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(54) **Water jet propulsion device**

(57) A water jet propulsion device 10 for a water vehicle, such as a boat, is disclosed. The propulsion device 10 comprises a main duct 12 having a main inlet 14 that is arranged to be submerged in use and a main outlet 16, an impeller 30 disposed within the main duct 12 be-

tween the main inlet 14 and the main outlet 16, and at least one auxiliary duct 24 having an auxiliary inlet 26 that is arranged to be submerged in use and an auxiliary outlet 28 that opens into the main duct 12 upstream of the impeller 30.

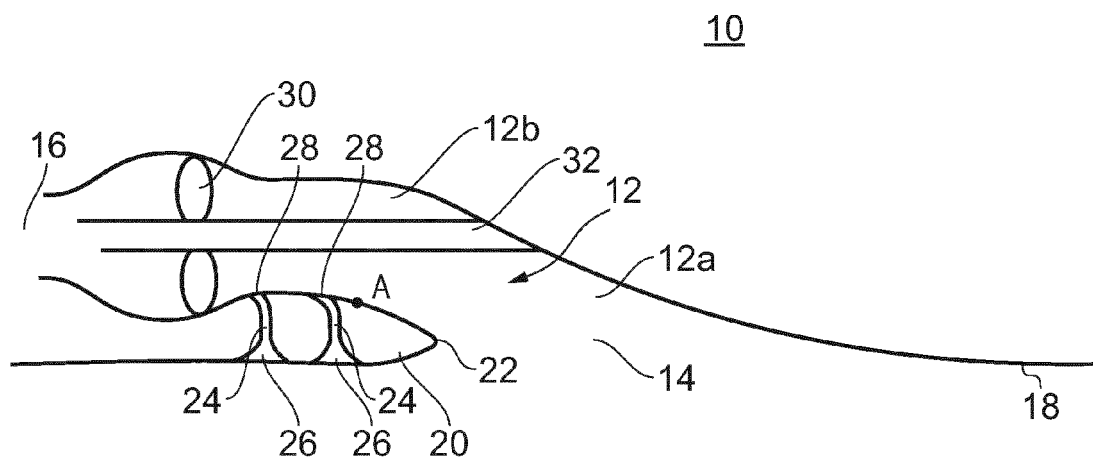


FIG. 1

Description

[0001] The invention relates to a water jet propulsion device for a water vehicle such as a boat.

[0002] Water jet propulsion devices are often used to power water vehicles such as boats. They are also sometimes known as pump-jets or hydro-jets. Water jet propulsion devices typically comprise a pump having an inlet that is submerged in use and an outlet that is located above the water level. In use, the pump ejects a jet of water rearwards out of the outlet which provides a propulsive force to the boat to drive it forwards.

[0003] When the boat is travelling at low-speed the pump sucks water in through the inlet. For optimum performance it is desirable to have a relatively large inlet so that the necessary volume of water can be sucked through the inlet by the pump. However, when the boat is travelling at high-speed water is forced into the inlet due to the speed of the boat. This usually results in too much water being forced into the inlet and therefore it is desirable to have a smaller inlet. The dimensions chosen for the inlet are therefore a compromise for both low-speed and high-speed operation.

[0004] However, the inlet is usually still too small for low-speed operation and too large for high-speed operation. This can result in cavitation and the associated erosion occurring at various positions around the inlet at both low-speed and high-speed operation. Cavitation can also create imbalances on the pump and pressure pulses which impact the mechanical components of the pump and can result in excessive noise, erosion, and potential damage. Further, avoiding cavitation can help increase thrust at low speeds.

[0005] It is therefore desirable to provide a water jet propulsion device having an improved water inlet design.

[0006] According to an aspect of the invention there is provided a water jet propulsion device for a water vehicle, such as a boat or ship, for example, comprising: a main duct having a main inlet that is arranged to be submerged in use and a main outlet; an impeller disposed within the main duct between the main inlet and the main outlet; and at least one auxiliary duct having an auxiliary inlet that is arranged to be submerged in use and an auxiliary outlet that opens into the main duct upstream of the impeller.

[0007] In use, the impeller accelerates water within the main duct and ejects a jet of water out of the main outlet to propel the water vehicle. Typically, at low speeds water is sucked into the main duct through the main inlet by the impeller and at high speeds water is forced into the main duct through the main inlet due to the speed of the water vehicle. At low speeds additional water may be sucked into the main duct through the or each auxiliary duct, thus improving the performance of the propulsion device. At high speeds water may not be sucked into the main duct through the auxiliary duct. In some arrangements, water forced into the main duct at high speeds may in fact exit the main duct through the auxiliary duct, thus improving

the performance of the propulsion device and preventing cavitations along the hull. Further, the addition of the auxiliary duct helps to reduce the compromise between low and high speed flow which provides design freedom in the shape of the main inlet. The water jet propulsion device may be integrally part of a water vehicle or may be a separate device that can be attached to a water vehicle. The impeller may be coupled to a drive shaft which may be coupled to a motor which is arranged to rotationally drive the drive shaft and hence the impeller. At least part of the drive shaft may be substantially horizontal such that the impeller can be rotated about a substantially horizontal axis.

[0008] There may be a plurality of auxiliary ducts, each having an inlet that is arranged to be submerged in use and an outlet that opens into the main duct upstream of the impeller. At least some of the plurality of auxiliary ducts may be arranged side-by-side. At least some of the plurality of auxiliary ducts may be arranged downstream from one another.

[0009] At least part of the main duct may be inclined. The main duct may be inclined rearwards (downstream) and upwards. The inclined main duct may define a main duct lip. The main duct lip may have a forward facing edge. The or each auxiliary duct may extend through the main duct lip. The or each auxiliary duct may be at least partially inclined. The auxiliary inlet may be larger than the cross-section of a main portion of the auxiliary duct.

[0010] A valve may be disposed within the or each auxiliary duct, or only some of the auxiliary ducts. The or each valve, or only some of the valves may be non-return valves. The or each non-return valve may only allow the flow of water into the main duct through the or each auxiliary duct. The or each valve, or only some of the valves may be arranged to open at a pre-determined pressure threshold. The or each valve may be spring loaded.

[0011] The or each valve may arranged to be selectively opened and/or closed. The or each valve may be arranged to be automatically opened and/or closed on the basis of a detected parameter. There may be a sensor for detecting the parameter. The or each valve, or only some of the valves, may open or close when the detected parameter reaches a predetermined threshold. The parameter may relate to pressure, speed, impeller power, impeller rotational speed, ship speed or differential pressure across the valve, for example.

[0012] The water jet propulsion device may include one or more auxiliary ducts which each include a valve arranged to allow water to flow from the auxiliary outlet in the main duct to the auxiliary inlet.

[0013] Control of the valves may be achieved as part of an closed loop system. Alternatively or additionally, the valves may be controlled by an open loop. Preferably, the valves are operable upon command by an operator.

[0014] The invention also concerns a water vehicle, such as a boat or ship, comprising a water jet propulsion device in accordance with any statement herein.

