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(54) **PERSONAL HYDROFOIL WATER CRAFT**

Publication Classification

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(US)

(51) **Int. Cl.⁷** **B63B 1/00; B63B 35/73**

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(57) **ABSTRACT**

(21) Appl. No.: **10/058,044**

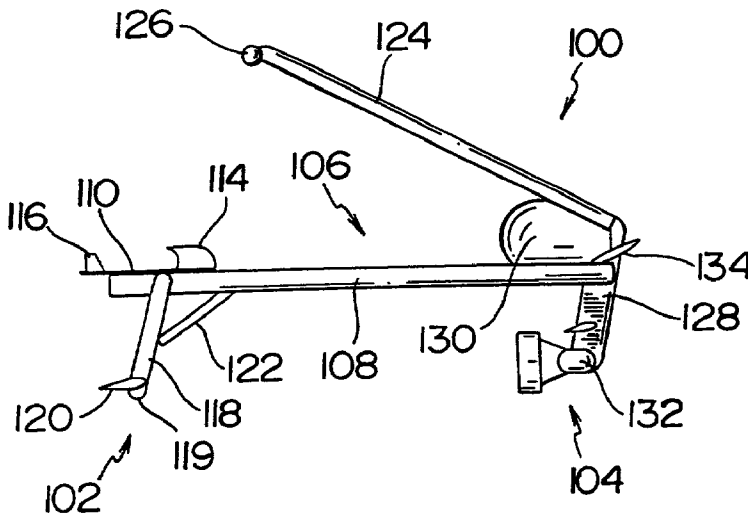
(22) Filed: **Jan. 29, 2002**

Related U.S. Application Data

(63) Continuation-in-part of application No. 09/771,656, filed on Jan. 30, 2001, now abandoned, which is a continuation of application No. 09/177,622, filed on Oct. 23, 1998, now Pat. No. 6,178,905.

(60) Provisional application No. 60/097,053, filed on Aug. 19, 1998.

A hull-less personal water craft is provided which reduces air, water, noise, and wake pollution over personal water craft presently on the market. The craft includes a strut assembly having forward and rearward ends, with an operator platform attached at the rearward end, and having at least one hydrofoil positioned below the operator platform. A propulsion system is provided, as is a control column which provides the operator interface when the craft operator is kneeling, standing or sitting on the operator platform. The hydrofoil provides substantially all of the lift for the craft when in operation, and the elimination of a hull greatly reduces the power requirements and wake generated by the craft in operation.



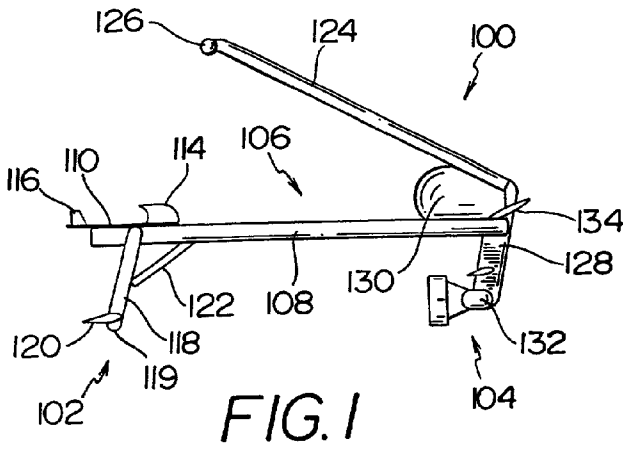


FIG. 1

FIG. 3

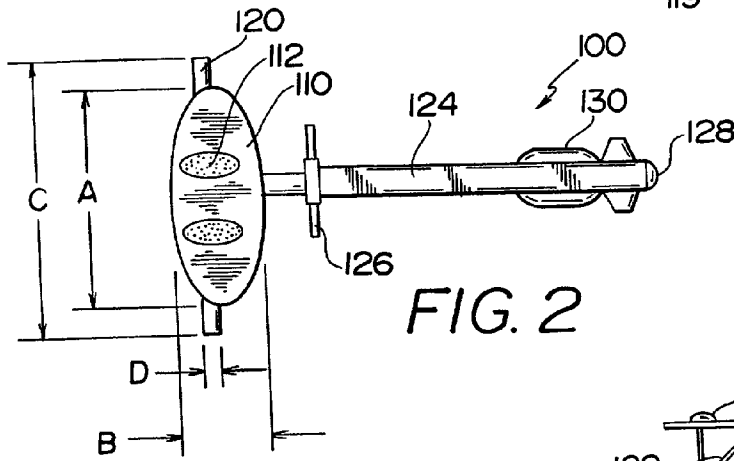
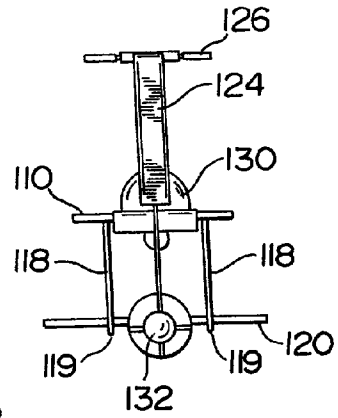


