OUTBOARD JET DRIVE MARINE PROPULSION SYSTEM AND CONTROL LEVER THEREFORE

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Abstract

A jet pump for an outboard propulsion marine engine includes a support member and at least one impeller blade extending helically from said support member. At least one inducting blade extends helically from said support member. A stator having a volume reduction member is disposed downstream of the blades. The jet pump is supported in a housing having a stepped profile to reduce drag. A single lever controls both the speed and direction of the jet stream exiting the stator.
FIG. 5
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CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This Application is a Non-Provisional of Provisional (35 USC 119(e)) Application No. 60/574,019 filed on May 25, 2004 and Application No. 60/653,652 filed on Feb. 16, 2005.

BACKGROUND OF THE INVENTION

[0002] This invention relates to outboard jet drive marine propulsion systems. The present invention relates to an outboard jet drive for a boat and especially to an outboard jet drive having an engine and jet drive mounted in a housing, which is remotely attached to a boat hull.

[0003] There have been several proposed types of outboard jet drives for watercraft but most are similar to an outboard motor in which the outboard motor propeller and lower unit have been replaced with a jet drive. The jet drive includes a jet pump in the lower unit that operates to provide propulsion force for a watercraft. There are advantages in employing jet pumps for propulsion units as opposed to propellers. The jet drive permits operation in shallower water, also the propeller is shrouded, and there is less likelihood of injury. There has been a variety of proposed constructions for outboard jet drives for positioning the jet pump in different positions relative to the hull transom and bottom of the transom but in a typical jet drive, the engine and jet drive are located directly in the hull with an opening in the bottom of the hull for capturing water passing under the hull and then utilizing the jet pumps to thrust the water out the rear of the hull to propel the boat. Outboard jet drive units are made similar to typical outboard motors with a motor driving a drive unit, which operates a jet drive unit.

[0004] Generally, the engine package includes an internal combustion engine mounted in a thin fiberglass hull. The base plate of the hull includes a water inlet scoop for feeding water to the pump and an exhaust port for exhausting the water. The pumps high-pressure water outlet is pointed in the aft direction above the water line to propel the craft by the reaction force resulting from the high velocity water jet. In the F. C. Clark U.S. Pat. No. 3,055,175, a marine propulsion unit takes a conventional outboard motor and replaces the prop unit with a marine jet motor using a pump to issue a jet of water to propel a boat. The Parker U.S. Pat. No. 5,356,319, is for a boat with a remotely inboard jet propulsion unit in which the integral jet power unit is encased in a waterproof housing and positioned in a well located in the hull and is mounted to be removed from the hull.

[0005] A well matched water jet allows a diesel engine nearly ideal working conditions for reliability, fuel economy and performance in any planning boat, up to 50 mph; however until now this has only been demonstrated on larger vessels. This is evidenced by an increasing number of larger vessels seen using diesel jet propulsion while very few diesel jets are seen on smaller vessels. The weight of the diesel engine, gearbox and jet, coupled with the traditional inline installation make it much more difficult to properly match a waterjet with a diesel engine in a small vessel.

[0006] Many of the shortcomings of the prior art were overcome by Applicant’s U.S. Pat. No. 6,398,600 in which an outboard jet propulsion unit is detachably mounted to a boat so that the main fuel tank and controls are mounted within the hull of a boat while the outboard jet drive unit is mounted away from the boat in a housing with an engine and is removable attached to the transom of the boat. The fuel tank and controls are connected between the hull and outboard drive through quick disconnect couplings. The housing is shaped to support an engine on a platform directly over the jet drive unit for actuating the jet drive unit through a clutch mechanism with the engine and jet drive positioned parallel to each other.

[0007] Over many years, the reliability of inboard diesel engines (the most reliable method of marine propulsion) in pleasure boat use has been documented. Approximately 30% of engine failure is raw water pump related, 30% is due to water ingestion from exhaust risers or engine height, and 30% of failures are installation related. It is very hard to guarantee the reliability of individually fitted engines regardless of how adept or experienced the installer is. Less than 10% of all pleasure boat engine failures are deemed engine or component failure.

[0008] The outboard jet unit as designed by Applicant was satisfactory, however, it did not fully realize the efficiencies of jet propulsion. Accordingly, an outboard jet propulsion unit, which overcomes the deficiencies of the prior art, is desired.

BRIEF SUMMARY OF THE INVENTION

[0009] An outboard jet drive includes a housing sealed against the intrusion of water, the housing having front and rear sides and a top and bottom. An engine is disposed in the housing, supported generally horizontally within the housing, and a jet drive unit is disposed in said housing. The jet drive housing is shaped so that at least the bottom surface, when submerged in water, creates a high-pressure area along the bottom of the housing.

[0010] In a preferred embodiment, the jet drive unit includes an exhaust for exhausting a water jet. A bucket mechanism is mounted at the water exhaust, the bucket mechanism includes a housing disposed on said jet drive, which communicates with a water jet exiting said jet drive unit. The housing has a first exhaust and a second exhaust and a bucket member movably attached to the housing to selectively cause the water jet to either exit through the first exhaust or the second exhaust.

[0011] In yet another embodiment, the housing includes a heat exchange unit, which is vertically disposed within the housing. The heat exchange unit allows automatic draining of water from the heat exchangers.

[0012] In yet another embodiment of the invention, a stabilizing structure is provided to support a jet drive unit internally of the housing to reduce excessive vibration of the jet unit thereby reducing wear and tear.
BRIEF DESCRIPTION OF THE DRAWINGS

Other objects, features, and advantages of the present invention will be apparent from the written description and the drawings in which:

FIG. 1 is a sectional view taken through an outboard jet drive as mounted on a boat in accordance with the present invention;

FIG. 2 is a sectional view of an outboard jet drive housing having a jet drive unit mounted therein;

FIG. 3 is a rear elevation of the jet drive unit of FIG. 2;

FIG. 4 is a block diagram of the connected fuel tanks;

FIG. 5 is an elevation view of a drive assembly for an outboard jet drive constructed in accordance with the invention;

FIG. 6 a rear elevation view of an outboard jet drive housing constructed without the jet drive housing attached thereto;

FIG. 7 is a drive shaft housing constructed in accordance with the invention;

FIG. 8 is a perspective view of a jet drive housing constructed in accordance with the invention;

FIG. 9 is a perspective view of a drive shaft support assembly mounted within said housing in accordance with the invention;

FIG. 10 is a side elevation view of another embodiment of the invention in which a bucket assembly is mounted on the jet drive unit in accordance with the invention;

FIG. 11 is a side elevation view of the bucket assembly in the open position;

FIG. 12 is a side elevation view of the bucket assembly in the closed position;

FIG. 13 is a sectional view of a saddle assembly for supporting the bucket assembly;

FIG. 14 is a side elevation view of a control assembly for the bucket in the open position;

FIG. 15 is a side elevation view of a control assembly for the bucket in the closed position;

FIG. 16 is a top plan view of the bucket assembly;

FIG. 17 is a top plan view of a bucket assembly steering a boat to the left;

FIG. 18 is a top plan view of a bucket assembly steering a boat to the right;

FIG. 19 is a schematic view of the bottom of the housing showing relative water and airflow;

FIG. 20 is a schematic diagram showing the relative widths of the jet inlets and convex portion of the housing;

FIGS. 21A-C are schematic drawings of the water and air flow relative to the housing and jet intake;

FIG. 22 is a schematic drawing of the water shape as it moves past the housing;

FIG. 23 is a side elevation view of the air and water movement relative to the boat and outboard jet unit;

FIG. 24 is a perspective view of an outboard jet propulsion unit constructed in accordance with another embodiment of the invention;

FIG. 25 is a perspective view of a jet pump constructed in accordance with the invention;

FIG. 26 is a top plan view of a stator constructed in accordance with the invention;

FIG. 27 is a side elevation view of a stator constructed in accordance with the invention;

FIG. 28 is a front elevation view of a housing for a jet drive marine propulsion system constructed in accordance with the invention;

FIG. 29 is an edge perspective view of a housing for an outboard jet drive marine propulsion system in accordance with the invention;

FIG. 30 is a schematic drawing of the relative profiles of a propulsion system and boat constructed in accordance with the invention;

FIG. 31 is a side elevation view of a shift plate constructed in accordance with the invention;

FIG. 32 is a side elevation view of a throttle plate constructed in accordance with the invention;

FIG. 33 is a partial elevation view of a first side of a lever plate constructed in accordance with the invention;

FIG. 34 is a partial elevation view of the reverse side of a lever plate constructed in accordance with the invention;

FIG. 35 is a side elevation view of a lever control assembly constructed in accordance with the invention; and

FIG. 36 is a schematic view of a turbocharger constructed in accordance with the invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIGS. 1-3, an outboard jet drive unit 10 is shown attached to the hull of a boat 11 on the transom 12. The jet drive unit 17 includes a housing 13 having a platform 14 mounted therein and having a plurality of flexible engine mounts 15 attached to the platform 14. An internal combustion engine 16 is mounted to the engine mounts 15 on the platform 14. Engine 15 is preferably a diesel engine having a turbocharger with an intercooler, but may be a gasoline engine as well, and is preferably a conventional car or truck engine. A jet drive unit 17 is mounted beneath the platform 14 of the housing 13 and is attached to the front end 18 of housing 13. The housing 13 is sealed against the intrusion of water thereto and sealed between the platform 14 and the housing 13 to prevent water intrusion and to prevent oil or engine antifreeze from escaping therefrom.