[0015] According to another aspect of the invention

there is provided a water jet propulsion device for a water vehicle, such as a boat or ship, for example, comprising: a pump having a main inlet which is arranged to be submerged in use and a main outlet; and at least one auxiliary passage that opens upstream of the pump and is arranged to be submerged in use.

[0016] In yet another aspect, the a water jet propulsion device for a water vehicle, comprising: a main duct having a main inlet that is arranged to be submerged in use and a main outlet; an impeller disposed within the main duct between the main inlet and the main outlet; an auxiliary duct having an auxiliary inlet arranged to be submerged in use and an auxiliary outlet that opens into the main duct upstream of the impeller; and a door disposed in the auxiliary duct and movable between at least a closed position in which the passage of fluid through the auxiliary duct is restricted and an open position.

[0017] The closed position the door may be substantially flush with a surface within which the auxiliary inlet and/or the auxiliary outlet is formed. The door may permit flow through the auxiliary duct when in an open position. When in an open position the door at least partially projects below a surface within which the auxiliary inlet is formed. When in an open position the door may at least partially project into the main duct. The door may be pivotable between the closed position and an open position. The door may be biased to either the closed position or an open position.

[0018] The device may further comprise an actuator which can be controlled to move the door between at least the closed position and an open position. The door may be actuated based on a determined parameter. Alternatively, the door may be arranged to be passively moved between the closed position and an open position by local pressure changes. There may be a plurality of doors disposed in the auxiliary duct, each movable between at least a closed position and an open position. There may be an inlet door and an outlet door in the region of the auxiliary inlet and the auxiliary outlet respectively.

[0019] There may be a plurality of auxiliary ducts, and wherein at least one door, moveable between at least a closed position and an open position, is disposed in each auxiliary duct.

[0020] At least part of the main duct may be inclined. The incline may be part of the main duct and may define a main duct lip.

[0021] The or each auxiliary duct may pass through the main duct lip.

[0022] The invention may comprise any combination of the features and/or limitations referred to herein, except combinations of such features as are mutually exclusive.

[0023] Embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 schematically shows an embodiment of a

water jet propulsion device;

Figure 2 schematically shows the underside of the water jet propulsion device of Figure 1;

Figure 3 schematically shows the water jet propulsion device of Figure 1 when operating at low-speed; Figure 4 schematically shows the water jet propulsion device of Figure 1 when operating at high-speed;

Figure 5 schematically shows a second embodiment of a water jet propulsion device.

Figure 6 schematically shows an embodiment of a water jet propulsion device in accordance with the invention;

Figure 7 schematically shows a second embodiment of a water jet propulsion device in accordance with the invention;

Figure 8 schematically shows a third embodiment of a water jet propulsion device in accordance with the invention, with inlet and outlet doors in closed positions;

Figure 9 schematically shows the water jet propulsion device of Figure 8 with inlet and outlet doors in open positions;

Figure 10 schematically shows the water jet propulsion device of Figure 8 with the inlet door in an alternative open position;

Figure 11 schematically shows the underside of a further embodiment of a water jet propulsion device in accordance with the invention.

[0024] Figure 1 shows an embodiment of a water jet propulsion device 10 which is integrally part of a water vehicle which in this embodiment is a boat. In should be appreciated that in other embodiments the water jet propulsion device 10 could be a separate device arranged to be attached to a water vehicle. The propulsion device 10 comprises a main duct 12 having a main inlet 14 and a main outlet 16. The main inlet 14 lies in a substantially horizontal plane and is formed in the lower surface of the hull 18 of the boat. In use, the main inlet 14 is submerged underwater. The main outlet 16 lies in a substantially vertical plane and is formed in a side surface of the hull 18 of the boat. In use, the main outlet 16 is located above the water line. A nozzle (not shown) may constitute or form part of the main outlet.

[0025] The main duct 12 comprises an inclined portion 12a and a substantially horizontal portion 12b. The inclined duct portion 12a extends from the main inlet 14 rearwards (downstream) and upwards and transitions into the horizontal portion 12b that extends rearwards to the main outlet 16. In other embodiments the main duct 12 may be entirely inclined along its length. The main duct 12 defines a main duct lip 20, the lower surface of which forms part of the hull 18. The duct lip 20 has a forward-facing edge 22 which is also part of the edge of the main inlet 14.

[0026] A plurality of auxiliary ducts 24 extend through the duct lip 20 and open into the main duct 12. Each

auxiliary duct 24 comprises an auxiliary inlet 26 that is formed in the lower surface of the hull 18 and an auxiliary outlet 28 that opens into the main duct 12. The auxiliary inlets 26 are arranged to be submerged underwater in use. In this particular embodiment there are six auxiliary ducts.

[0027] As can be seen in Figure 2, there are two rows of auxiliary ducts 24 with one row located downstream from the other row. Each row of auxiliary ducts comprises three individual auxiliary ducts 24 that are located side-by-side. The auxiliary duct inlet 26 of each duct 24 is larger than the cross-section of the main portion of the auxiliary duct 24.

[0028] The water jet propulsion device further comprises a pump having a ducted impeller 30 which is disposed in the horizontal portion 12b of the main duct 12. The impeller 30 is mounted to a substantially horizontal rotational drive shaft 32 that passes through the upper wall of the main duct 12 into the interior of the boat. The drive shaft 32 is coupled to a motor (not shown) which is arranged to rotationally drive the drive shaft 32 and hence the impeller 30 about a horizontal axis.

[0029] In use, the hull 18 of the boat is partially submerged in water so that the main inlet 14 and the auxiliary inlets 26 are submerged. The impeller 30 is rotated about a horizontal axis by the drive shaft 32 and water in the main duct 12 is accelerated by the impeller 30 and forced out of the main outlet 16 as a jet of water which causes the boat to be propelled forwards. The speed of the impeller 30 can be increased or decreased in order to increase or decrease the propulsive force generated by the water jet propulsion device 10.

[0030] The operation of the water jet propulsion device 10, and the flow of water through the main duct 12 and the auxiliary ducts 24, differs depending on whether the boat to which the water jet propulsion device 10 is attached (or integrated) is travelling at low speed or high speed.

[0031] Figure 3 schematically shows the operation of the water jet propulsion device 10 when the boat is travelling at low speed. Low speed may be considered to be less than 20 knots. When the boat is travelling at low speed the impeller 30 acts to suck water into the main duct 12 through both the main inlet 14 and through the auxiliary inlets 26 of the auxiliary ducts 24. The overall inlet area (the sum of the areas of the main inlet 14 and the auxiliary inlets 26) is larger than the overall inlet area of a conventional water jet propulsion device 10 having only a main inlet 14. The auxiliary ducts 24 therefore allow for the additional flow of water into the main duct 12 upstream of the impeller 30. Thus, it is easier for the impeller 30 to suck, or draw, water into the main duct 12 and expel it out of the main outlet 16 in order to generate a propulsive force.

[0032] When a conventional water jet propulsion device operates at low speed, water is drawn from behind the main inlet and is turned around the duct lip into the main duct. This can lead to flow separation at A which is

a position on the upper surface of the duct lip 20 rearward of the edge 22. In turn, this flow separation can lead to cavitation if the pressure of the liquid falls below its vapour pressure and gas bubbles form. Cavitation can cause significant damage to the pump impeller due to pressure imbalances and the creation of pressure pulses.