FIG. 2

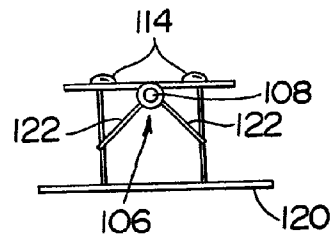


FIG. 4

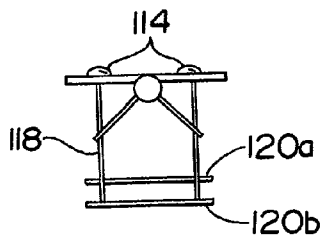


FIG. 5

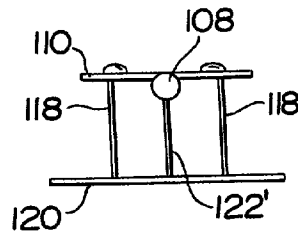
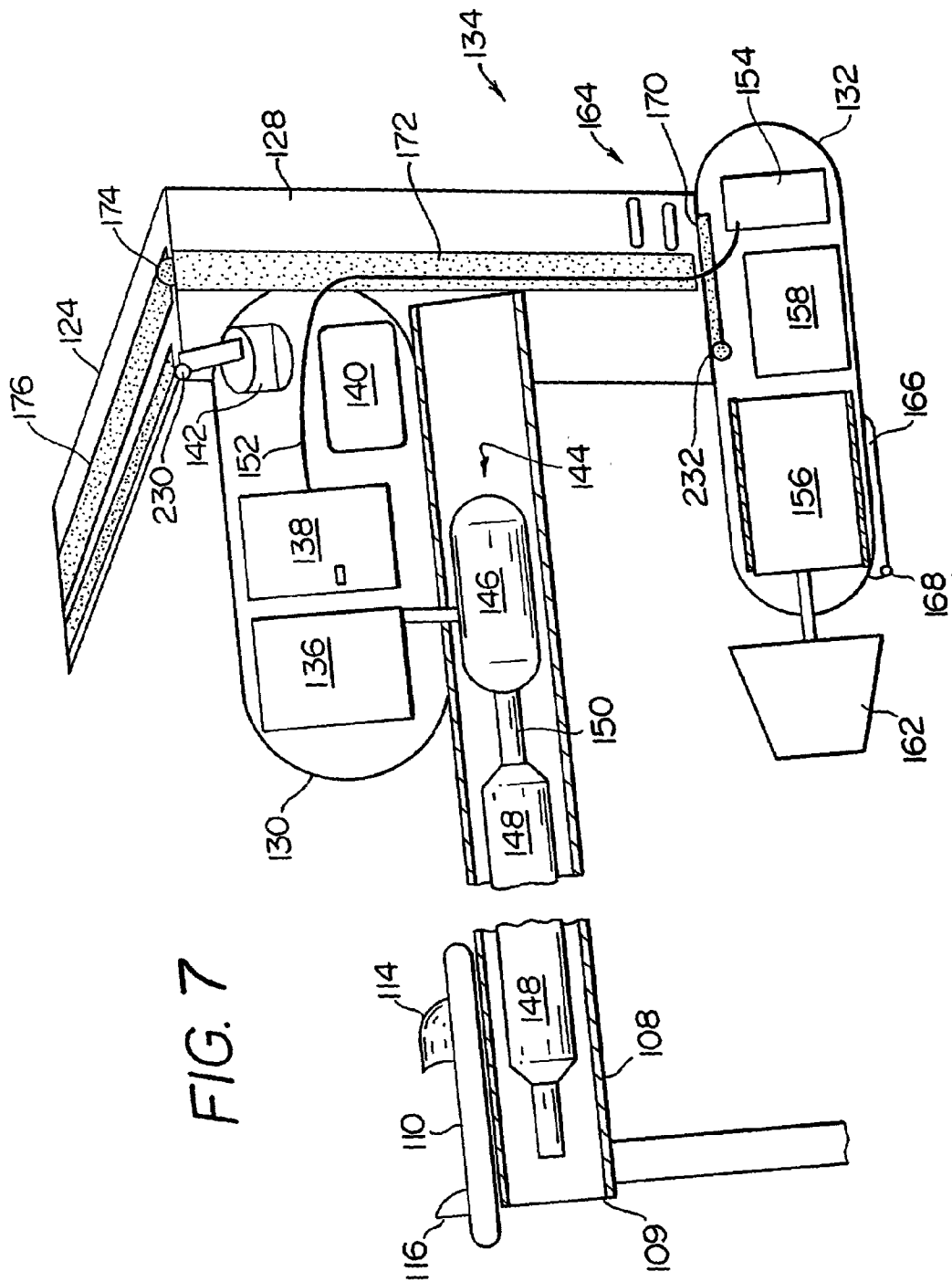
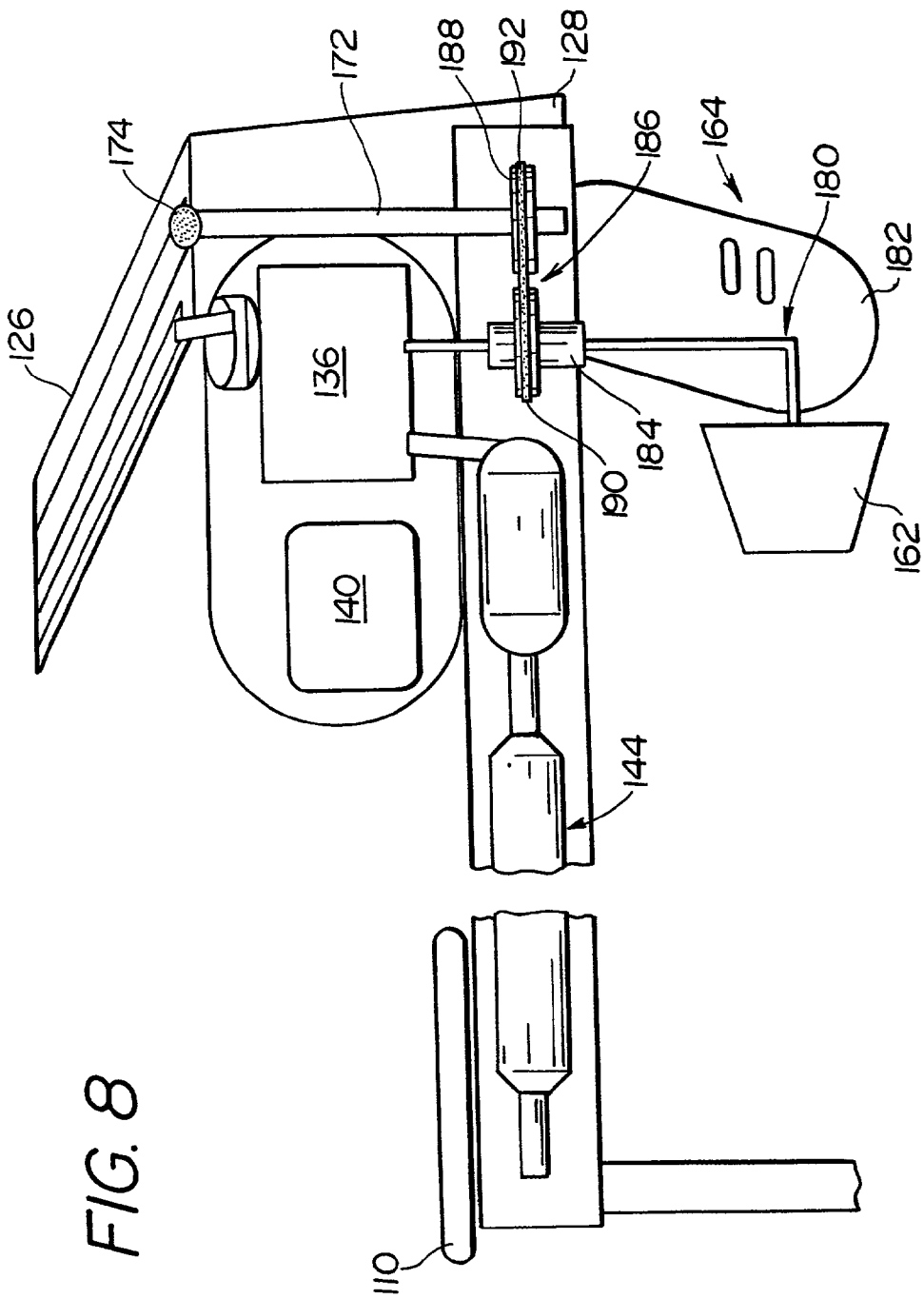