The predominant prior art configuration of inboard jet boats is the inline setup, that is, the engine is connected
in line with the jet drive; this has the engine’s flywheel and drive pulley facing the transom (back of the boat) from inside the boat and the jet attached to it. By turning engine 16 and jet drive unit 17 around as compared to the prior art (i.e., 180 degrees) so that they are outside the boat behind the transom, as shown in the FIG. 1, in accordance with the present invention, the engine gear 120 and jet drive pulley 28 are positioned so that they both face in the same direction toward the transom from outside the boat, i.e., they face in the opposite direction of the inline arrangement. Thus, in this configuration, the drive pulley and engine flywheel are facing the back of the boat, but from outside the boat. Then, by using the drive belt system 27, the jet is placed substantially directly below the engine.

[0052] It should be appreciated by those of skill in this field that by turning the engine around 180 degrees from the inline configuration, this will cause the impeller to turn in the opposite direction (backwards) from other impellers in use currently. Thus, the jet drive unit and engine are in essence installed “backwards” causing the impeller in the jet drive unit to rotate in the opposite or reverse or “backwards” direction, as compared to impellers in jet drive units configured inline.

[0053] Open propeller driven vessels, inboard, outboard, and stern drives create excessive engine loads when “luging” to get on plane. Product life is reduced in direct proportion to the number of hours accumulated at partial planning speeds. This design does not experience this phenomenon. When the throttle is placed at the desired position, the engine accelerates immediately to engine speed. The jet instantly pumps the required flow for the selected speed and the boat catches up. The engine and the drive train never experience the level of duress that conventional propeller driven vessels experience.

[0054] In an exemplary, non-limiting embodiment, engine 16 has a belt drive 27 having a clutch mechanism therein for connecting the engine 16 to the drive pulley 28 of the jet drive unit 17. More particularly, as shown in FIG. 5, a drive train is formed between a gear 120 on a flywheel of engine 16 connected on gear 122 (drive pulley 28) mounted on drive shaft 124 of jet drive shaft 17. In a preferred embodiment, belt drive 27 is a Kevlar® belt, preferably teethed to engage gears 120, 122 to prevent slipping and slippage.

[0055] While the parallel position is the most efficient and preferred position for jet drive unit 17 and the internal combustion engine 16 system to be placed relative to each other, it is not the only possible position. In addition, by being positioned in parallel, it allows use of a standard horizontal engine and drive belt drive as illustrated in FIGS. 1, 2, 5 and 6 and discussed above.

[0056] While it is preferred for jet drive unit 17 to be positioned below engine, other locations are contemplated by the present invention, such as on top, opposed, or on the side of the internal combustion engine.

[0057] Although acceptable within the scope of the invention, they are not preferable. By way of example, if jet drive unit 17 is positioned on top or above the engine, it will operate, however, it would require pumping water up to the jet. The higher the water is pumped, the more power is lost to pumping water and the larger the water intake needs to be (the water intake needs to gradually decrease in size throughout the water intake system, to avoid air bubbles from forming and causing cavitation).

[0058] Also, the best water flow for the jet intake is at the bottom center of the boat, which may create a problem diverting water around the engine. This position would also most likely cause the engine to be lower which creates another problem. That is corrosion and exhaust riser problems. The lowest part of a boat or marine engine compartment invariably gets water in it. Having the engine low puts the engine in the water.

[0059] If the jet drive unit 17 is positioned on one or both sides of engine 16, while this positioning is believed to be better positioning than on top, it still has the problems mentioned above, and would require much greater width of the finished unit, it may create a weight distribution problem in that engine 16 is much heavier than jet drive unit 17, especially if only one jet drive unit is employed. In addition, putting too much weight to one side or the other would most likely create handling problems with the boat.

[0060] As already indicated, when the jet drive unit is placed on the bottom or underneath the engine, this positioning is by far the most practical and preferred placement. The engine is elevated, reducing problems from corrosion and riser problems. The jet is at the lowest possible position, creating the best water flow into the jet intake. The weight is centered. Further, by putting the, weight of the engine directly over the jet drive unit and the water intake, the water intake is less likely to come out of the water as often happens in the current systems. When the water intake comes out of the water, both power and maneuverability are lost in a jet drive unit.

[0061] It is also preferential for the water path entering and exiting the jet drive unit to be axial or straight, as opposed to, for example, a circular or bent.

[0062] Furthermore, it should be understood that the engine could be attached with a chain, or possible with a direct drive system with a series of two or more gears, although the belt is preferable. A clutch may be used but is not required.

[0063] The advantage of the belt drive system efficiency. The belt drive in theory transfers 98% of the engine’s power to the jet impeller. Other systems in practice lose approximately 15% of the engines power by the time power is transferred to the propeller or jet impeller.

[0064] Also, it is believed that this is the most cost effective method for a jet. For the jet to operate at its best efficiency, the jet should be sized appropriately to the horsepower and expected load. Most jet boats in operation today are using jets sized too small for optimum efficiency. This is done because the jet is being run at engine speed. Smaller jets can run at higher speeds (rotations per minute or “RPM”), larger jets must operate at lower speeds (RPM). In order for the jet to operate at a lower RPM than the engine, some sort of gearing reduction is required. Currently when a reduction is put in place it is done with a transmission. With the belt drive system of the present invention, it is able to operate the jet at a lower RPM by using different sized gears and the gear size is preferably matched to the engine and jet size when installed.

[0065] Jet drive unit 17 extends through the rear 21 of housing 13 out an opening 20 in the housing 13. The jet
drive unit 17 has a water intake 22 and is positioned to be about level with the bottom 23 of the hull 11. A water exhaust 24, providing the exit path for jetted water, extends out the rear of the housing 13. A jet pump 25 is mounted in the jet drive 17 for drawing the water thereinto through the jet pump and out the water exhaust 24. The jet drive unit 17 is shown below the water line 26 and is supported on brackets 29 on the front 18 of the housing 13.

[0066] Reference is now made to FIG. 6-9 in which a mounting structure in accordance with the preferred embodiment for the drive jet unit 17 is provided. As discussed above, jet drive unit 17 is mounted to housing 13 in a way to operate cooperatively with engine 16. Housing 13 is provided at its rear face 21 with an opening 20. Opening 20 communicates with the interior of housing 13.

[0067] Jet pump 25 is a series of jet blades radially affixed about drive shaft 124. Reference is made to FIG. 25 in which a perspective view of a jet pump 25, constructed in accordance with the invention is provided. Helical blades 500 extend from a support member 502 schematically shown in FIG. 1. Support member 502 is preferably conical. Because the blades are helical and spaced, water is drawn between the blades in the direction of arrow 0. Because the jet pump assembly 25 rotates, water is pushed outwardly as well as forwardly. As the rpm’s of the blade increase, cavitation increases between the blades. As cavitation increases, thrust is lost. Furthermore, water escapes through the path of least resistance. Most goes forward out through water exhaust 24. However, because of the spacing between blades, some water travels upstream adding to cavitation and loss of power. The greater the cavitation, the less speed and less thrust. The cavitation decreases as a function of the size of the gap between overlying blades. The gap is reduced as a function of 1-(n-x)/n expressed as a percentage where n is the number of current blades and x is equal to the number of additional blades as compared to the comparison jet pump. By way of example, if the number of blades is increased from 3 to 4, then n=4 and x=1 so that the increase is 1-75%/25%. If the increase is from 2 blades to 4 blades, the gap is closed by 50%, assuming equidistant spacing of the blades. The more blades, the less cavitation; however, while thrust may increase, speed does not.

[0068] Accordingly, the jet pump is formed from two types of blades, impeller blades 510 and induction blades 512. Induction blades 512 draw water towards impeller blades 510 to provide a more dense water stream to impeller blades 510 so that impeller blades 510 force a greater mass of water out of exhaust 24. In effect, induction blades 512 prime the pump.

[0069] Each blade 500 of induction blades 512 has a length L_{IM} and a width W_{IM}. Each induction blade 512 has a lead edge and a trailing edge. Each induction blade 512 has a non-uniform pitch, i.e. it is bent so that a leading edge 522 of each induction blade is 512 has a pitch less than the pitch of the remaining portion. In a preferred, but not limiting example, leading edge 522 has a pitch of about 14° while a trailing portion 524 of induction blade 512 has a pitch of about 170°.

[0070] Each blade 500 of impeller blades 510 has a length L_{IM} and a width W_{IM}. The width W_{IM} is substantially smaller, about 50%-85% than the width W_{IM} of impeller blades 510. Furthermore, the length L_{IM} of impeller blades 510 is substantially greater than the length L_{MN} of blade 512. Impeller blades 510 are also of non-uniform pitch having a leading edge 506, having a lower pitch, than a trailing section 504. The change in pitch along each of the blades found in impeller blades 510 and induction blades 512 occurs closer to the leading edge than the trailing section.

[0071] It should be noted that induction blades 512 are shown as an distinct leading section upstream of impeller blades 510. However, it would still be in accordance with the invention to provide induction blades 512 interspersed or interleaved among impeller blades 510. By providing an induction blade in cooperation with an impeller blade in the jet pump, preferably upstream of the impeller blades, denser water is carried to the impeller blades providing better thrust and speed. By providing at least four impeller blades, the gap is sufficiently closed between blades to significantly reduce the reverse flow of water. The addition of more blades increases cavitation on acceleration reducing speed. Therefore, the induction blades 512 are provided.

