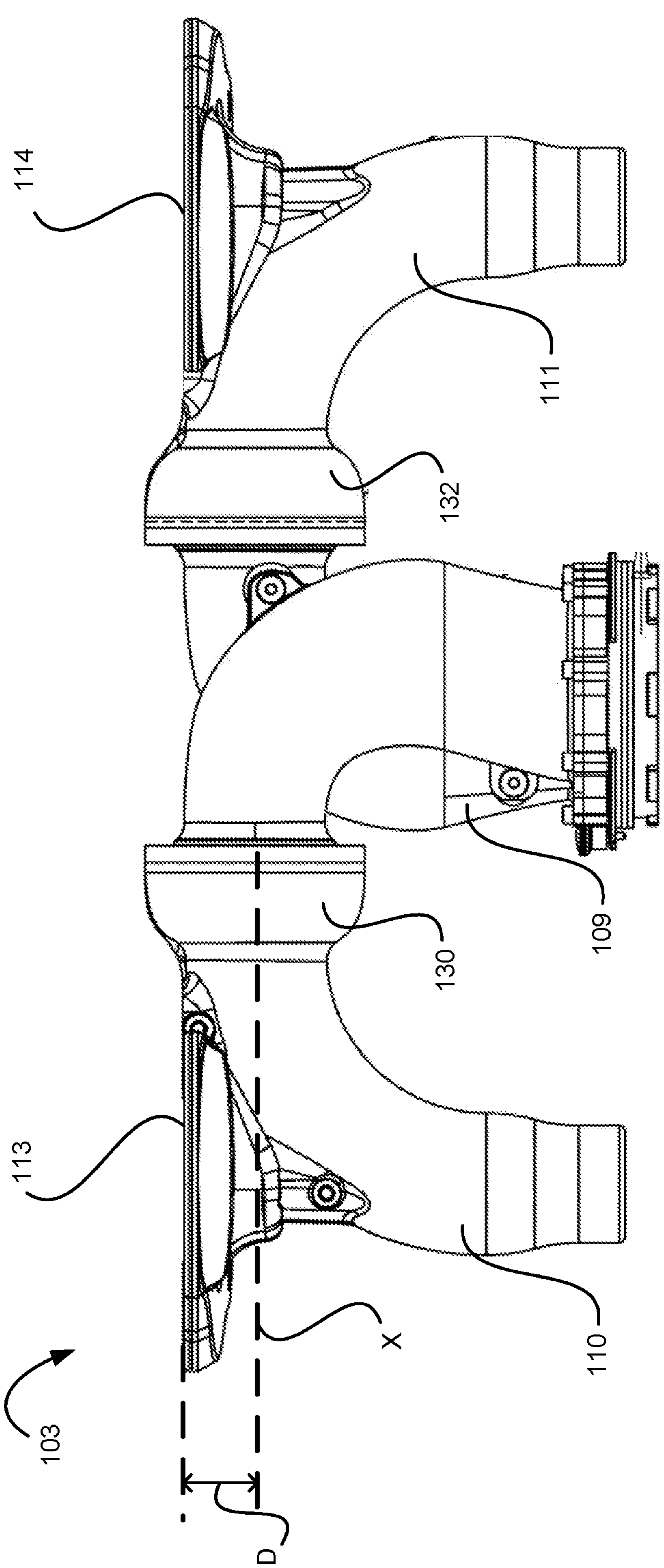


Fig. 5

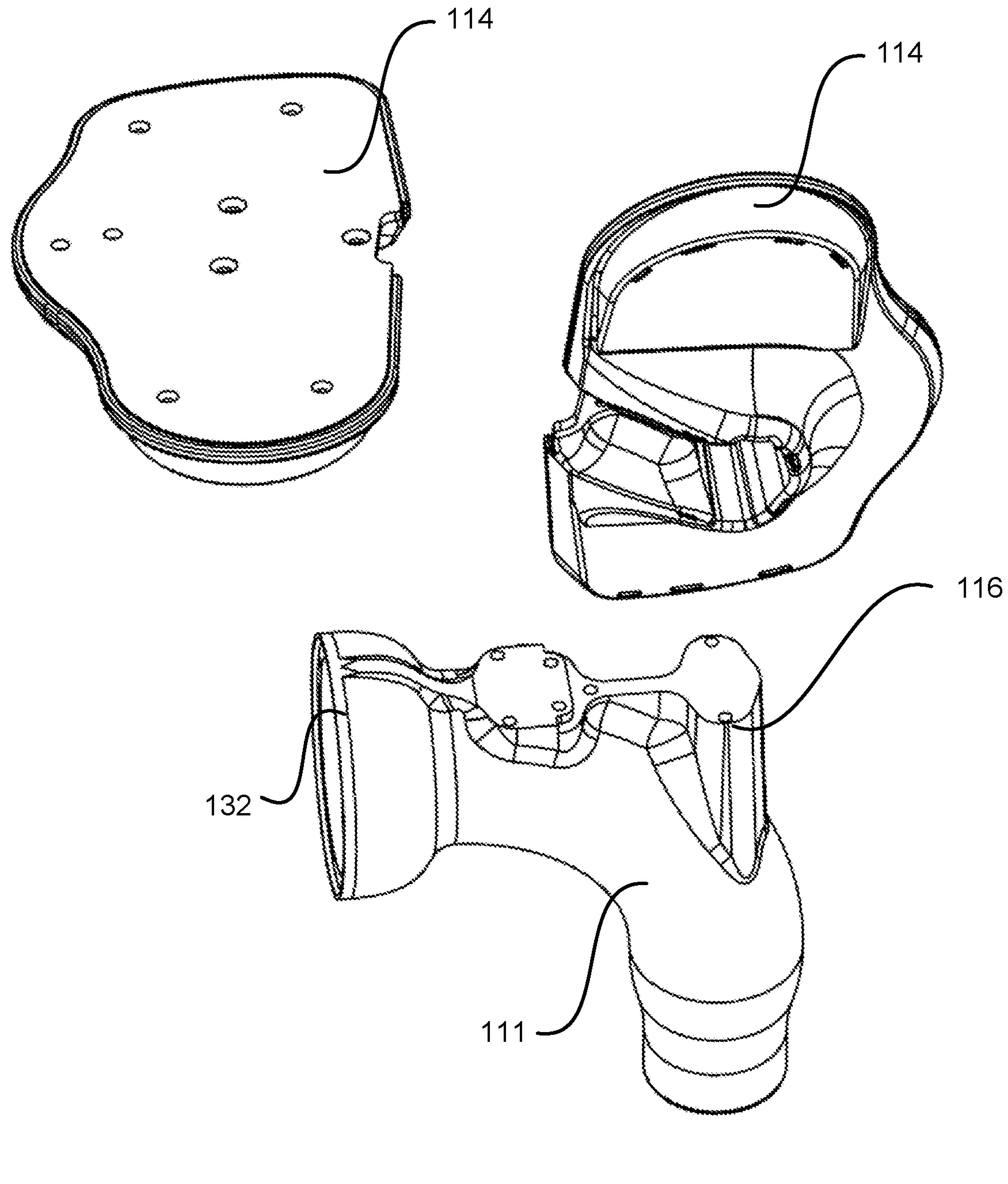
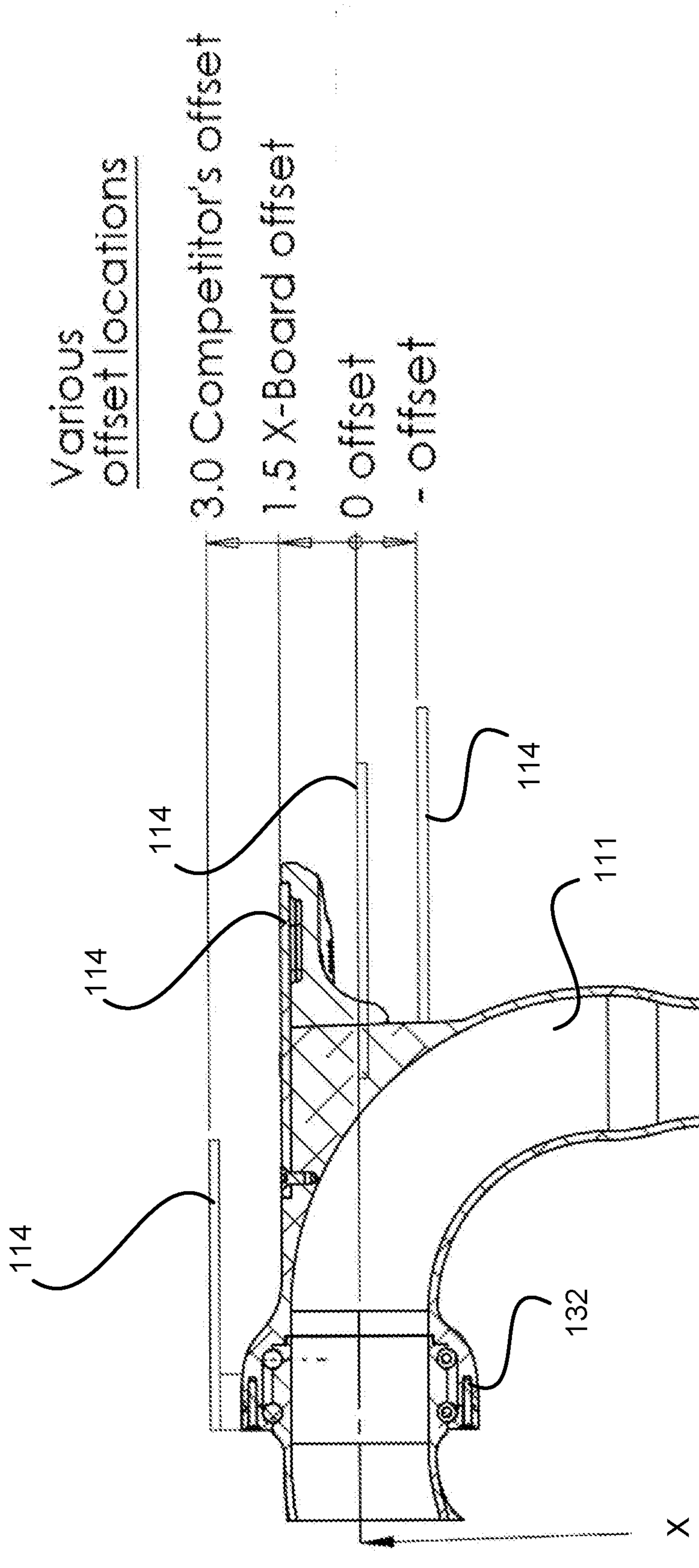


Fig. 5A


Various
offset locations
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1.5 X-Board offset
0 offset
- offset
114
114
114
114
114
111
132
X