[0033] The provision of auxiliary ducts 24 that extend through the main duct lip 20 means that during operation at low-speed less, or no water is forced to flow around the edge 22 of the duct lip 20. This reduces the likelihood of flow separation occurring at position A and hence cavitation is less likely to occur. Avoiding cavitation may also increase the life of the water jet propulsion device and provide a beneficial increase in flow rate and thrust.

[0034] Figure 4 schematically shows the operation of the water jet propulsion device 10 when the boat is travelling at high speed. High speed may be considered to be greater than 20 knots. At high speed water is in forced, or rammed, into the main duct 12 through the main inlet 14 due to the forward speed of the boat. In fact, at certain speeds too much water may be forced into the main duct 12 through the main inlet 14 and the impeller 30 may not be able to eject all of the water forced into the duct 12. In such circumstances excess water may be forced out of the main duct 12 through the auxiliary ducts 26. This can improve the performance of the water jet propulsion device 10.

[0035] When a conventional water jet propulsion device operates at high speed, if too much water is forced into the main inlet due to the speed of the boat, water must also exit through the main inlet. The excess water tends to exit the main inlet and flow rearward around the lip edge 22 and under the duct lip 20. The flow of the excess water around the lip 20 can cause flow separation and hence cavitation at B which is a position on the lower surface of the duct lip 20 rearward of the edge 22.

[0036] In certain embodiments of the invention excess water can exit the main duct 12 through the auxiliary ducts 24, as opposed to through the main inlet 14, and therefore flow separation and hence cavitation can be prevented or reduced at position B during high speed operation.

[0037] The solution provided by the water jet propulsion device 10 described above is particularly advantageous as it comprises no moving parts. This makes it particularly reliable and resistant to debris that may impact the propulsion device 10 during use.

[0038] Figure 5 shows a further embodiment of a water jet propulsion device 10 which is similar to the embodiment described with reference to Figures 1-4. The only difference is that there is a fluid control valve 34 disposed within each auxiliary duct 24 which can control the flow of water through the respective duct 24.

[0039] The valves 34 may be passive non-return valves, for example, arranged such that water can only flow into the main duct 12 or arranged such that water can only flow out of the main duct 12 through the auxiliary ducts 24. In one embodiment, the fluid control valves 34 may be arranged to open at a specific pressure. The

valves 34 may be spring-loaded so that they only open and allow flow through the auxiliary ducts 24 at a particular pressure threshold. In other embodiments, the valves 34 may be connected to a pressure pick-up (not shown) disposed at the edge 22 of the duct lip 20, for example, or elsewhere near the main inlet 14. The pressure pick-up may be coupled to the valves such that they open and close at specific pressure thresholds. It will be appreciated that the pressure pick ups could actuate the valve directly or may operate the valves via hydraulic or electrical actuators.

[0040] In a further embodiment the valves 34 may be fully externally controlled. The valves 34 may be connected to control circuitry (not shown) which in turn is connected to one or more sensors (not shown) that are arranged to detect or measure various parameters. The parameters could be boat speed, pressure levels at a particular point or shaft power, impeller rotational speed, ship speed or differential pressure across the impeller, for example. The control circuitry could be arranged to open or close the valves individually, or as a group, in response to the detected parameter values. For example, if the boat speed is detected as "low" (e.g. less than 20 knots) the valves 34 could be opened to allow one-way flow into the main duct 12 through the auxiliary ducts 24, and if the boat speed is detected as "high" (e.g. greater than 20 knots) the valves could be opened to allow one-way flow out of the main duct 12 through the auxiliary ducts 24.

[0041] In yet another embodiment, the valves may be operable on command by a person so as to provide open loop control.

[0042] As will be appreciated by one skilled in the art, any combination of the aforementioned valves may be used.

[0043] It will be appreciated that the auxiliary ducts may be configured to allow the optimisation of the main duct above and below the duct lip for different flow conditions. In one embodiment, there is included at least one duct which includes a valve configured to allow unidirectional flow during particular flow conditions. In another embodiment there is one or more auxiliary ducts arranged to provide an auxiliary flow from below the duct lip to the main duct and one or more auxiliary ducts to provide flow from the main duct to below the duct lip.

[0044] In a yet further embodiment, two or more of the auxiliary ducts are interconnected towards the main duct. The interconnection may be between all of the auxiliary ducts. In this way, the effective shape of the main inlet can be altered to accommodate low and high speed flows.

[0045] Figure 6 shows an embodiment of a water jet propulsion device 110 which is integrally part of a water vehicle which in this embodiment is a boat. It should be appreciated that in other embodiments the water jet propulsion device 110 could be a separate device arranged to be attached to a water vehicle. The propulsion device 110 comprises a main duct 112 having a main inlet 114

and a main outlet 116. The main inlet 114 lies in a substantially horizontal plane and is formed in the lower surface of the hull 118 of the boat. In use, the main inlet 114 is submerged underwater. The main outlet 116 lies in a substantially vertical plane and is formed in at the rear surface of the hull 118 of the boat. In use, the main outlet 116 is located above the water line. A nozzle (not shown) may constitute or form part of the main outlet.

[0046] The main duct 112 comprises an inclined portion 112a and a substantially horizontal portion 112b. The inclined duct portion 112a extends from the main inlet 114 rearwards (downstream) and upwards and transitions into the horizontal portion 112b that extends rearwards to the main outlet 116. In other embodiments the main duct 112 may be entirely inclined along its length. The main duct 112 defines a main duct lip 120, the lower surface of which forms part of the hull 118. The duct lip 20 has a forward-facing edge 122 which is also part of the edge of the main inlet 114.

[0047] An auxiliary duct 124 extends through the duct lip 120 and opens into the main duct 112. The auxiliary duct 124 comprises an auxiliary inlet 126 that is formed in the lower surface of the hull 118 and an auxiliary outlet 128 that opens into the main duct 112. The auxiliary inlet 126 is arranged to be submerged underwater in use. In this particular embodiment there is one auxiliary duct 124, however, in other embodiments there may be a plurality of auxiliary ducts which may be arranged side-by-side, in a longitudinally extending line behind the main duct lip 20 or arranged in rows behind the main duct lip 120, for example.

[0048] The water jet propulsion device further comprises a pump having a ducted impeller 130 which is disposed in the horizontal portion 112b of the main duct 112. The impeller 130 is mounted to a substantially horizontal rotational drive shaft 132 that passes through the upper wall of the main duct 112 into the interior of the boat. The drive shaft 132 is coupled to a motor (not shown) which is arranged to rotationally drive the drive shaft 132 and hence the impeller 130 about a horizontal axis.

[0049] An inlet door 140 is disposed in the auxiliary duct 124 and is located substantially in the region of the auxiliary inlet 126. The inlet door 140 is pivotable between a closed position (not shown) in which the door is substantially flush with the lower surface of the lip 120 and an open position (shown in Figure 6). The door 140 is pivotably mounted to the duct lip 1120 at a pivot 142 that is connected to the upstream edge of the door 140.