[0072] As a result of the action of the blades of jet pump 24, the water exits exhaust 24 in the direction of arrow P (FIGS. 1, 2). However, the water is turbulent and energy is flowing in all directions. Accordingly, a stator 600 as shown in FIG. 26 is provided at exhaust 24 to collimate water exiting from jet pump 25. Stator 600 includes a central member 602. In a preferred embodiment, central member 602 is conical. A plurality of blades 604 extend radially from conical member 602 to a wall of exhaust 24. In a preferred embodiment, a wall 606 is integrally formed with blade 604 to form a unitary unit which is mounted within water exhaust 24 or blades 604 and conical member 602 can be unitarily formed with a housing structure within water exhaust 24.

[0073] As water flows through stator 600, it is guided to flow in one direction, but some energy is lost and the flow of water loses speed. In turn, the boat loses speed. However, a volume reduction member 610 extends from conical member 602 into the exhaust portion of water exhaust 24. In a preferred embodiment, volume reduction member 610 is merely an extension member from conical member 602. However, any structure which reduces the volume within water exhaust 24 without substantially interfering with the flow path of water exiting through stator 600 may be used. By reducing the volume available to the water in water exhaust 24, the water speed increases, the pressure of the water column exiting the jet at water exhaust 24 is increased, providing increased thrust and speed to engine 10.

[0074] Jet drive unit 17 may be formed as a removable cartridge. In a preferred embodiment, jet drive unit 17 is housed in a removable jet housing 206. Jet housing 206 supports a driveshaft housing 201 in which drive shaft 124 is disposed. Drive shaft housing 201 is received in opening 20 and extends through opening 20 and forms a watertight seal with housing 13. In a preferred embodiment, housing 201 is bolted using a mating bolt plate 204 of housing 13. Gaskets and seals, as known in the art, are utilized to affix housing unit 201 to housing 13 in a watertight manner.

[0075] Jet unit 17 is formed as a unit about drive shaft 124. Therefore, drive shaft 124, mounted within housing unit 201, can be easily mounted to housing 13 by simply sliding the entire unit including housing 201 through opening 20. Drive pulley 28 is affixed to drive shaft 124, which in turn
is attached to drive belt 27, and the entire jet propulsion unit is affixed to engine housing 13. As a result, simple assembly is provided while maintaining a separation between the engine structure, which remains away from water to prevent corrosion and the jet unit structure, which must come in contact with water.

[0076] In one embodiment, drive shaft housing 201 is slidably received within jet unit housing 206. Jet unit housing 206 is mounted to the rear surface 21 of housing 13 by bolting the housing in the rear. To maintain the overall shape of the outboard propulsion system 10, engine housing 13 may be formed with a recess 210 for receiving jet unit housing 206. Housing 206 is provided with a plate 208 for attachment to housing 13.

[0077] Vibration along drive shaft 124 results in wear and tear on the drive shaft. This is especially true at each of the ends of the drive shaft 124. As seen in FIG. 9, brackets 212 affix drive shaft housing 201 to the interior of housing 13 at an end of drive shaft 124 adjacent drive pulley 28. A bracket 212 is provided at either side of drive shaft housing 201 to stabilize drive shaft 124 at its end.

[0078] In an exemplary embodiment, the brackets can be made from milled steel, aluminum, stainless steel or other materials. Stainless steel provides the best combination of stiffness, corrosion resistance and weight for the marine environment. In the preferred embodiment, brackets 212 need to be attached as close to the end of drive shaft 124 as possible to provide the best support although it is understood and within the scope of the invention, that brackets 212 could be attached to various positions in the engine compartment. Attaching brackets 212 above and on each side of drive shaft 124 provides the best support while keeping the brackets accessible for maintenance and keeping the fittings, bolt holes, bolts and the like as high above the bilge area as possible.

[0079] By placing bracket 202 substantially midway along the length of drive shaft housing 201, further support of drive shaft 124 is provided. When attached, flange 202 is disposed between housing 13 and jet unit housing 206, and is firmly attached to both, further supporting drive shaft 124 along its length. As discussed above, shaft housing 201 slides into the engine housing 13 as well as the jet housing 206. The three components are attached at flange 202 by welding, bolting or other known means and bolt plate 208 of jet housing 206 is bolted to rear surface 21 of housing 13. In this way, jet housing 206 is received and positioned within a receiving area 210 on the rear surface 21 of housing 13.

[0080] In a preferred embodiment, having flanges close to the middle of the drive shaft housing provides the best support. Other supports at the end of the drive shaft are helpful, but not required. A support system can be made from milled steel, aluminum, stainless steel or other materials. Again, stainless steel provides the best combination of stiffness, corrosion resistance and weight for the marine environment.

[0081] Outboard propulsion unit 10 utilizes a closed loop cooling system similar to those used in an automobile. In a preferred embodiment, propulsion unit 10 uses a water-to-water heat exchanger to cool engine 16 in a similar fashion to a radiator in an automobile. The water that circulates through the engine, the water-cooled exhaust manifold, and the oil cooler (where applicable) is treated with fresh water just like used in an automobile. However, propulsion unit 10 cannot expose the engine interior to seawater or dirty fresh water it utilizes during operation. Rather, the hot engine water is circulated by the engine water pump through a heat exchanger where it is cooled by the circulating seawater. Sea water is pumped through the heat exchanger by the water jet eliminating the requirement for a separate engine driven sea water pump and eliminating the high maintenance rubber sea water pump impeller.

[0082] In another advantage, the propulsion unit 10 may be equipped with turbochargers. The marine propulsion unit 10 also includes a stainless steel and cupronickel intercooler to cool the compressed air before it is inserted into the engine's intake manifold. The process of compressing the inlet air with the turbocharger increases the temperature of the air. Cooling the inlet air with seawater in the intercooler enables the engine to produce more power more economically and reduces the smoke and other pollution from the engine exhaust to meet environmental standards.

[0083] In another advantage, the marine propulsion unit 10 may be equipped with fuel coolers. It is believed that fuel injected engines deliver more fuel to the engine than the engine requires. The excess fuel is returned to the fuel tank for use later. The returned fuel is heated by the engine and tends to raise the temperature of the fuel in the tank over a period of time. The higher fuel temperature reduces the engine power and performance. The fuel cooler eliminates this problem. The fuel cooler is constructed of stainless steel and cupronickel and uses seawater for cooling.

[0084] Reference is now made to FIG. 24 in which yet another embodiment of outboard propulsion unit 10 utilizing a cooling system is provided. Like numerals are used to indicate like structure for ease of description. Propulsion unit 400 includes an engine 16 and a jet unit 17. A heat exchanger 402 is coupled to jet unit 17 by hosing 404. Heat exchanger 402 is also coupled to engine 16 by hosing 406. A second hosing 408 couples heat exchanger 402 to an intercooler 410. Intercooler 410 is connected by hosing 412 to an exhaust 414 of engine 16. Furthermore, intercooler 410 is coupled to the fuel line of engine 16 and the turbo charger of engine 16.

[0085] During operation, hosing 404 is coupled to the jet unit 17 and siphons a portion of the jet stream as it travels through jet unit 17 so that water under pressure travels in the direction of arrow M into heat exchanger 402. Hose 406 communicates with piping (not shown, but known in the art) within heat exchanger 402 which is surrounded by the cool water flowing from hosing 404 into heat exchanger 402. In this way, engine 16 is isolated from the water passing through jet unit 17. The pressure provided by the jet stream and gravity cause heated water to exit heat exchanger 402 through hose 408 in the direction of arrow N into intercooler 410. Intercooler 410 includes piping systems, which communicate with the turbo charger, exhaust 414, and fuel line of engine 16 cooling the air and fuel within the engine to provide greater efficiency for a turbo charged engine.

[0086] It should be noted that heat exchanger 402 and intercooler 410 are each preferably oriented vertically relative to the horizontal orientation of engine 16. In this way, if in fact outboard propulsion system 10 is not running, gravity drains the seawater or clear water from heat.
exchanger 402 into hose 408 or back into hose 404. In this way, no seawater remains in the heat exchanger 402 longer than necessary, reducing the corrosion to any piping within heat exchanger 402 or structure within intercooler 410. Furthermore, heat exchanger 402 is preferably made of stainless steel and cupro-nickel, both highly corrosion-resistant alloys to help ensure that the interior of engine 16 is never exposed to seawater. Additionally, no engine flushing is required after each boat trip because a closed cooling system is provided, engine 16 should experience a longer and more reliable life.

It is understood that because jet drive unit 17 is continuously coupled to engine 16, a jet stream is flowing as long as the engine is on. Therefore, barring a catastrophic failure of the drive system, there is always ample water for cooling.

In a preferred embodiment, turbocharger 420 controls increases in the back pressure when matching the turbo to the engine rather than releasing energy through a waste gate as known in the art. The housing diameter is adjusted to control the exhaust gas volume and speed to optimize turbine speed to provide more pressure on the housing side. Reference is now made to FIG. 35 where a schematic diagram of a turbo charger constructed in accordance with the invention is provided.

It is often required to obtain extra power from an engine. Applicants have determined that it is possible to boost a 150 horsepower engine to a 200 horsepower engine utilizing a turbocharger 420. Turbocharger 420 includes a first turbine housing 424. The housing includes an intake 426, coupled to an exhaust 428 of engine 422. A turbine 430 is rotatably disposed within turbine housing between intake 428 and housing exhaust 432 so that exhaust from engine 422 exiting through engine exhaust 428 drives turbine 430 as it passes through the blades of turbine 430 towards exhaust 432. Turbine 430 is in the exhaust flow path.