Fig. 6

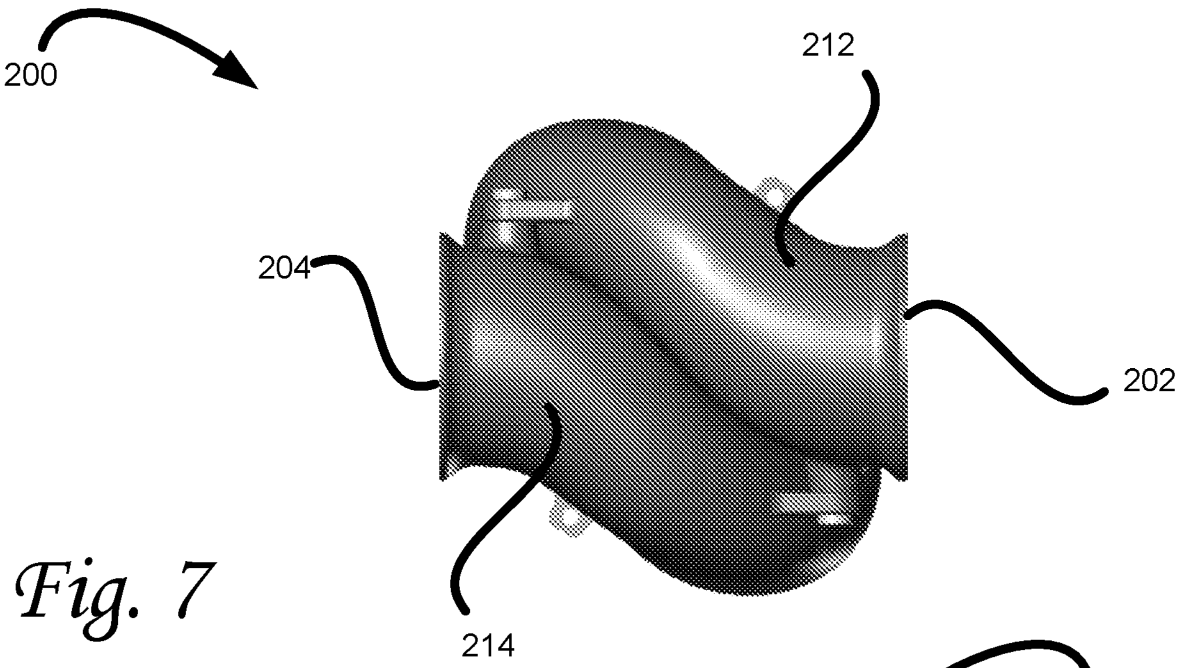

Fig. 7

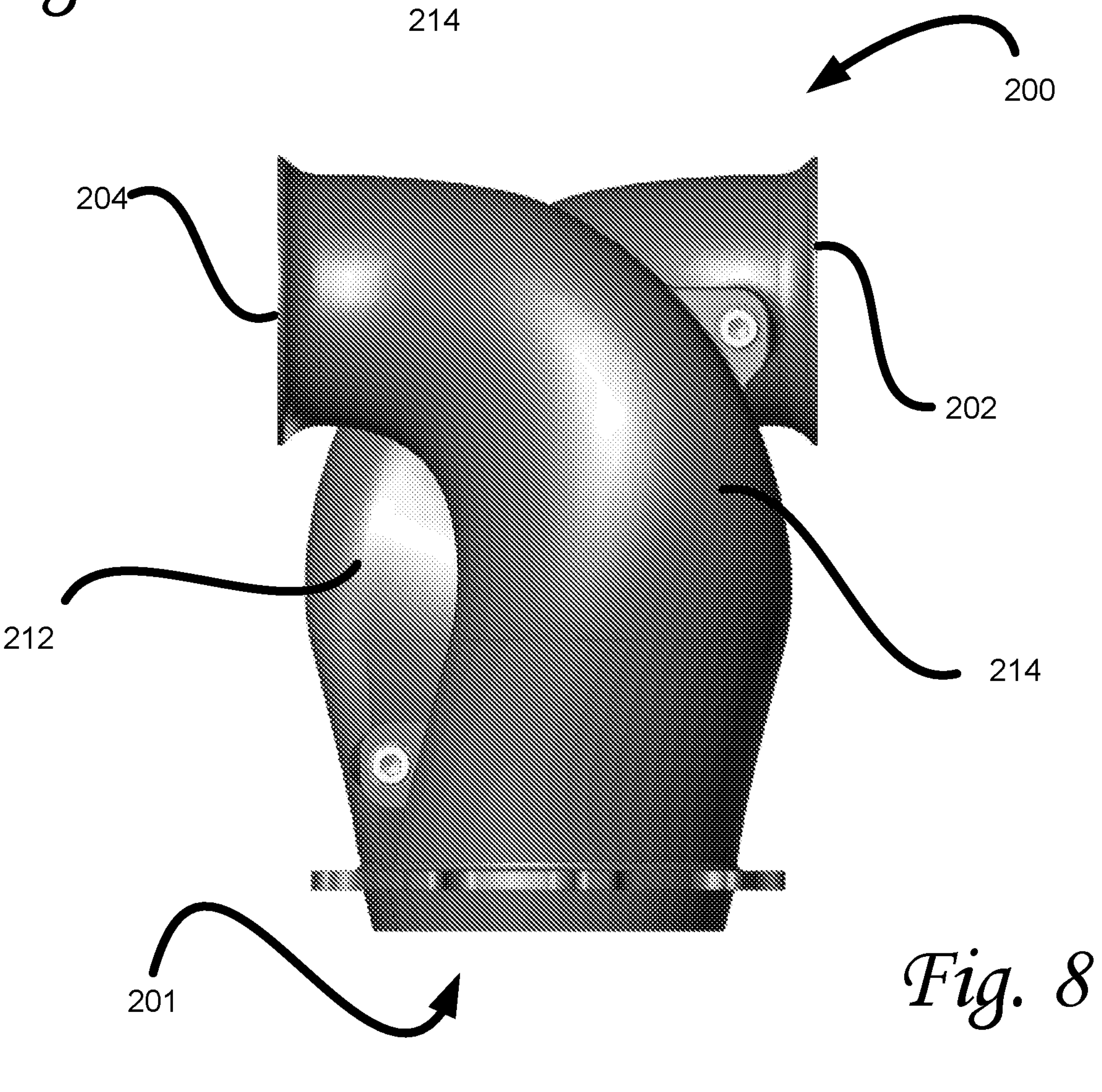

Fig. 8

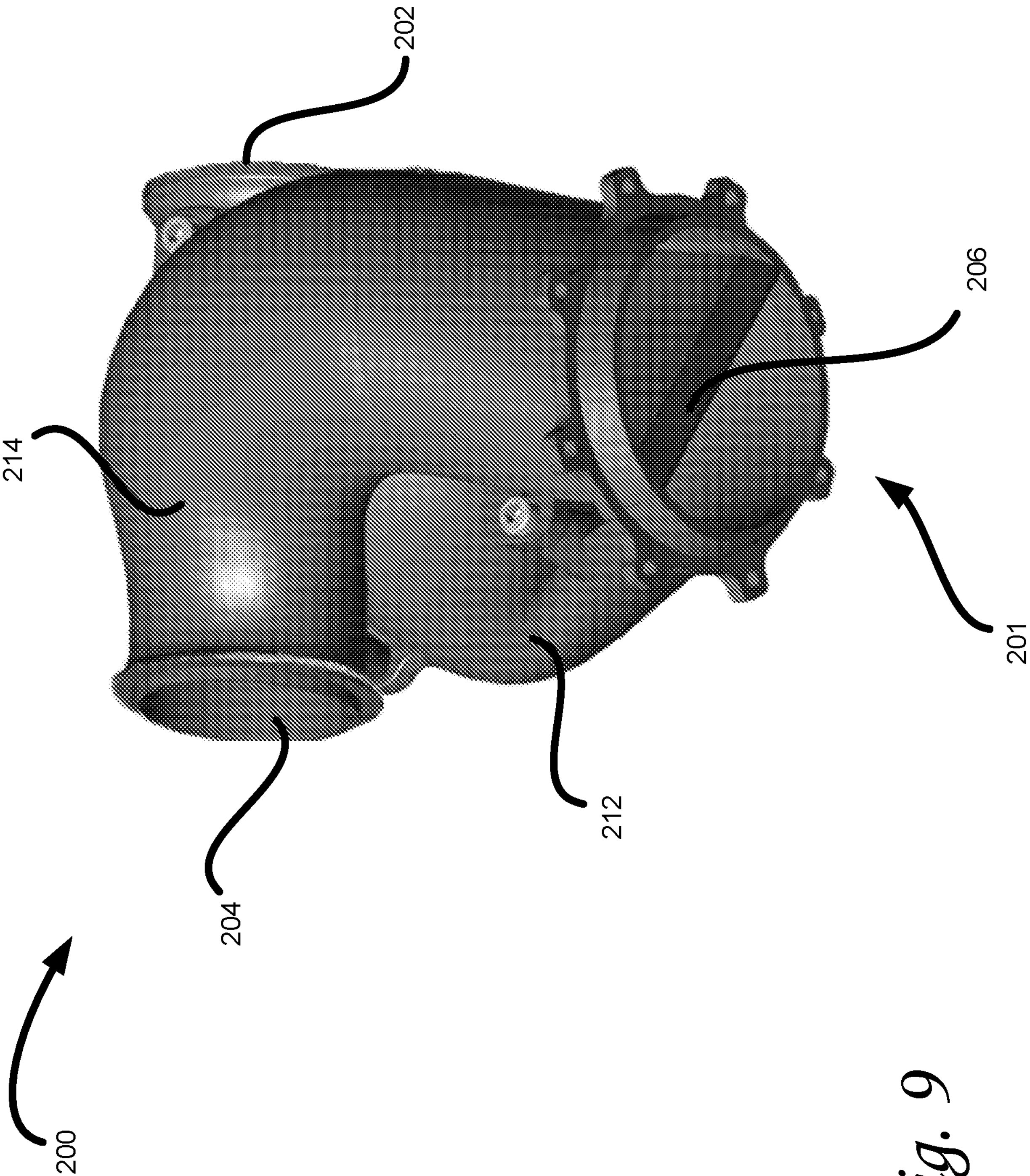

Fig. 9

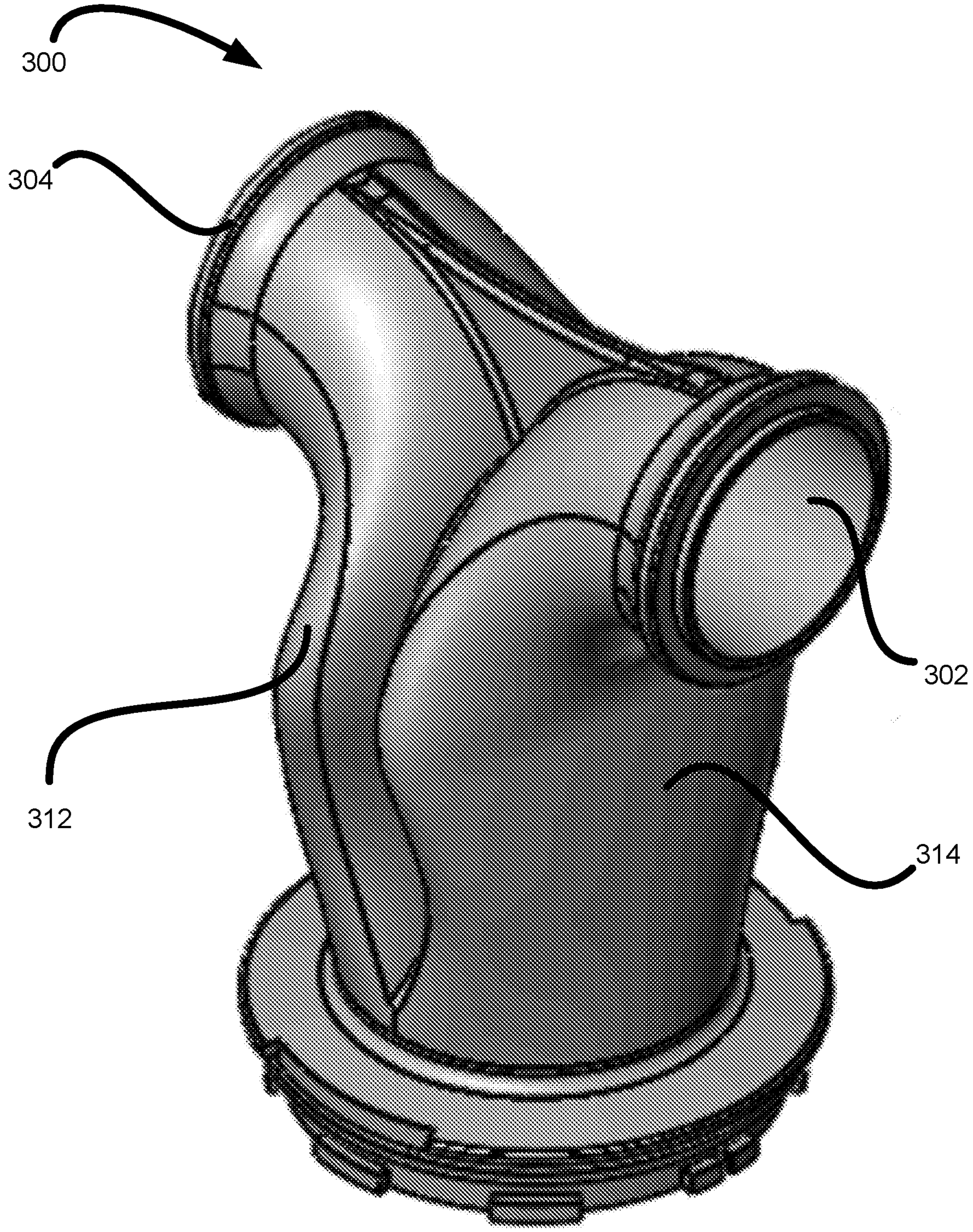

Fig. 10

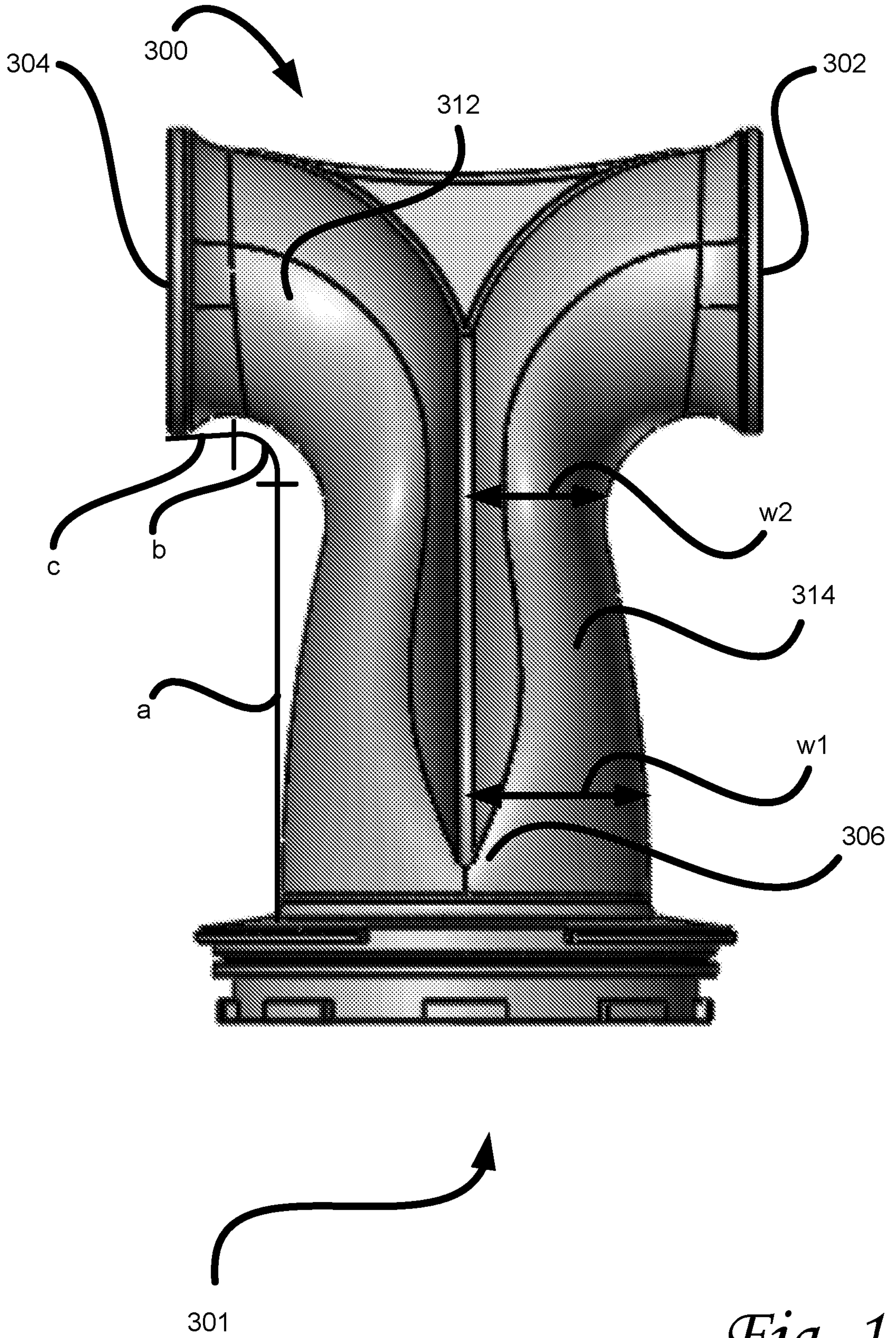

Fig. 11

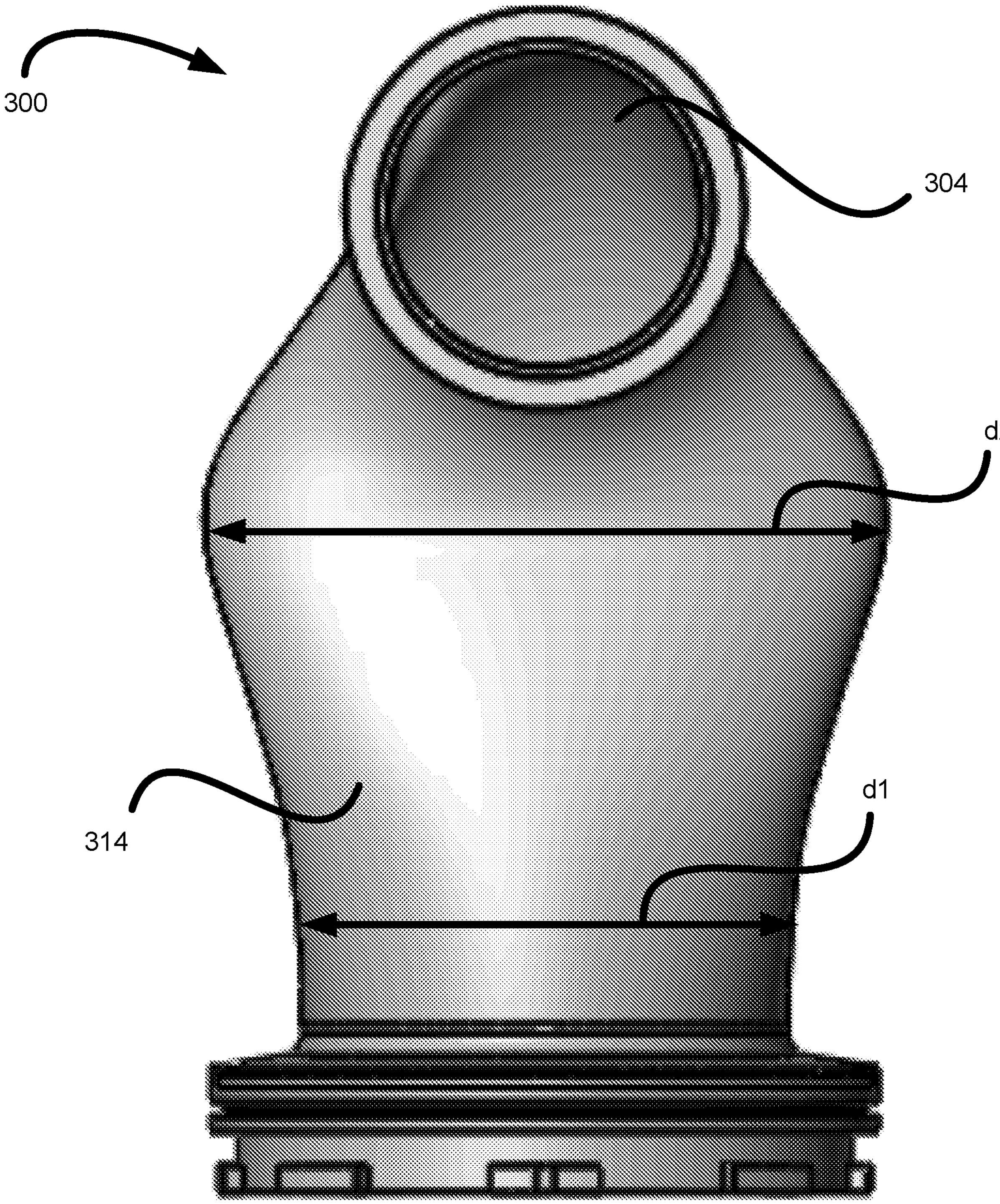

Fig. 12

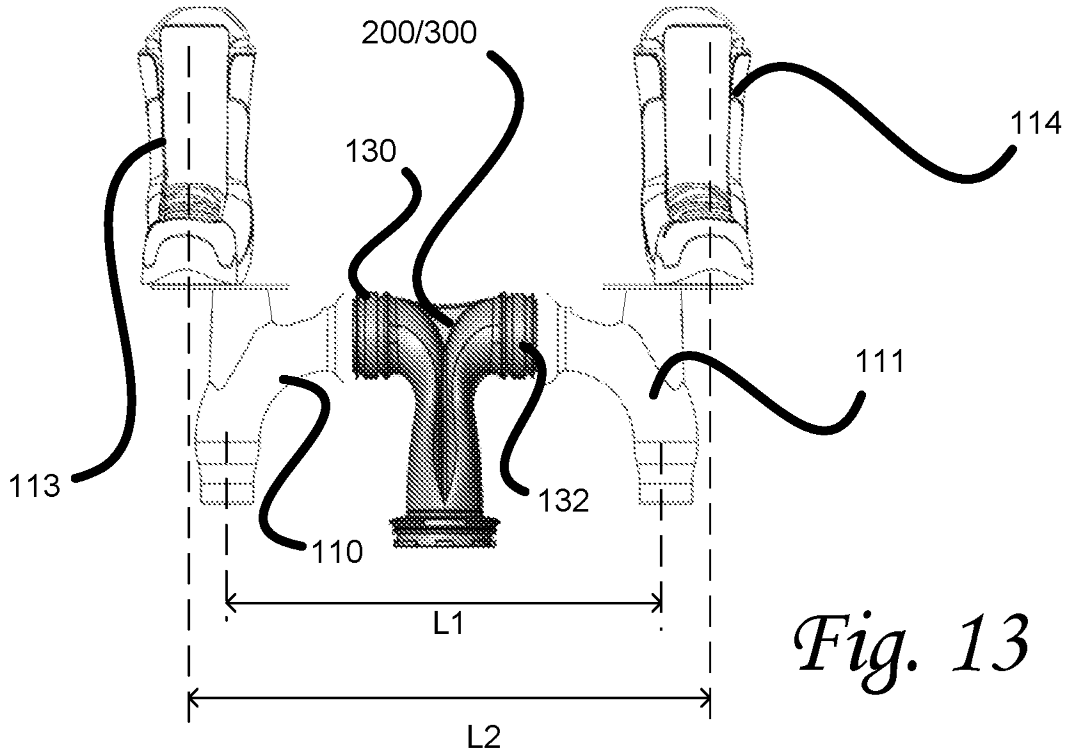
200/300
114
130
113
111
132
110
L1
L2

Fig. 13

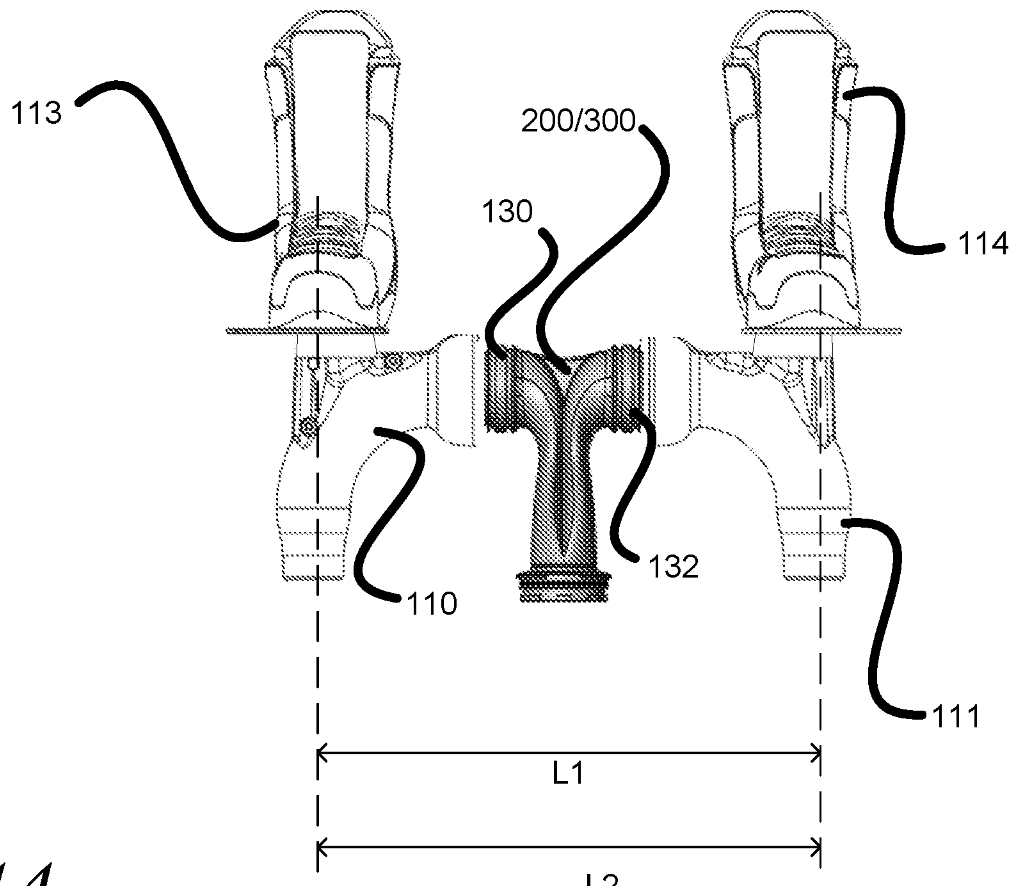