[0050] In the open position, water is able to flow through the auxiliary duct 124 into the main duct 112. In the closed position the flow of water through the auxiliary duct 124 is restricted.

[0051] In use, the hull 118 of the boat is partially submerged in water so that the main inlet 114 and the auxiliary inlet 126 is submerged. The impeller 130 is rotated about a horizontal axis by the drive shaft 132 and water in the main duct 112 is accelerated by the impeller 130 and forced out of the main outlet 116 as a jet of water

which causes the boat to be propelled forwards. The speed of the impeller 30 can be increased or decreased in order to increase or decrease the propulsion force generated by the water jet propulsion device 110.

[0052] The operation of the water jet propulsion device 110, and the flow of water through the main duct 112 and the auxiliary duct 124, differs depending on whether the boat, to which the water jet propulsion device 110 is attached (or integrated) is travelling at low speed or high speed.

[0053] When the water vehicle is travelling at low speed, the inlet door 140 can be moved to an open position (shown in Figure 6). This allows additional water to be sucked into the main duct 112 through the auxiliary duct 124. Therefore, water may not be forced to flow forward around the edge 122 of the duct lip 120 into the main duct 112. This reduces the likelihood of flow separation and hence cavitation occurring at position A. Avoiding cavitation may increase the life of the water jet propulsion device. Further, avoiding separation may result in a higher effective inlet area, thereby increasing the flow of water to the impeller resulting in increased thrust and acceleration capability at low speed.

[0054] The auxiliary duct inlet 126 may be shaped to facilitate the smooth flow of water into the auxiliary duct 124. For example, for improved performance at low to intermediate speeds, the duct may be shaped to accept flow from a forward direction.

[0055] When the water vehicle is travelling at higher speeds, additional flow through the auxiliary duct 124 may not be required to maintain efficiency and thrust capability. Therefore the inlet door 140 can be moved to the closed position in which it is substantially flush with the lower surface of the duct lip 120. In the closed position, the inlet door 140 restricts or prevents the flow of water through the auxiliary duct 124 into the main duct 112. The closure of the inlet door 140 at higher speeds also protects it from damage by foreign objects in the flow.

[0056] The inlet door 140 is designed to be substantially flush with the lower surface of the duct lip 120 when in the closed position such that it does not present an obstruction to the flow and is not susceptible to damage. In the closed position, the door substantially blends with the hull profile as if it were part of the lower surface of the duct lip 120.

[0057] In this particular embodiment the door 140 is biased towards the closed position and automatically moves to the open position at low speed. At low speed there is a pressure reduction within the main duct 112 which pulls the door 140 to the open position in order to permit flow through the auxiliary duct 124 into the main duct 112. When the speed of the boat increases, the pressure within the main duct 112 increases and therefore the door 140 returns to the closed position.

[0058] It should be appreciated that in other embodiments an actuator (not shown) may be provided in order to move the door 140 between open and closed positions. This actuator could be manually controlled or could be

connected to a controller (not shown) which automatically opens or closes the door based on detected data. For example, the controller could be connected to one or more sensors (now shown) arranged to measure various parameters such as water pressure, impeller speed, vehicle speed, for example. The controller could be configured to open or close the door when the measured parameter exceeds or falls below a threshold.

[0059] Figure 7 shows a second embodiment of a water jet propulsion device 110 which is similar to the embodiment described with reference to Figure 6. However, the pivot 142 by which the door 140 is pivotally attached to the boat is positioned at a mid-point along the length of the door between the upstream and downstream ends. The inlet door 140 can be rotated about the pivot 142 between a closed position in which it is substantially flush with the lower surface of the hull 118 and an open position (Figure 7). When the inlet door 140 is in this open position an upstream portion 144 of the inlet door 140 (which is the upstream portion of the door beyond the pivot) projects below the general lower surface of the duct lip 120 in which the auxiliary inlet 26 is formed. The downstream portion 146 of the inlet door 140 projects into the auxiliary duct 124. When the water vehicle is travelling at low speeds in a forward direction, the inlet door 140 is moved to the open position and the upstream portion 144 of the door 140 directs the water into the auxiliary duct 124 from where it flows into the main duct 112. The upstream part 144 of the inlet door 140 therefore acts as a scoop when in the open position shown in Figure 7.

[0060] Figures 8-10 show a third embodiment of a water jet propulsion device 110 which is similar to the second embodiment. However, the water jet propulsion device 110 further comprises a second outlet door 150 that is disposed in the auxiliary duct 124 in the region of the auxiliary outlet 128. The outlet door 150 is pivotally mounted by a pivot 152 which is positioned at a mid-point along the length of the door. The outlet door 150 is pivotable between at least a closed position (Figure 8) in which it is flush with the upper surface of the lip 120 and restricts fluid flow through the auxiliary duct 124 and an open position (Figures 9 and 10).

[0061] In the open position of the outlet door 150, a downstream portion 156 of the door 150 projects into the main duct 112 and an upstream portion 154 projects into the auxiliary duct 124.

[0062] The inlet door 140 is movable between a closed position (Figure 8), a first open position (Figure 9) and a second open position (Figure 10). The inlet door 140 is moved from the closed position to the first open position by clockwise rotation about the pivot 142 and is moved to the second open position by anticlockwise rotation about the pivot 142. The first open position (Figure 9) is the same as the open position of the second embodiment and the upstream portion 144 of the door 140 projects below the lower surface of the duct lip 120. In the second open position (Figure 10) the downstream portion 146 of the door 140 projects below the lower surface of the duct

lip 120.

[0063] When the inlet and/or outlet doors 140, 150 are in the closed position flow through the auxiliary duct 124 is restricted or prevented. When the inlet door 140 is in the first or second open position and the outlet door 150 is in an open position water can flow through the auxiliary duct 124.

[0064] Figure 9 shows the water jet propulsion device 110 of Figure 8 in use at low speeds with the inlet door 140 in the first open position and the outlet door 150 in an open position. Water is able to flow through the auxiliary duct 124 into the main duct 112.

[0065] In the first open low-speed configuration additional water can be directed into the main duct 112 and therefore less flow turning is required at A. Further, the sloped position of the outlet door 150 further reduces the flow turning required at A, and separation and cavitation is therefore reduced or prevented when the water vehicle is travelling at low speeds. The outlet door 150 also acts to direct water from the auxiliary duct 124 upwards and towards the impeller 130. Further, the inlet door 140 may act as a scoop to force water into the auxiliary duct.

[0066] Figure 10 shows the water jet propulsion device 110 of Figure 9 in use at high speeds with the inlet door 140 in the second open position. This deployment may prevent separation and cavitation at high speeds by allowing excess water to flow out of the main duct 112 through the auxiliary duct 124. The outlet door 150 deflects the main duct flow upwards towards position C, therefore reducing the risk of separation and cavitation and provides a more uniform water flow to the impeller 130. The inlet door 140 is in the second open position, allowing excess water to flow out of the main duct 112 through the auxiliary duct at high water vehicle speeds, thereby providing additional flow at B where the flow may otherwise be separated and/or cavitating.