A second housing 450 has an intake 456 for receiving atmospheric air and an output 452 providing output to engine 422 into respective cylinder chambers. An air compressor 454 is rotatably housed within housing 450 and along a flow path between intake 456 and exhaust 452. A shaft 460 connects turbine 430 to air compressor 454. Therefore, as engine 422 produces exhaust, it spins turbine 430, in turn turning shaft 460 in air compressor 454. The turning of air compressor 454 creates a vacuum at exhaust 456 drawing atmospheric air into housing 450 through compressor 454 and then forced under positive pressure through exhaust 452 into engine 422. This provides extra oxygen in the cylinders 422 of the engine creating larger explosions and more energy for driving the pistons.

As is known in the art, air will sometimes backflow through housing 450 decreasing efficiency. It is known in the art to provide a waste gate to allow excess pressure as a result of the backflow to vent. By sizing housing 450 to provide the correct volume and velocity of air flow through the housing, the need for the waste gate is eliminated.

This engine and associated control is also suitable for use with rigid, inflatable boats (RIB) such as those manufactured by Zodiac® by way of non-limiting example. Furthermore, the use of the current engine provides a novel advantage of a self-maintaining RIB. One shortcoming with RIBs is that the inflatable structures essentially change volume as a function of the atmosphere. Inflatable sections that appear solid when trailered in the sun, lose volume when placed in the cooler water. Furthermore, no matter how air tight, inflated objects do tend to deflate over time at the valve, the seams or leakage through the material. Accordingly, a self-inflating mechanism is desired.

As discussed above, there is air under pressure traveling through the engine constructed in accordance with the invention. Generally, air travels through the engine at 25 psi. In the present invention, a tap is provided along the inlet air passage of the engine for siphoning off a portion of the air under pressure. A hose or other type piping or tube couples the tap or a manifold to the structure to be inflated. A regulator may be provided along the line formed by the tubing. The regulator is a pressure-controlled diaphragm that opens when the downstream pressure falls below a predetermined level allowing inflation. Air may be released in the reverse direction if pressure in the inflated structure exceeds a predetermined amount.

Reference is now made to FIGS. 10-18 in which another embodiment of the jet engine is provided. Like numerals are utilized to identify like structure for ease of description. Water exiting jet exit portion 54 (FIG. 1) is what provides the driving force for the outboard jet propulsion engine, and in turn, the boat to which it is attached. Because exhaust portion 54 is fixed to the fixed structure of housing 13 as described above, a mechanism is required to allow reverse operation and steering. As shown in FIG. 10, a bucket assembly, generally indicated as 300, is attached to jet drive unit 17 at exit portion 54 so that water exiting water exhaust 24 is operated upon by bucket assembly 300.

Bucket assembly 300 includes a bucket housing 308. Bucket housing 308 is supported by a saddle 302 suspended from housing 13 by a suspension arm 35. Suspension arm 35 is operatively linked to a steering rod 306. It is understood and within the scope of the invention that any structure for supporting bucket housing 308 may be used so long as bucket housing 308 is supported at water exhaust 24 so as to receive water exiting water exhaust 24. Bucket housing 308 has an entrance port 309 for receiving water exiting water exhaust 24 and a first exhaust 311 and second exhaust 314 for causing water to exist housing 308.

A bucket 310 is pivotally mounted on housing 308. A bucket linkage 312 is connected to bucket 310 and a reverse cable 314, which controls linkage 312 to rotate bucket 310 in the direction of arrow C to a first position in which bucket 310 is open to allow water to pass through exhaust 311 in the direction of arrow A. Linkage 312 also controls bucket 310 to move in the direction of arrow B to close first exhaust 311 (FIG. 12) and redirect the water path through second exhaust 314 of housing 308. A directional member 316 is provided at exhaust 314 to guide the water in a direction substantially in the direction of arrow D back towards housing 13.

It should be noted that a pivoting bucket shaped member is utilized, but any structure which selectively opens and closes water exhaust 311 may be utilized. In a preferred embodiment, by way of example only, linkage mechanism 312 is a bi-armed structure having a pivot, connecting one arm to the other at a position linked to reverse cable 314 such that movement of reverse cable 314
in the direction of arrow E (FIG. 13) lifts the pivot point of member 312 bringing the two arms together (FIG. 14) shortening the distance, drawing bucket 310 toward saddle 302 and lifting bucket 310 in the direction of arrow C. In this way, water is allowed to pass substantially unimpeded in the direction of arrow A, pushing housing 13 and the boat affixed thereto in the forward direction. However, any control structure for moving bucket 310 may be used.

[0098] When reverse cable 314 moves in the direction of arrow F (FIG. 12), the arms of member 12 are spread (FIG. 15) rotating bucket 310 in the direction of arrow B closing one end of housing 308 and forcing water to exit in the direction of arrow D back towards the boat. The force of water exiting through opening 314 as guided by guide member 316, pushes the boat in a reverse direction. Reverse cable 314 is coupled to the controls of the boat by either mechanical or electro controls.

[0099] In a preferred embodiment, the reverse cable is mounted with a steering nozzle. This gives maximum reverse thrust control with a steering nozzle mounted to maintain normal reversing direction with a reverse bucket using a standard 3-inch stroke cable. In order to keep the cable out of the water, the vertical operation was designed, i.e., the cable structure is mounted to cooperate with housing 308 above jet pack unit 17 substantially away from the water. This keeps the entire cable, except for the stainless push/pull rod of member 312 over the normal water line eliminating the need for boots, seals or rust-proofing. In order to keep the reverse bucket from moving up and down excessively during steering, reverse cable 314 is positioned close to the rotational point of the steering, i.e., near the steering cable 304, 306 at steering rod.

[0100] In a preferred embodiment, the reverse bucket, levers, bearings and bolts are made of stainless steel and could be made of any suitable material such as aluminum, fiberglass, plastic or any rigid material. The stroke of cable 314 is preferably limited to about 3 inches and is to be hand-powered and moved in a maximum amount of reverse direction with a maximum amount of reverse direction within which is achieved by putting an additional stationary diverter, or the like, below the exhaust that the reverse bucket comes down to meet in the full reverse position, that, when connected, adds additional reverse rotation to the bucket. The end of cable 314 has a swivel (ball-type) at the saddle 302 to allow the cable to stay stationary while steering is being turned and also allows angle changes on any steering or reverse bucket position. The arms of member 12 provided at the boat are designed to lock in the forward position and in reverse, eliminating kickback on the cable and allowing the use of full thrust in reverse gear without relying on the cable to hold the bucket in place.

[0101] In another preferred embodiment, a simple control lever which appears to the operator to behave as known in the art propeller engine throttles are preferred. Reference is now made to FIGS. 31-35 in which a lever assembly, generally indicated as 1000, for controlling direction and speed of the engine in accordance with the invention is provided. The desired benefit is to provide a single lever, which through a range of motion controls cable 314 to control both the speed at which the boat will travel as well as the direction.

[0102] Shift assembly 1000 includes a housing. A shift plate 1010, a throttle plate 1200 and a lever plate 1100 disposed therebetween, and in operative communication with shift plate 1010 and throttle plate 1200, are mounted within housing 1001.

[0103] Shift plate 1010 (FIG. 31) includes a through hole 1012 forming an axis of rotation for the plate as will be discussed later. A first arc channel 1014 has a substantially L-shape along a surface 1016 of shift plate 1010 and extends through shift plate 1010. A detent 1018 is provided along the path of channel 1014 at one end thereof. An elbow region 1020 is formed along the path of channel 1014 at the other end of channel 1014. A second substantially L-shaped channel 1030 is formed in shift plate 1010 along surface 1016. Channel 1030 extends through shift plate 1010. Channel 1030 includes a detent 1032 and an elbow region 1034. Detent 1032 and elbow region 1034 are formed at opposite ends of channel 1030.

[0104] A third channel 1040 is formed through shift plate 1010 along its surface 1016. Channel 1040 also includes an elbow region 1042 located at a first end and a detent 1044 located at a second end. Like channels 1014 and 1030, channel 1040 has one end with a detent and another end with an elbow section.

[0105] It should be noted that generally channels 1018 and 1013 substantially lie on shift plate 1010 on an opposed side of axis of rotation 1012 from channel 1040.

[0106] Cable 314 connects shift plate 1010 to bucket 310. Cable 314 is connected to plate 1010 at a shift section 1050. Movement of shift plate 1010 causes movement of bucket 310.

[0107] Reference is now made to FIG. 32 which shows throttle plate 1200. Throttle plate 1200 includes an axis of rotation hole 1202 extending through throttle plate 1200. A channel 1204 having a substantially scythe shape extends along a surface 1206 and through throttle plate 1200. Channel 1204 includes a curved portion 1208 extending into a first flattened portion 1210 across an elbow portion 1212 from curved portion 1208. At a second opposite end of channel 1204, is a second substantially straight portion 1214 separated from curved portion 1208 by a detent 1216 formed by the straightening of channel 1204.

[0108] A substantially U-shaped channel 1220 is formed through throttle plate 1200 across surface 1206. A lever shaft receiving channel 1222 is formed through throttle plate 1200 along surface 1206 and disposed substantially within the arms formed by U-shaped channel 1220.

[0109] Throttle plate 1200 includes an activation region 1250. Activation region 1250 is connected to cable 720 which in turn is connected to a throttle of engine 16. In a simplified embodiment, a connection hole 1252 is provided at a distal end of region 1250 to provide maximum torque for attaching cable 720 thereto. However, any attachment method known in the art such as the use of a coupling, buckle or the like may be used for attaching cable 720 to throttle plate 1200. As cable 720 is pulled in the direction of arrow Y, the rpm's of engine 16 increase in turn increasing rpm's of jet drive 26 and pressure and speed of the water flow from exhaust 24.