113
200/300
114
130
132
110
111
L1
L2

Fig. 14

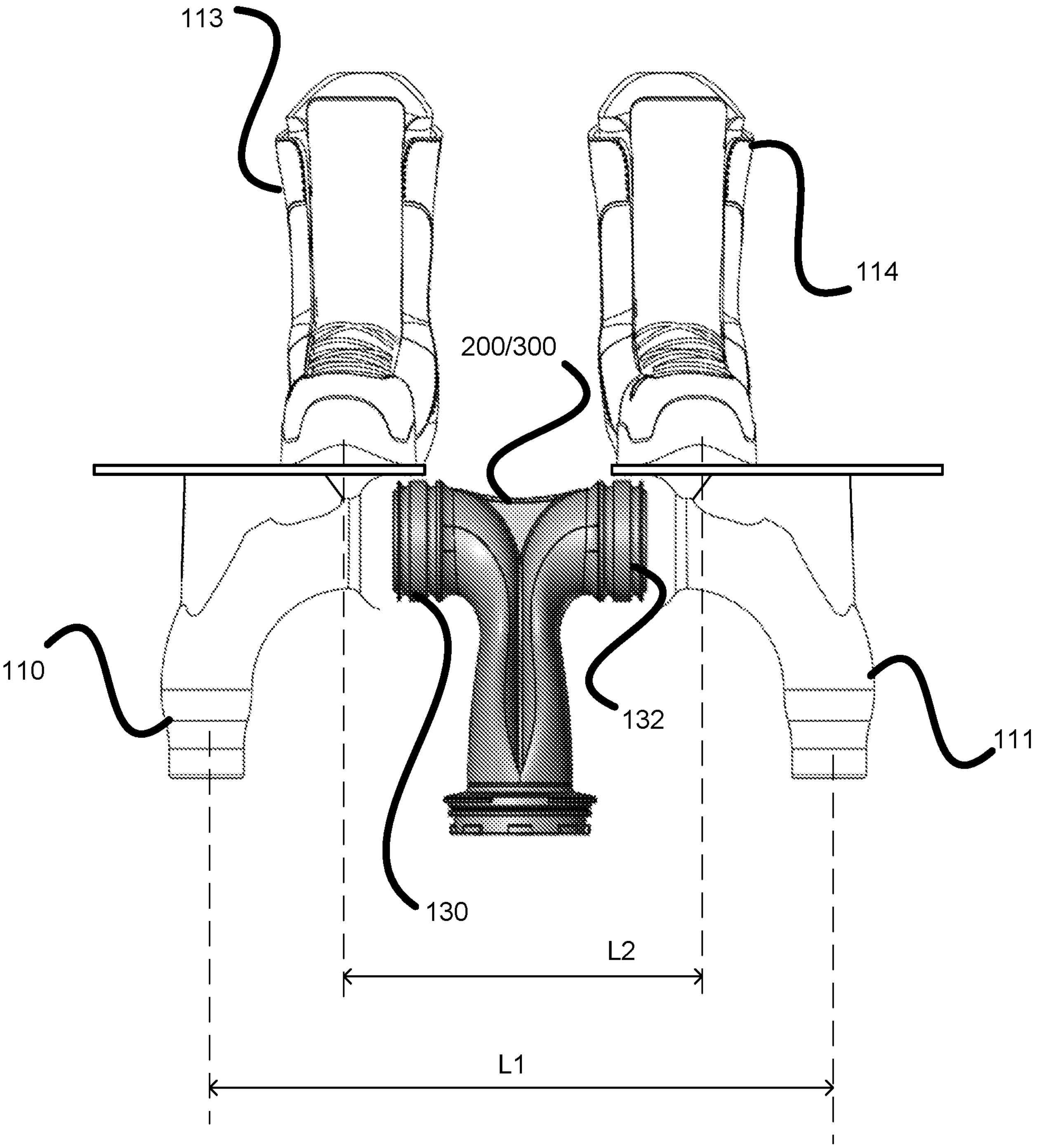

Fig. 15

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 16/50834

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - B63H 11/04 (2016.01)
CPC - B63H 11/04, B63H 2011/006, B63B35/85
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)
CPC: B63H 11/04 B63H 2011/006 B63B 35/85