[0067] Excess water may also flow out of the main duct 112 through the auxiliary duct 124 by rotating the outlet door 150 in the opposite direction such that the upstream portion 154 projects into the main duct 112 and the downstream end of the 156 projects below the auxiliary outlet 128.

[0068] Providing at least one auxiliary duct 124 with at least one inlet and/or outlet door 140, 150 may reduce or prevent separation, cavitation and pump face distortion at both low and high speed. This may therefore extend the operating range of the device, providing improved thrust capability at low and high speeds whilst avoiding damage and low efficiency performance.

[0069] It should be appreciated that any of the embodiments described may comprise more than one auxiliary duct, each with an inlet door 140 and/or an outlet door 150. Figure 11 shows the underside of the hull in an embodiment where multiple auxiliary ducts are arranged in rows downstream of the main duct lip 120.

[0070] In some embodiments, the doors 140, 150 may be arranged to open and close under the action of local pressure forces. They may be spring-loaded so that they

open and allow flow through the auxiliary ducts 124 at a particular pressure threshold. In other embodiments, the doors 140, 150 may be connected to a pressure pick-up (not shown) disposed at the edge 122 of the duct lip 120, for example, or elsewhere in the main inlet 114. The pressure pick-up may be coupled to the doors 140, 150 such that they open and close at specific pressure thresholds.

[0071] In a further embodiment the doors 140, 150 may be fully externally controlled. The doors 140, 150 may be connected to control circuitry (not shown) which in turn is connected to one or more sensors (not shown) that are arranged to detect or measure various parameters. The parameters could be boat speed, pressure levels at a particular point or shaft power, for example. The control circuitry could be arranged to open or close the doors 140, 150 individually, or as a group, in response to the detected parameter values. For example, if the boat speed is detected as "low" (e.g. less than 20 knots) the doors 140, 150 could be opened to allow flow into the main duct 112 through the or each auxiliary duct 124, and if the boat speed is detected as "high" (e.g. greater than 20 knots) the doors 140, 150 could be opened so as to allow flow out of the main duct 112 through the or each auxiliary duct 124.

[0072] The doors 140, 150 may be arranged to open and close under the action of local pressure forces and be movable by an actuator.

[0073] The actuation of the doors 140, 150 may be hydraulic or electrical, for example.

[0074] Although the main outlet 116 has been described as being above the water line, it will be appreciated that the main outlet 116 may also be below the water line, which may be useful for certain applications.

[0075] As will be appreciated by one skilled in the art, any combination of the aforementioned doors and door positions may be used.

[0076] In a yet further embodiment, two or more of the auxiliary ducts are interconnected towards the main duct. The interconnection may be between all of the auxiliary ducts. In this way, the effective shape of the main inlet can be altered to accommodate low and high speed flows.

Claims

1. A water jet propulsion device for a water vehicle, comprising:

a main duct having a main inlet that is arranged to be submerged in use and a main outlet;
an impeller disposed within the main duct between the main inlet and the main outlet; and
at least one auxiliary duct having an auxiliary inlet that is arranged to be submerged in use and an auxiliary outlet that opens into the main duct upstream of the impeller,
wherein a valve is disposed within at least one

auxiliary duct.

2. A water jet propulsion device according to claim 1, wherein there are a plurality of auxiliary ducts, each having an inlet that is arranged to be submerged in use and an outlet that opens into the main duct upstream of the impeller. 5
3. A water jet propulsion device according to claim 2, wherein at least some of the plurality of auxiliary ducts are arranged side-by-side. 10
4. A water jet propulsion device according to claim 2 or 3, wherein at least some of the plurality of auxiliary ducts are arranged downstream from one another. 15
5. A water jet propulsion device according to any preceding claim, wherein at least part of the main duct is inclined. 20
6. A water jet propulsion device according to claim 5, wherein the inclined main duct defines a main duct lip.
7. A water jet propulsion device according to claim 5, wherein the or each auxiliary duct extends through the main duct lip. 25
8. A water jet propulsion device according to any preceding claim, wherein the valve is a door disposed in the auxiliary duct and movable between at least a closed position in which the passage of fluid through the auxiliary duct is restricted and an open position. 30
9. A water jet propulsion device according to claim 8, wherein the or each valve is a non-return valve. 35
10. A water jet propulsion device according to claim 9, wherein the or each non-return valve only allows the flow of water into the main duct through the or each auxiliary duct. 40
11. A water jet propulsion device according to any of claims 8-10, wherein the or each valve is arranged to open at a pre-determined pressure threshold. 45
12. A water jet propulsion device according to claim 11, wherein the or each valve is spring loaded.
13. A water jet propulsion device according to any of claims 8-12, wherein the or each valve can be selectively opened and/or closed. 50
14. A water jet propulsion device according to any of claims 8-13, wherein the or each valve is arranged to be automatically opened and/or closed on the basis of a detected parameter. 55
15. A water jet propulsion device according to any of claims 8 to 14 comprising one or more auxiliary ducts which include a valve arranged to allow water to flow from the auxiliary duct outlet in the main duct to the auxiliary duct inlet.