[0110] Reference is now made to FIGS. 33 and 34 in which a lever plate, generally indicated as 1100, is provided. An axis of rotation hole 1102 extends through lever plate
On a first surface, rollers 1104, 1106, and 1108 are disposed on a first surface 1110 of lever plate 1100. Roller 1104 extends outwardly from face 1110 and is received through channel 1040 of shift plate 1010 when lever assembly is assembled. Similarly, roller 1106 is received within channel 1020, and roller 1108 is received within channel 1032.

Rollers 1110, 1112 are disposed on an opposed side 1116 of lever plate 1100 and are positioned to be received within channels 1214 and 1220 of throttle plate 1200. Specifically, roller 1110 is received within channel 1220 and roller 1112 is receiving within channel 1214. As discussed below, each roller is adapted to slide along its respective channel.

Lever plate 1100 includes a lever 1120 for actuating lever plate 1100 when lever assembly 1000 is fully assembled. Lever assembly 1000 is disposed in housing 1001. A first shaft (not shown) extends from housing 1001 through axis of rotation holes 1012 and 1020. A second shaft extends from housing 1001 through axis of rotation holes 1102 of lever plate 1100. When each of rollers 1104, 1106, 1108, 1110 and 1112 are positioned within the respective channels in the reverse direction it is shown in solid lines. The locked in forward position is shown in phantom.

For this description, as shown in the solid lines, the description begins with the engine locked in the reverse direction at full throttle. As lever plate 1100 is rotated in the direction of arrow W, roller 1104 travels along channel 1040 in the direction of arrow Y while roller 1108 travels in the direction of arrow U and roller 1106 travels along channel 1018 in the direction of arrow V. Roller 1104 is maintained in the reverse position by elbow region 1042. Without an exertion of force, it is difficult for roller 1104 to traverse elbow region 1042. Similarly, it is difficult for roller 1106 and 1108 to traverse respective detents 1018 and 1030, maintaining those respective rollers in the reverse direction.

As the roller traverse the respective channels, the rollers apply a force on the respective guide channel rotating plate 1010 about axis of rotation 1012 having the effect of carrying lever plate 1100 in its rotation. This raises cable 314 which in turn raises bucket 310 diverting more and more of the water flow from exhaust 314 to exhaust 311, initially reducing speed in the reverse direction.

At the same time, rollers 1110 and 1112 are traveling through their respective channels 1220, 1204. When going from reverse to forward, roller 1110 travels along channel 1220 in the direction of arrow S while roller 1112 travels in the direction of arrow R through channel 1204. This causes throttle plate 1200 to rotate in the direction of arrow Q. Furthermore, because of the operation of shift plate 1010 as shift plate 1010 rotates with the change of direction, lever plate 1100 is cammed downward relative to throttle plate 1200 its axis of rotation 1102 moves in the direction of arrow X in effect lowering as throttle plate 1200 rotates about axis of rotation 1202 in effect raising throttle plate 1200. Another way of considering it, plate 1200 rises relative to throttle 12 so that shaft plate 1200 comes in contact with shaft 1122.

During operation, beginning in an idle position, rollers 1104, 1106, 1108 are disposed somewhere along the guide channels between the respective elbow regions 1042, 1020, 1034 respectively and detent regions 1040, 1030, 1018. To provide forward propulsion, lever 1120 is rotated in the direction of arrow W causing rollers 1104, 1106, 1108 to move towards the position of the phantom rollers in each respective guide channel. Because the rollers are fixed to lever plate 1100, as the rollers travel through the respective guide channels, they have the effect of lifting the guide channels and in turn shift plate 1010 about its axis of rotation 1012 and lifting cable 314, in turn lifting bucket 310. This lifting occurs until roller 1106 traverses elbow region 1020, roller 1108 traverses elbow region 1034 and roller 1104 traverses detent region 1034. In at least one position, during movement between respective elbow regions and detents, without disengaging the engine from the jet drive, engine is substantially idle; bucket 310 is at a position balancing jet pressure through exhausts 310 and 314.

Once each respective roller is past the respective elbow or detent in the forward position, shift plate 1010 no longer rotates despite movement of the roller. However, what has happened to throttle plate 1200 is that the rotation of the shift plate along with the lever has cammed the axis of rotation shaft 1122 of lever plate 1100 in the direction of arrow X relatively raising throttle plate 1200. Further rotation of lever plate 1100 causes movement of roller 1110 in the direction of arrow S and roller 1112 in the direction of arrow R which comes in contact with guide channels 1220 and 1208 respectively, lifting and rotating throttle plate 1200 in the direction of arrow Q so that activation region 1250 moves in the direction of arrow Y causing cable 720 to move in the direction of arrow Y causing the opening of the throttle of engine 10. As cable 720 moves further in the direction of arrow Y, the engine provides more rotation to the jet drive, causing more water jet to exit from the water exhaust 24 increasing the speed of the boat in the forward direction. At full throttle, the respective rollers 1110, 1112 are shown in the position as shown in phantom as are rollers 1104, 1106, 1108.

As rollers 1110, 1112 are moving within their respective guide channels 1220, 1204, roller 1106, by way of example, is moving between elbow region 1020 and a stop end 1024 of guide channel 1018. Although traversing that region has no real affect on shift plate 1010, throttle plate 1200 is experiencing rotation. Similarly, during that same period, roller 1108 traverses a region from elbow region 1034 to a stop wall 1036 of guide channel 1030 and roller 1104 travels from detent 1044 to a stop wall 1046 of guide channel 1040.

To cause reverse thrust of the engine the travel path is reversed.

However, it should be noted that although shift plate 1000 will rotate in the reverse direction, as shaft 1122 moves in the reverse direction within channel 1222 it causes throttle plate 1200 to move in the direction of arrow Q a second time as the rollers 1110, 1112 reverse direction, but to a lesser extent. In this manner, engine throttle is lower relative to the full open position so that at least a portion of the exiting jet stream is caught by the bucket, and at a lower speed as it is deflected through exhaust 314 at directional member 316.

In a preferred embodiment, the motion of activation region 1250 in the direction of arrow Y moves about 1/4 inches when in the forward orientation; it moves about 1/2 inch in reverse. It should be noted that in a preferred
embodiment for control purposes, bucket 310 is never entirely lowered to prevent an excessively fast or quick reverse movement of the engine in the boat. Furthermore, idling occurs somewhere between a stroke length of ⅓ inch and ⅔ inch where the reverse thrust is balanced with the forward thrust.

[0121] To the user, operation of the lever will be continuous and seamless. As the lever is moved from a first position and second position, shifting of the bucket occurs to reduce the speed in the forward direction as a portion of the jet stream is deflected in the reverse direction through exhaust surface 314. Continued shifting from a second position to a third direction reduces the throttle, increasing the speed in the forward direction. A fourth position, somewhere between the second and third position is that position where the shift plate has been rotated sufficiently to balance the thrust in the forward and reverse directions at the jet drive unit. This idles the boat without disengaging the engine.

[0122] When operating in the reverse direction, at first the boat is slowed down as shifting occurs between the third and second position and throttle plate 1200 is rotated to reduce the pull on cable 720 from, in a preferred and non-limiting example, 1-3/4 inches to 5 inches. Bucket 310 becomes lowered as the lever is shifted from the second to the first position, causing change of direction of the boat. A single lever controls speed and direction.

[0123] By utilizing an outboard motor, so that exhaust portion 54 of jet drive unit 17 is distanced away from hull 12 of boat 11, the water jet exiting housing 308 through exhaust opening 314 does not substantially interact with hull 11. As a result, the hull does not substantially interfere with the exiting jet stream and the efficiency of the jet engine when driving in reverse is greatly increased.

[0124] Reference is now made to FIGS. 16-18. Steering rod 306 is pivotally connected to bucket housing 308. Steering rod 306 is also coupled to hand controls on boat 11 so that a driver may control steering. Through movement of steering rod 306, bucket assembly 308 is rotated in the direction of arrow G to produce a left turn or in the direction of arrow H to produce a right turn.

[0125] Top 30 of housing 13 is removable from the housing main part 31, as shown in FIG. 3. The housing 13 with the engine 16 and the jet drive unit 17 mounted therein may be attached to the transom 12 of the hull 11 with a pair of brackets 32. Brackets 32 allow the housing 13 to be mounted substantially even with the bottom of the boat hull or higher than the bottom of the boat hull so as to reduce ingress of debris and damage to wildlife.

[0126] Reference is now made to FIGS. 19-23 in which a preferred embodiment of the engine housing is discussed. In a preferred embodiment, housing 313 has a convex lower surface 315. In a preferred embodiment, the lower surface of housing 313 is substantially bowl-shaped. In the preferred, but not limiting embodiment, the convex surface is disposed between 1 inch higher than a bottom of the hull 11, or 2 inches lower than the bottom of hull 11. This significantly reduces cavitation in jet drive unit 17.

[0127] As hull 11 of a boat passes through the water, air becomes mixed in the water as is noticed in any foaming wake. Air in the water as it passes through jet unit 17 causes cavitation, which reduces the power of outboard propulsion unit 10. However, by providing a rounded, convex lower surface 315 at a trailing position from hull 11, a high-pressure force area is provided along the submerged bottom surface 315 of housing 313. Furthermore, the water assumes a shape, as shown in FIG. 22, as it moves across housing 313. As the water moves relatively in the direction of arrow I, its path is widened around housing 313 and then narrowed as it travels across housing 313. This because a high-pressure area is formed along the surface of housing 313 as it moves through the water relative to the surrounding water.