IPC(8): B63H 11/04 (2016.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
CPC: B64C 39/026 B63B 35/731 B63B 35/85 B63H 2011/008 B64C 29/04; IPC(8): B63H 11/02 B63B 35/73 (2016.01); USPC: 244/23R 244/4R 440/39 440/40 440/42 244/4A; keyword limited, terms below

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatBase; Google (Web, Patent, Scholar); terms used: user personal personnel propulsion propelling fluid water liquid outlet nozzle exit egress oval elliptical cross section area morph transition flow stream inlet input splitter divider partition panel pane wall obstruction foot boot feet platform stirrup holder strap mount parabolic aerodynamic inc

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X -- Y -- A	WO 2014/205419 A1 (HOMER) 24 December 2014 (24.12.2014), entire document, especially FIG. 7-11; pg. 10, ln. 1-2, pg. 10, ln. 13-15	1-6, 20 --- 7 --- 8-19
Y	US 2014/0263849 A1 (LI) 18 September 2014 (18.09.2014), entire document, especially FIG. 3; para [0021]	7
A	US 2004/0253885 A1 (WESTHOFF et al.) 16 December 2004 (16.12.2004), entire document, especially FIG. 3	1-20
A	US 5,779,188 A (FRICK) 14 July 1998 (14.07.1998), entire document, especially FIG. 1d	1-20
A	US 2013/0068895 A1 (ZAPATA) 21 March 2013 (21.03.2013), entire document	1-20
A	US 2015/0028161 A1 (PARKS) 29 January 2015 (29.01.2015), entire document	1-20

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"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
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"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
21 November 2016	20 DEC 2016

Name and mailing address of the ISA/US	Authorized officer:
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774