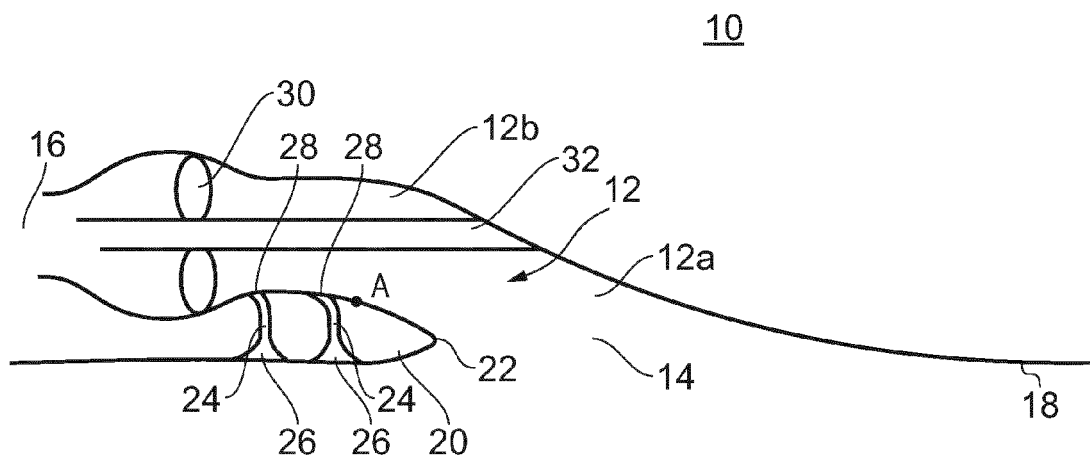


FIG. 1

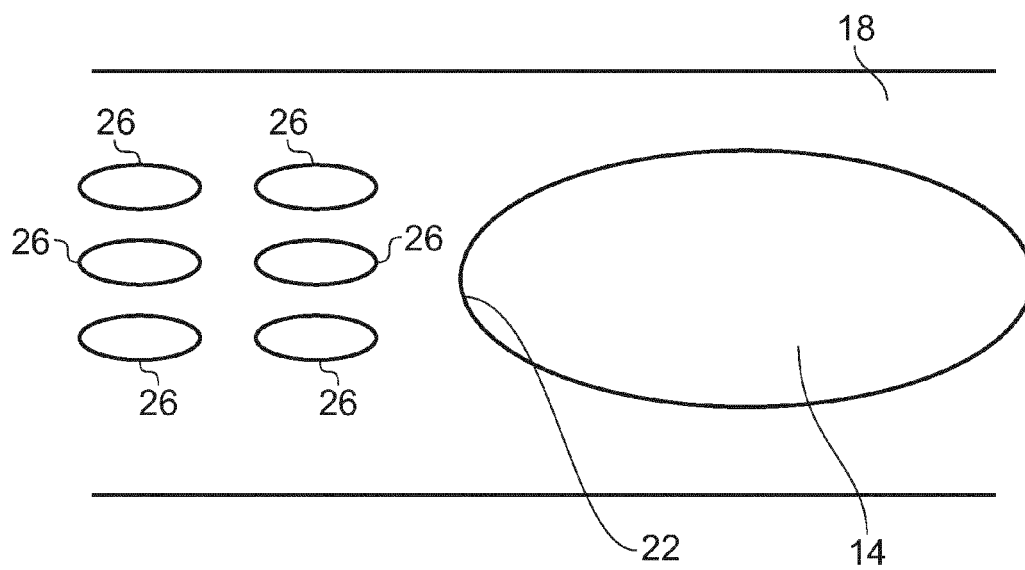


FIG. 2

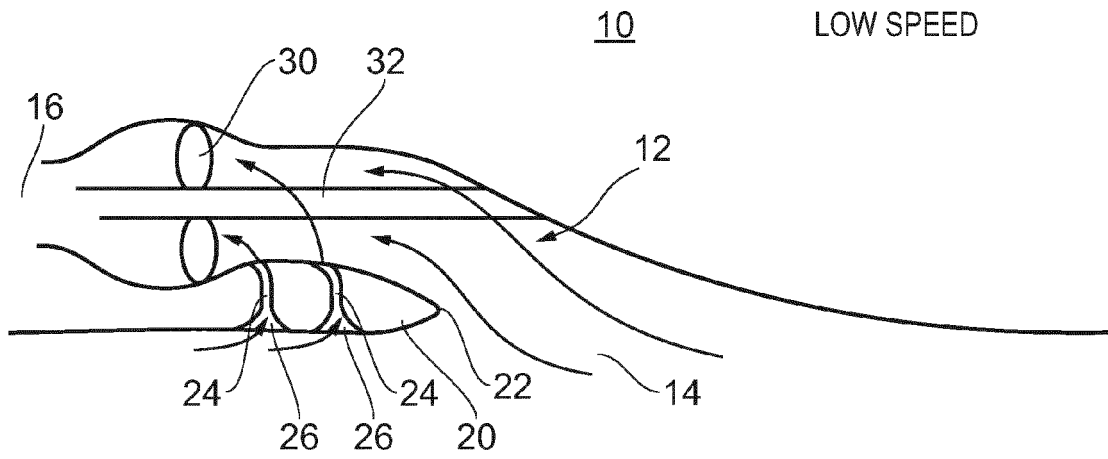


FIG. 3

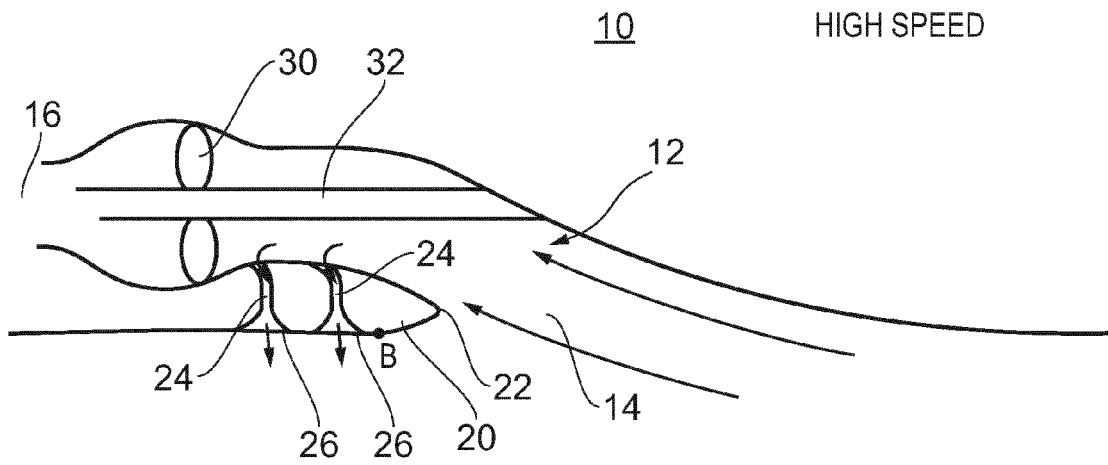


FIG. 4

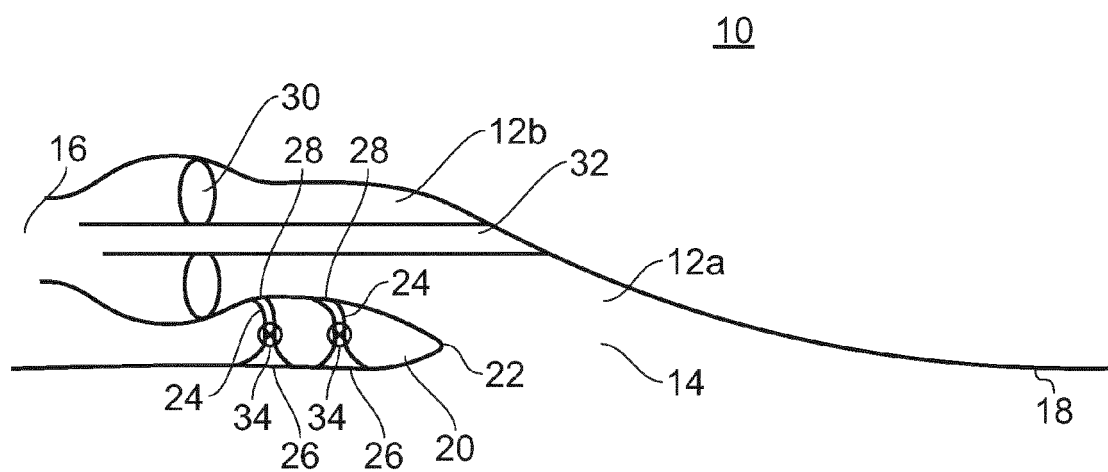


FIG. 5

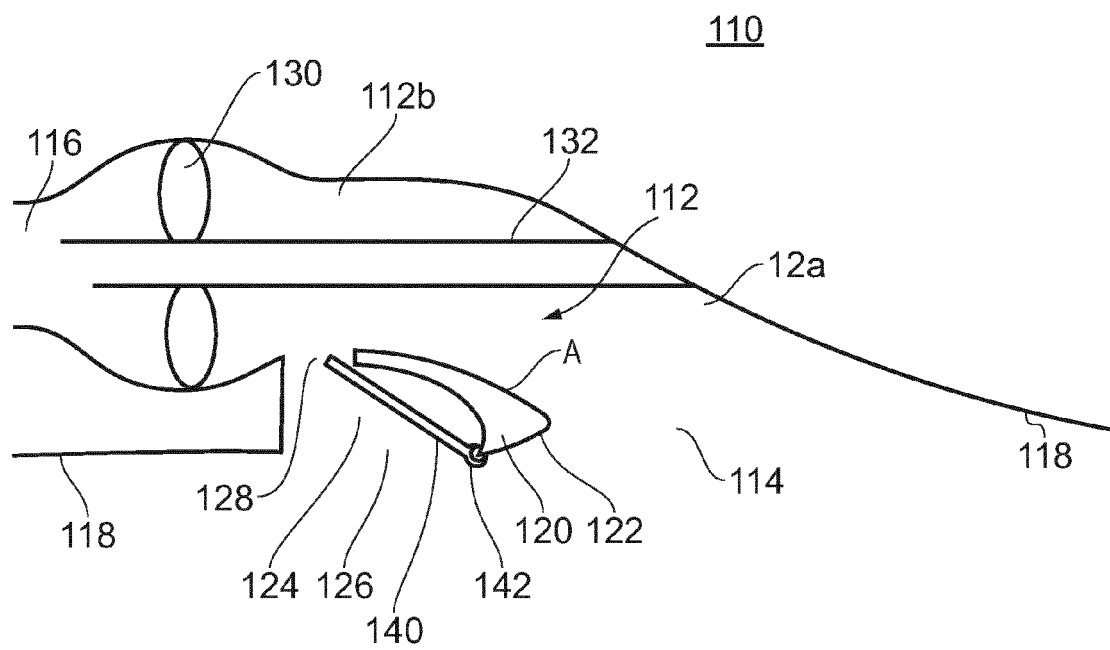


FIG. 6

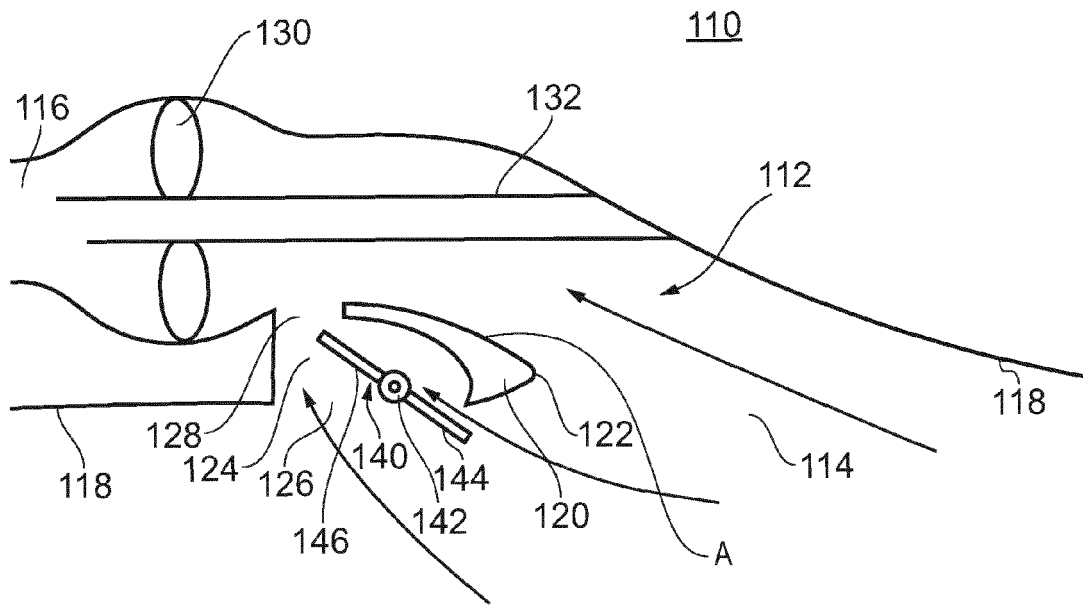


FIG. 7

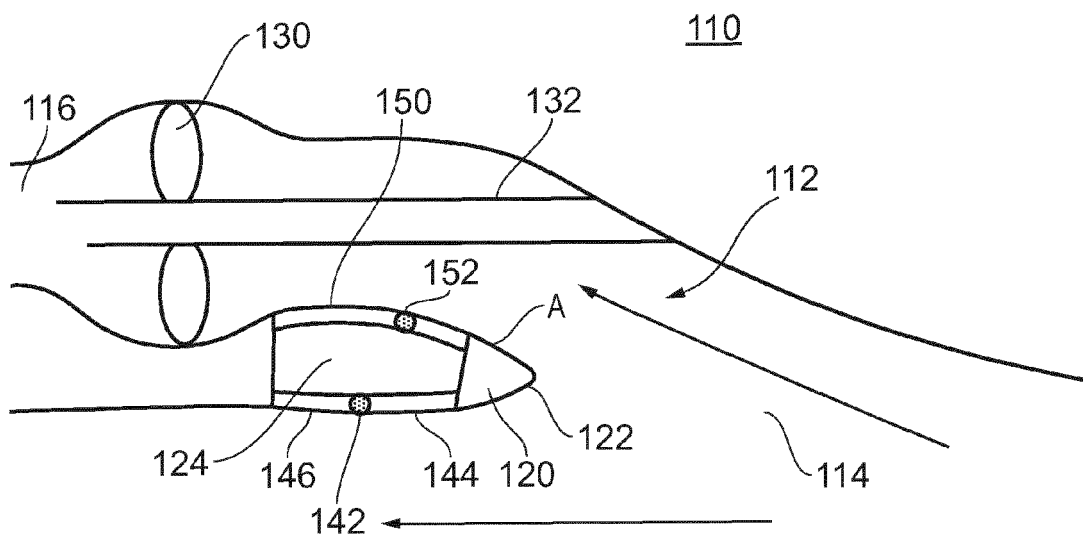


FIG. 8

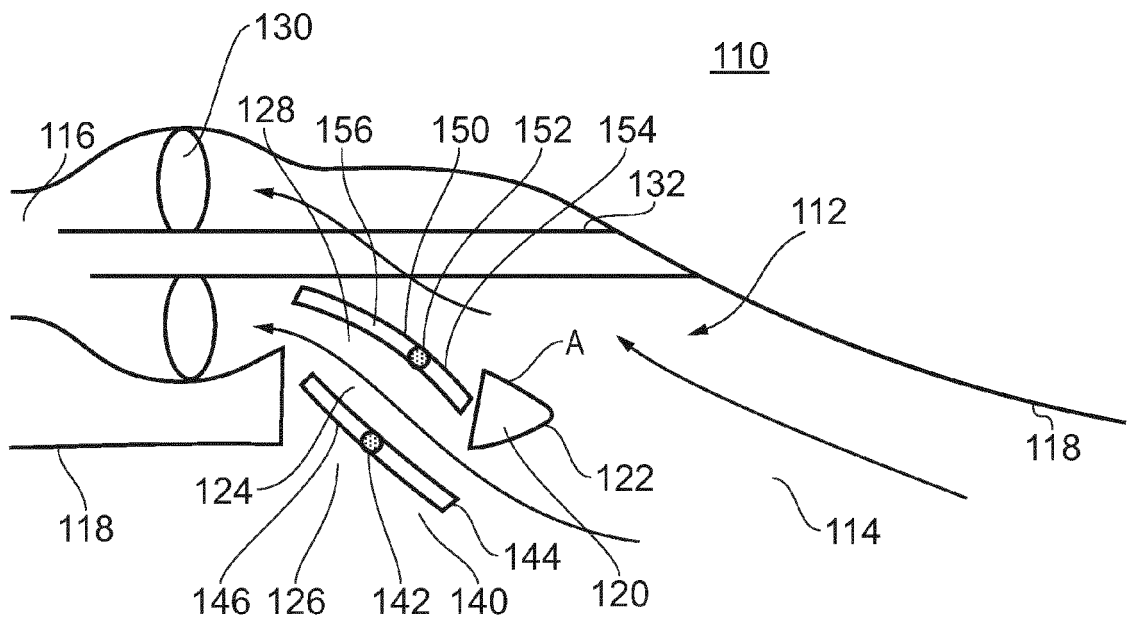


FIG. 9

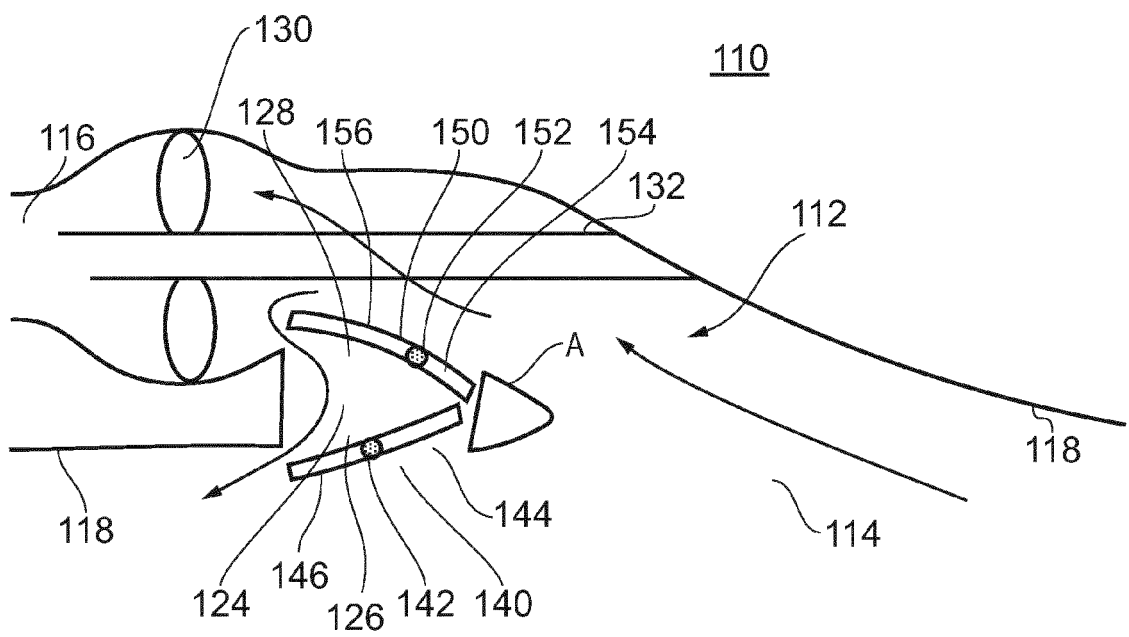