[0128] Because air is less dense and lighter than the water which contains it, it either escapes in the direction of arrow J (FIG. 19) through a low pressure area K located between hull 11 and trailing housing 313 or moves to the sides of housing 313 as shown in FIG. 23. In effect, air bubbles are pushed from the water by the high pressure. Air bubbles 320 seek the low-pressure area at the sides of housing 313, allowing the remaining water to proceed directly to inlet 22. The rounded shape of housing 313 also maintains air close to it in the direction of arrow L, more efficiently guiding the water from which the bubbles have escaped towards inlet 22. "Solid" water is what is provided into the inlet, i.e. water from which substantially all air bubbles have been removed, preventing cavitation.

[0129] It should be noted that the water traveling in the direction of arrow L, tends to travel faster than the water away from housing 313 so that it clings to inlet 22. It also widens in its shape when under pressure as shown in FIG. 22 providing more squeezing of air bubbles out of the desired water stream. As seen in FIG. 23, bubbles 320 seek their own escape as they are squeezed out, allowing a purer stream of water 324 to enter inlet 22 of jet unit 17.

[0130] In a preferred embodiment, the width of the convex shape of housing 313 at the width M is greater than a width N of inlet 22. In this way, it is assured that the water 324 flowing towards inlet 22 is at the center of the high-pressure region, further ensuring the removal of the air bubbles 320 from the water. In a preferred embodiment, the width of a convex portion of housing 313 is about 120% the width of inlet 22. Again, bottom surface 315 may be positioned, in a preferred, but non-limiting example, from one inch above a bottom 317 of hull 11 to two inches below bottom 317 of hull 11. As can be seen, when bucket assembly 300 is substantially orthogonal with hull 11, the boat is driven forward. When bucket assembly 300 forms an angle of less than 90 degrees (on either side) with hull 11, the boat is turned.

[0131] However, as shown in FIG. 20 there is some overhang of the engine housing 313 relative to hull 11. These overhang regions 370 catch the water and provide drag. In order to maintain the relative width of housing 313, and reduce drag, a housing 380 is stepped sufficiently (FIGS. 28-30) to maintain the overall width of housing 313 while being narrow at those positions adjacent hull 11 to prevent overhang. Housing 380 includes a first convex portion 382, having a centerline 384. Convex portion 382 is curved in a direction extending from the hull of the boat in a direction away from the boat. Furthermore, the pitch of convex section 382 increases away from centerline 384. The pitch may be as steep as about 26°. The convex portion further aids in keeping air bubbles away from the intake reducing cavitation.
[0132] Only one side of housing 380 shall be described because in a preferred embodiment, housing 380 is substantially symmetrical about centerline 384. Extending from centerline 384, a step portion 386 forms a shelf portion 388. A pocket 390 is formed as a further step within step portion 386. Pocket 390 includes a sidewall 393, a second wall 396, and a step 384 formed therebetween.

[0133] An exhaust 397 for venting engine 400 is provided within pocket 390. Because pocket 390 is surrounded on at least two sides, one wall 393 being that portion of pocket 390 closest to centerline 384, air and gas escaping through exhaust 397 are deflected away from centerline 384 and are deflected towards the side of housing 380 by the step walls 386, 393 particularly when moving in a reverse direction. Therefore, the bubbles would not reenter the intake of the jet reducing cavitation.

[0134] In any event, the width should be sufficient so that the bubbles 320 are diverted sufficiently wide as shown in FIG. 21a, they are deflected away from a sufficient radius of intake 22 so as not to interfere or enter inlet 22, whether inlet 22 is in line with hull 11, or during left and right turns (FIG. 21b, 21c).

[0135] Fitting the waterjet directly below the engine raises the engine much higher than in traditional installations reducing the need for a riser (or raised exhaust elbow). The exhaust, mixed with a raw water spray, also supplied by pressure from the jet, exits the exhaust manifold and is carried down through a fiberglass exhaust/muffler system and ultimately exits under the water line at the rear of the fiberglass housing of the system. By eliminating the need for a riser system, not only is a high maintenance item eliminated, but the possibility of water being trapped and ingested back into the engine is avoided.

[0136] Hull 11 has the main fuel tank 33 mounted therein having a fuel tank inlet 34 and a fuel line 35 extending therefrom through the transom 12 and to a quick disconnect 36 where it can be quickly coupled or decoupled from an internal fuel line 37 located inside the housing 13. The fuel line 37 enters an auxiliary internal fuel tank 38 which has a fuel line 40 connected thereto which is connected to a fuel pump 41 for pumping the fuel from the auxiliary fuel tank 38 and from the main fuel tank 33 and into the fuel line 42 where it is fed directly into the fuel injectors of the engine 16. A fuel return line 43 is connected to the auxiliary fuel tank 38 and to a de-aerator 44 having a bleed top 45 and having a return fuel line 46 from the engine 16 fuel injectors.

[0137] A battery 47 is shown mounted within the housing 13 and is connected through a ground line 48 to the jet drive unit 17. The engine and drive unit are controlled through electrical control lines 50 which are connected through a quick electrical connector 51 which is a waterproof connector mounted through the housing 13 and to the engine 16 and clutch unit 27 to control the operation of the outboard jet drive unit.

[0138] The rear wall 21 of the housing 13 has a tow bracket 52 attached thereto for attaching a line.

[0139] As seen in FIG. 4, the main fuel tank 33 having the filler cap 34 is connected through the fuel line 35 to the auxiliary tank 38 having an auxiliary tank opening 55 and having the fuel pump 41 connected through the fuel line 40 from the auxiliary tank 38 and through a line 42 to the fuel injectors and back through a de-aerator 44 from the fuel injectors and through the fuel line 43 back to the auxiliary fuel tank 38. A breather 45 is connected to the de-aerator unit 44.

[0140] In operation, the hull 11 has the fuel tank 33 installed therein along with all the controls and sensors. The controls and sensors are connected through the multi-line electrical conductor 50 while the fuel tank is connected through the fuel line 35 through the transom 12. The outboard drive unit 10 can then be attached to the brackets 32 on the transom 12 in a position to align the bottom of the unit with the bottom of the hull 23. In a preferred embodiment, brackets 32 may be shock absorbers to further reduce vibration to engine 16 and jet drive unit 17. Then, merely attaching the quick connect couplings 36 to the fuel line, connects the fuel lines to the outboard jet drive while connecting the quick coupling 51 connects the electrical controls. If the unit has to be removed for any reason, it can be disconnected from the brackets 32 by disconnecting the quick couplings 36 and 51 to remove the entire unit. The outboard jet drive unit 10 is made by constructing a water-proof housing 13, mounting the jet drive unit 17 therein underneath the platform 14 and mounting the engine 16 to the engine mounts 15 on the platform 14 and then connecting the belt drive clutch mechanism 27 between the engine 16 and the jet drive unit 17 through the pulley 28.

[0141] Because in a preferred embodiment engine 16 and jet unit 17 ship as a unit, the jet size to use is known. Smaller boats usually forego the reduction and just use a jet, which is too small, operated at engine speed. For those who wish to use a larger jet and a reduction, a transmission must be used. This is an extra cost an extra layer of complexity and an extra gearing change which robs the engine’s efficiency. Furthermore, although transmissions could be made to match a particular engine to a particular jet, the current volumes of production make this cost prohibitive.

[0142] Another key advantage of the present invention is that the gear ratio can be changed just by changing one or both gears. As a result, any engine power can be matched to a desired RPM in a single jet design. With four or five different jets, a range of engines from 35 HP to 2000 HP can be covered. Thus, one jet can now be used with engines from 50 HP to 400 HP. This is a huge advantage in that different jets do not need to be designed for different engines.

[0143] A series of engine parameters were tested. The test boat is a Zodiac ZH630, a 6.71 meter rigid inflatable boat with a 24-degree deadrise. The boat used was setup for an I/O (inboard/outboard) installation and had a full transom. This boat is normally powered with a 200 horsepower I/O. The 150 horsepower diesel jet unit was fitted and tested under varying conditions and loads.

[0144] The following data was obtained:

<table>
<thead>
<tr>
<th>RPM</th>
<th>Speed (knots) Direction 1</th>
<th>Speed (knots) Direction 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>3.7</td>
<td>3.4</td>
</tr>
<tr>
<td>1500</td>
<td>5.4</td>
<td>5.0</td>
</tr>
</tbody>
</table>

Engine: 150 horsepower diesel
Fuel: 10 US gallons fuel
Load: 2 persons
Conditions: Calm, lake, good wind
Preferably, housings 13, 201, 206 are sealed mostly to create buoyancy and to protect the engine from corrosion or damage; however, prevention of oil and anti-freeze leaks to the outside (surrounding water) is a side benefit. The leaks from the engine could be isolated by providing a pan below the engine with separate drainage.

Notwithstanding the above, it should be appreciated that, in accordance with the present invention, in certain models, water may enter and exit the heat exchanger and intercooler through holes drilled specifically for that purpose; however, these holes are sealed to prevent water from entering or leaking into the engine compartment. In addition, water may enter into the exhaust ports. However, the engine is far enough above the water line to prevent water from rising high enough to enter the engine or engine compartment. Water also may enter the jet intake and exits the jet nozzle; this water is prevented from entering the engine compartment by sealing the hole around the jet impeller shaft. There may also be air intake vents in the lid in which water may enter. These are made with baffles designed to drain any water, which gets in out through the lid before it gets into the engine compartment.

While the bottom of the housing may be mounted in any suitable position, such as about even with or higher than the bottom of the boat hull, any position around or even with the bottom of the boat is workable. In a preferred position, the bottom of the housing is at about an inch below the bottom of the boat hull on boats to ensure or maximize the amount of clean water that enters the water intake of the jet drive unit. In addition, this position will reduce ingestion of debris and damage to wildlife. It of course should be understood that this position may vary depending upon the configuration of the bottom of the boat. It is believed that this is the optimum position, because the jet intake is built into the housing. Nevertheless, the bottom center of the boat is the optimum depth position for the water intake in the preferred embodiment.

In a preferred embodiment, marine propulsion unit 10's steering nozzles, exhaust of bucket assembly 300, are generally about 30 inches or more behind boat transom 12. This provides excellent steering leverage and, with a large diameter having water jet 313 moving large amounts of water, it provides crisp steering response and solid tracking with very little correction. The steering control pressures of marine propulsion unit 10 are very light and do not require power steering for comfortable boating.

Because of bucket assembly 300, propulsion unit 10 provides the capability of "putting on the brakes". When propulsion unit 10 is shifted into reverse, all the power of the engine and water jet are applied to stop and reverse the boat. Tests on a 5,000-pound boat equipped with a propulsion unit 10 as described herein show that the boat could be stopped completely within two boat lengths from 30 mph with ease.

The recommended procedure to stop outboard propulsion unit 10 is to reduce the engine RPM by about 50 percent and shift into reverse. If desired, the engine RPM can be increased. In an emergency, the boat can be shifted into reverse directly at any power setting, but that may injure the boat passengers.

Useable space inside a boat is usually at a premium. The outboard propulsion system, in accordance with the invention, and the traditional outboard engines have a distinct advantage over inboard/outboard and inboard systems that require valuable space inside the boat for engines and essential equipment. Even traditional outboards are at a disadvantage compared to the propulsion unit 10 because they generally require space inside the boat when in the tilted up profile. Also, many outboards require a notch in the transom to achieve the correct propeller depth requiring a second "transom" inside the boat to prevent following seas from swamping the boat. That space is lost boat space.
Propulsion unit 10 requires no space inside the boat for any of its components. The increase in space inside the boat is available for any use, e.g., for passengers, bait wells, fish holds, and even for lounging decks.

Because engine 16 is mounted on high quality vibration isolators inside the fiber glass shell and housing 13 is mounted on the boat transom using a second system of vibration isolators, an exceptional and unexpected level of quiet and comfort is provided. As a result, the boat ride is more comfortable and less tiring.

Internal combustion engines get hot when running. That engine heat is handled several ways in a boat. The engine water-cooling system is designed to remove a considerable amount of that heat, but that system operates at about 160 to 220 degrees Fahrenheit to insure that the engine operates correctly. The balance of the heat is released in convection, radiated into the air in the engine compartment. This heat can make it quite uncomfortable in the area of the engine compartment, especially on a hot day. This problem exists with any inboard or UO drive configuration. Ventilating fans and insulation can reduce the problem to a degree, but it is difficult to eliminate.

Outboard marine engines are mounted behind the transom behind the boat. Any heat from these engines that is not carried overboard by the water-cooling system is released into the air behind the boat. This gives all outboard engines a distinct advantage over inboard mounted engines.

Propulsion unit 10 has an added advantage because it has the engine mounted in a sealed box and the air inside the box is normally ingested into the engine and goes out the exhaust in the water. It is very unlikely that a passenger will feel any warming of the air in the boat caused by the propulsion unit.

As a result of scaling housing 313, propulsion unit 10 is uniquely designed with self-buoyant capability. Because the housing is sealed, it provides flotation. Indeed, in a preferred embodiment, at approximately 1 foot of draft, it floats about 250 lbs, at approximately 1.5 foot (18 inches) of draft, it floats about 500 lbs, and at approximately 2 feet of draft, it floats about 850 lbs (approximately the total weight of the marine propulsion system). This is a significant feature and advantage to any boat and especially valuable to smaller boats with low freeboard dimensions.

Some of the new four-cycle outboards are quite heavy and cannot be used on some existing boats because the extra weight causes the scuppers to be submerged. At least one boat manufacturer had to redesign their boat to accommodate these heavy engines. Inboard/outboard and inboard systems depend solely on the boat to provide their flotation. The weight of the propulsion system, in all of these instances, reduces the boats' cargo and passenger carrying capability.

Because of the buoyancy of housing, propulsion unit 10 allows boats to uniquely have more weight carrying capacity and, as a further benefit, more useable space inside the boat is available.

Propulsion unit 10 preferably uses a stainless steel water jet impeller to supply the seawater to the heat exchanger for engine cooling. If the impeller is turning, there is water for the cooling function. Even if the stainless steel impeller were severely damaged, there would be enough water flow to move the boat and provide engine cooling.

High-speed marine diesel engines are traditionally automotive truck or industrial engines with all the marine components plumbed and attached to the engine itself. These engines are designed for multipurpose marine uses and are generally complete with transmission, raw water pump and accessories not always needed for water jet purposes. As a consequence to the complexity of this arrangement, reliability, serviceability, weight and cost are adversely affected. With this new approach the engine is fitted basically stock with the addition of special engine mounts and a water-cooled exhaust manifold. All of the necessary marine components are fitted and plumbed in the fiberglass housing. Installation problems are significantly reduced due to the higher standards allowed by repetitive factory assembly and quality control procedures practiced on identical machines. As the unit is a self-contained stand alone system, no boat design, speed requirements or specific customer demands affect the quality control of the engine assembly and installation.

Traditional water jets are made to adapt to engines forward of the waterjet. Although jets should be fitted with a reduction to be efficient, most are fitted directly to the engine. This means the jet driveshaft has to be higher than ideal because of the engine crankshaft height. If the jet were fitted as close to the bottom of the boat as possible as in accordance with the invention, efficiency would be much higher for these reasons:

Frictional losses on the inlet and outlet would be less,

Jet outlet would be lower on the transom and thrust line would therefore be lowered. (A low thrust line is desirable because it moves the active center of gravity aft giving less of a nose down attitude to the boat).

The lower thrust line also makes the boat more stable by cutting down the tendency caused by directional changes of the nozzle and this would reduce wandering at all speeds.

Inlet size would be reduced; this would enhance the efficiency of the boat by reducing the hook effect caused by putting a large hole in the most critical part of the hull.

In most cases, the further aft the center of gravity, the faster the boat. This is a major part of the outboard performance advantage (a bracket increases this advantage). Because the engine is completely behind the transom, the passengers are typically located further aft also, further enhancing the performance. Just by moving the engine inboard, as in an inboard/outboard configuration and pushing the passengers forward, the performance per horsepower is drastically reduced. Noise, heat, vibration, fuel use and the need for service are greatly increased due to the engine having to work harder to perform the same work. Further, in a small jet boat, the undesirable combination of a forward center of gravity and high center of thrust line is exacerbated by the possibility of air from the continuous bottom entering a high speed jet (because the jet is usually driven at engine speed) and causing cavitations.
Internal components and internally stored fuel can be preserved indefinitely by replacing the oxygen in a sealed housing with an inert gas. A simple monitoring system can be installed to easily verify that the housing remains sealed and that oxygen is absent. This virtually assures that the condition of the components will be preserved. When the unit is needed for service, air intake and exhaust ports can be opened with a starting mechanism. This system could be used on ocean going lifeboats, eliminating the need for routine and costly removal and recertification of the complete vessel.

Because of the shallow draft and the added buoyancy at the rear of the vessel, launching and retrieving the unit into the surf is an option that can now be considered. The jet is manufactured of stainless steel and is tolerant of sand and small stones. On a shallow beach the unit could be launched with a four wheel drive truck, extending tow hitch and fat tired trailer. This would allow faster rescue deployment in places not covered by traditional land launched rescue lifeboats, at a fraction of the cost. In heavy conditions, this craft could be hard beached at speed and picked up by winching it onto a special trailer, without any significant damage.

The elimination of the exposed propeller makes this a preferable system for lifeboat use. Additionally the absence of propellers and any lower unit below the bottom of the boat significantly reduces damage and downtime from collisions with submerged debris and rocks, particularly during critical rescue operations.

The large diameter jet has ample thrust to maneuver a lifeboat in tight quarters at low speeds. The test boat exhibited exceptional maneuverability at low speed even in rough water with heavy loads.

The simplicity of the design and the elimination of high maintenance components should make this an extremely reliable system for lifeboat use. Further, the portability of the system enables the propulsion package to be quickly exchanged with a spare unit, eliminating the need to take entire boats out of service for recertification.

Durability under extreme conditions and service has yet to be proven but the simplicity of the unit and the testing already completed have demonstrated significant advantages over all current systems. Systems specifically designed for lifeboat operation could increase longevity, reliability, simplify service, reduce operational cost and make significant improvements in speed maneuverability and safety.

What is claimed as new and desired to be protected by Letters Patent of the United States is:

1. A jet pump for an outboard propulsion marine engine comprising:
   a support member;
   at least one impeller blade extending helically from said support member; and
   at least one induction blade extending helically from said support member.

2. The jet pump of claim 1, wherein each of said at least one impeller blades has a width, and each of said at least one induction blades has a width less than the width of each of said at least one impeller blades.

3. The jet pump of claim 1, wherein each of said at least one impeller blades has a length, each of said impeller blades has a length, said length of each said at least one induction blades being less than the length of each of said at least one impeller blades.

4. The jet pump of claim 1, wherein each induction blade has a leading edge and a trailing portion, the pitch of said leading edge being less than the pitch of said trailing portion.