FIG. 10

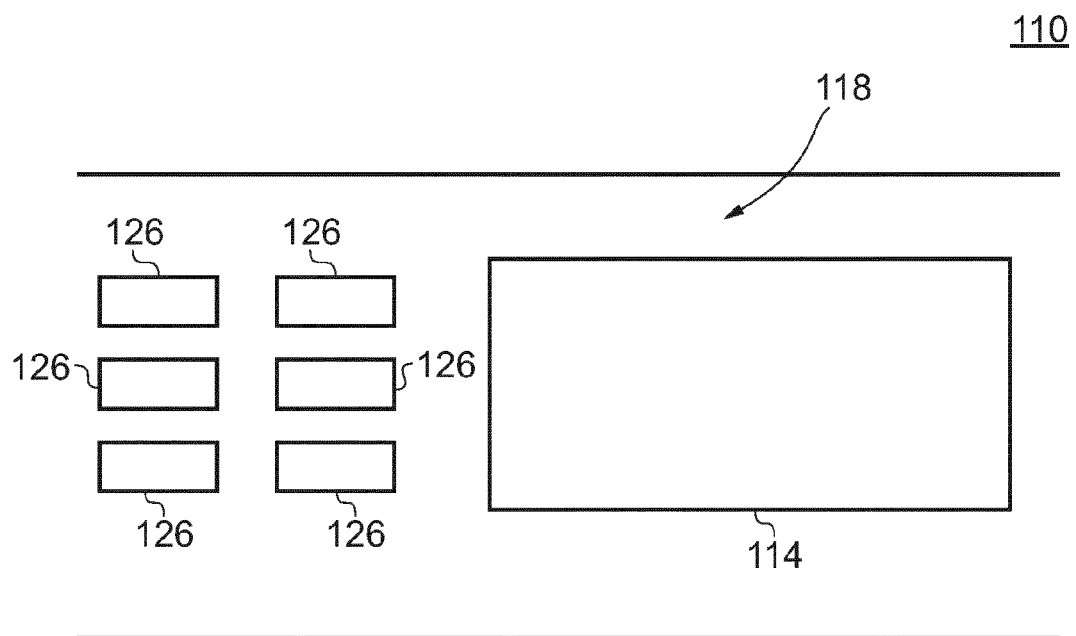


FIG. 11



EUROPEAN SEARCH REPORT

Application Number
EP 12 15 9188

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	JP 2008 074234 A (IHI CORP) 3 April 2008 (2008-04-03) * paragraph [0004]; figure 6 *	1,5,6, 9-13	INV. B63H11/08 B63H11/10
X	US 6 164 230 A (BEAUCHAMP CHARLES H [US]) 26 December 2000 (2000-12-26) * column 4, line 65 - page 5; figure 1 *	1,2,4,7, 13-15	
X	BE 398 241 A (ANDRÉ BALOCHE) 24 August 1933 (1933-08-24) * pages 2,3; figure 1 *	1-3,8, 13,15	
			TECHNICAL FIELDS SEARCHED (IPC)
			B63H
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 4 July 2012	Examiner Raffaelli, Leonardo
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EP 12 15 9188

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The members are as contained in the European Patent Office EDP file on
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04-07-2012

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