5. The jet pump of claim 1, wherein each impeller blade has a leading edge and a trailing portion, the pitch of said leading edge being less than the pitch of said trailing portion.

6. The jet pump of claim 1, wherein said support member is conical.

7. The jet pump of claim 1, wherein said induction blades are disposed on said support member upstream of said impeller blades.

8. The jet pump of claim 1, wherein said at least one induction blade defines a plurality of induction blades and said at least one impeller blade defines a plurality of impeller blades, at least one impeller blade being disposed between at least two of said plurality of impeller blades.

9. The jet pump of claim 7, wherein plurality of impeller blades includes at least four impeller blades.

10. The jet pump of claim 2, wherein each of said at least one induction blades has a length, each of said at least one impeller blades has a length, said length of each said at least one induction blades being less than the length of each one of said at least one impeller blades.

11. The jet pump of claim 2, wherein each induction blade has a leading edge and a trailing portion, the pitch of said leading edge being less than the pitch of said trailing portion.

12. The jet pump of claim 2, wherein said induction blades are disposed on said support member upstream of said impeller blades.

13. The jet pump of claim 4, wherein each impeller blade has a leading edge and a trailing portion, the pitch of said leading edge being less than the pitch of said trailing portion.

14. The jet pump of claim 1, further comprising a housing and a water exhaust formed within said housing, a stator disposed in said water exhaust downstream of said at least one impeller blade, said stator having a central member, a plurality of stator blades extending radially from said central member towards a wall of said housing; and

   a volume reduction member extending from said central member downstream of said plurality of stator blades, for reducing the volume within said water exhaust without substantially interfering with a flow path of water passing from said stator blades.

15. A jet pump for an outboard propulsion marine engine for use with a rigid inflatable boat comprising:
   a support member;
   at least one impeller blade extending helically from said support member; and
   at least one induction blade extending helically from said support member.

16. The jet pump for an outboard propulsion marine engine of claim 15, wherein each of said at least one impeller blades has a width, and each of said at least one induction blades has a width less than the width of each of said at least one impeller blades.

17. The jet pump for an outboard propulsion marine engine of claim 15, wherein each of said at least one
induction blades has a length, each of said impeller blades has a length, said length of each said at least one induction blades being less than the length of each of said at least one impeller blades.

18. The jet pump for an outboard propulsion marine engine of claim 15, wherein each induction blade has a leading edge and a trailing portion, the pitch of said leading edge being less than the pitch of said trailing portion.

19. The jet pump for an outboard propulsion marine engine of claim 15, wherein each impeller blade has a leading edge and a trailing portion, the pitch of said leading edge being less than the pitch of said trailing portion.

20. The jet pump for an outboard propulsion marine engine of claim 15, wherein said support member is conical.

21. The jet pump for an outboard propulsion marine engine of claim 15, wherein said induction blades are disposed on said support member upstream of said impeller blades.

22. The jet pump for an outboard propulsion marine engine of claim 15, wherein said at least one induction blade defines a plurality of induction blades and said at least one impeller blade defines a plurality of impeller blades, at least one induction blade being disposed between at least two of said plurality of impeller blades.

23. An outboard jet drive marine propulsion system having a housing and a water exhaust formed within said housing, said system comprising:

a stator disposed in said water exhaust, said stator having a central member, a plurality of blades extending radially from said central member towards a wall of said housing; and

a volume reduction member extending from said central member downstream of said plurality of blades for reducing the volume within said water exhaust without substantially interfering with a flow path of water passing from said blades.

24. The system of claim 23, further comprising a ring, said ring adapted to be received in said housing, said blades extending from said central member to said ring.

25. The system of claim 23, wherein said housing includes a wall, said blades extending to said wall, said stator being integrally formed with said housing.

26. The system of claim 23, wherein said central member is a conical member extending downstream from said blades.

27. An outboard jet drive marine system for a boat comprising:

a housing, said housing having a front and rear sides, and a top and a bottom, said housing adapted to be affixed behind a hull of said boat;

an engine disposed within said housing; and

a jet drive unit mounted to said housing and being operatively coupled to said engine in said housing, said engine having an exhaust and cylinders, a turbocharger operatively coupled between said exhaust and said cylinders, said turbocharger having a housing for receiving said exhaust, a turbine assembly, said exhaust rotating said turbine assembly, said turbine assembly providing compressed air to said cylinders, said housing having a diameter, said diameter being dimensioned to control the exhaust gas volume and speed to optimize a turbine speed of said turbine assembly to reduce back pressure.

28. The outboard jet drive marine system of claim 27, wherein said turbine assembly includes a first turbine disposed in said housing, said turbine rotating in response to exhaust from said engine, a shaft, a second turbine disposed in said housing coupled to said shaft so that said second turbine rotates with said first turbine, an air intake operatively communicating with said second turbine, said second turbine moving air from said air intake into said cylinders when rotating.

29. The outboard jet drive marine system of claim 27, wherein said engine has an effective horsepower of more than about 200 horsepower.

30. The outboard jet drive marine system of claim 28, wherein said boat is a rigid inflatable boat.

31. The outboard jet drive marine system of claim 29, wherein said boat is a rigid inflatable boat.

32. An outboard jet drive marine system for a boat comprising:

a housing, an engine disposed within said housing, said engine having an air intake;

a jet drive unit operatively coupled to said engine; and

a siphon tap provided along an inlet air passage of said engine for siphoning off a portion of air traveling through said engine under pressure, said boat being a rigid inflatable boat having inflatable structure, piping defining an air path extending from said siphon tap to at least one of said inflatable sections, a regulator disposed in the air path along said piping, said regulator opening when a downstream pressure falls below a predetermined level to allow inflation of at least one inflatable portion.

33. The outboard jet drive marine system of claim 32, wherein said regulator releases air in the upstream air path direction if pressure of said at least one inflated sections exceeds a predetermined amount.

34. A lever control for an outboard jet drive marine system for a boat, a water jet exiting said outboard jet drive marine system to move said boat, said system comprising:

a lever assembly movable between a first position and a second position, said lever operatively coupled to a shift, said shift controlling a direction of water jet exiting from said outboard jet drive marine system, said lever moving said shift in a first direction when said lever moves in said first direction between a first position and a second position and causing said water jet to exit said system in a first direction when said shift is in said first position and cause said water jet to exit said system in a second direction when said shift is in a second position.

35. The lever control for an outboard jet drive marine system of claim 34, further comprising a throttle operatively coupled to said lever for controlling the speed of said jet when said lever is in said first position and for controlling the speed of said jet in said second direction when said lever is in said second position.

36. The lever control for an outboard jet drive marine system of claim 35, wherein said lever moves between a
second position and a third position, said throttle increasing the speed of said jet as said jet moves from said second position to a third position.

37. The lever control for an outboard jet drive marine system of claim 34, further comprising a jet drive unit and an engine operatively coupled to said jet drive unit, said jet drive unit including an exhaust and a bucket, said shift being operatively coupled to said bucket and said throttle being operatively coupled to said engine.

38. The lever control for an outboard jet drive marine system of claim 37, wherein said lever moves said shift to a fourth position located between said second and third position wherein said shift causes said bucket to balance the force of a water jet exiting said system in both the first direction and second direction.

39. The lever control for an outboard jet drive marine system of claim 34, wherein said lever is a lever plate, said shift is a shift plate, said lever plate moving said shift plate in a first direction when said lever rotates in said first direction and a second direction when said lever rotates in said second direction.

40. The lever control for an outboard jet drive marine system of claim 39, wherein said throttle plate is a throttle plate operatively coupled to said lever plate, said throttle plate controlling the speed of the jet in a reverse direction when said lever plate is in said first position and controlling the speed of said jet in a forward direction as said lever plate moves from said second position to said third position.

41. The lever control for an outboard jet drive marine system of claim 39, wherein rotation of said shift plate causes said lever plate to selectively rotate said throttle plate in one of said reverse and forward directions.

42. The lever control for an outboard jet drive marine system of claim 34, wherein said shift is a rigid inflatable boat.

43. An outboard jet drive marine system for a boat comprising:

- a jet unit; a housing, said housing having front and rear sides and a top and a bottom, said housing adaptively affixed behind a hull of said boat, said housing including a convex portion at its bottom curved in the direction extending from the hull of the boat in a direction away from the boat for guiding air bubbles away from the jet unit.

44. The outboard jet drive marine system for a boat of claim 43, wherein said convex portion has a pitch and a centerline, the pitch of said convex portion increasing in a direction away from said centerline.

45. The outboard jet drive marine system for a boat of claim 44, wherein said pitch is between 0° and 26°.

46. The outboard jet drive marine system for a boat of claim 43, wherein said hull has a substantially V-shape.

47. The outboard jet drive marine system for a boat of claim 45, wherein said hull has a substantially V-shape.

48. The outboard jet drive marine system for a boat of claim 43, wherein said boat is rigid inflatable boat.

49. The outboard jet drive marine system for a boat comprising:

- a jet unit, a housing, said housing having front and rear sides, a top and a bottom surface, said housing adapted to be affixed behind a hull of said boat; said housing including a centerline, a respective side on each side of said centerline including at least a first step portion to form a shelf, the step being sufficiently narrow to maintain the overall width of said housing less than a width of said boat to which said housing is adjacent.

50. The outboard jet drive marine system for a boat of claim 49, wherein a pocket formed in said first step as a further step portion within said shelf, an engine disposed within said housing, said engine having an exhaust, a vent formed in said pocket and coupled to said exhaust for guiding gases away from the centerline when said engine moves in a reverse direction.

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