FIG. 6





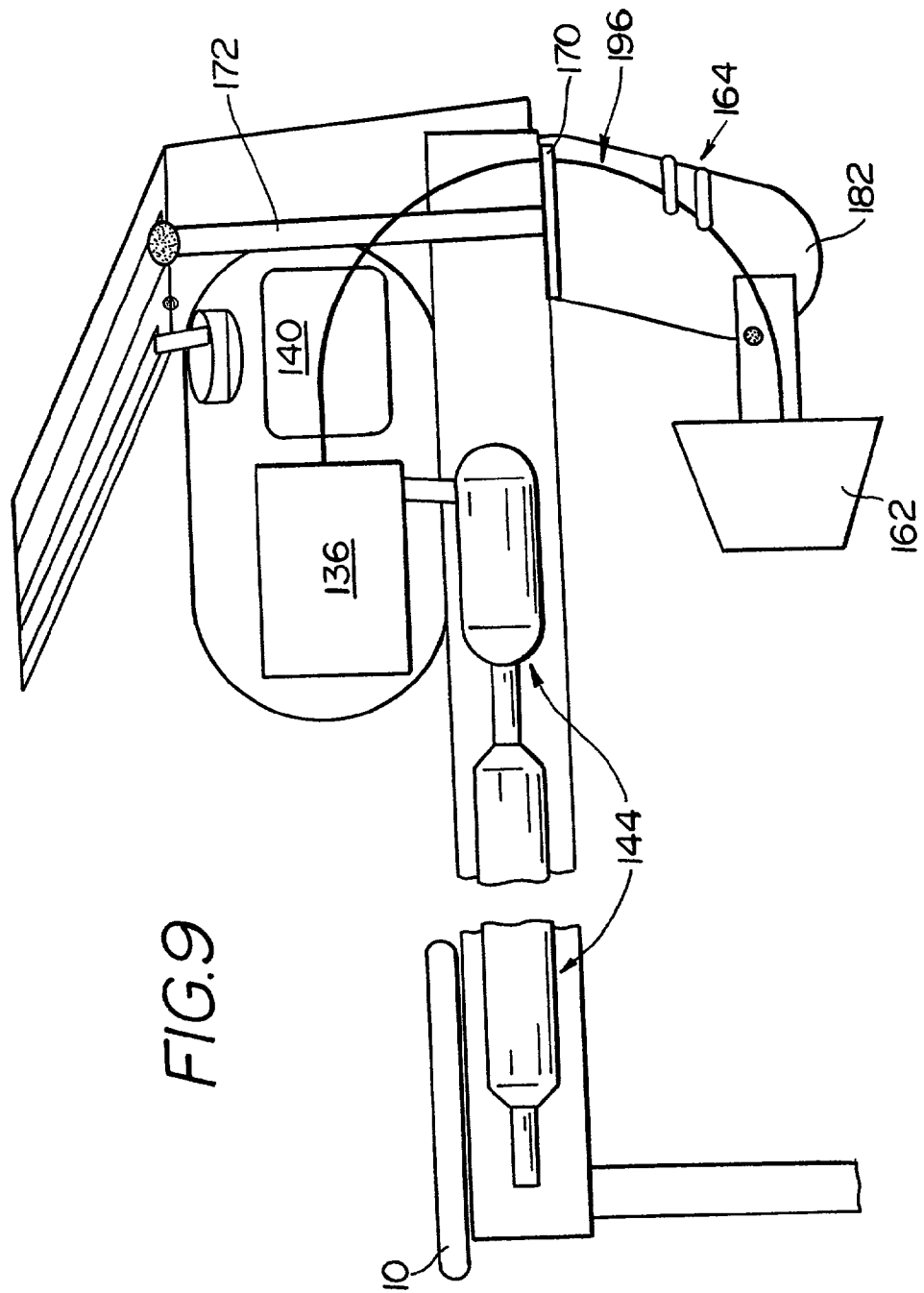
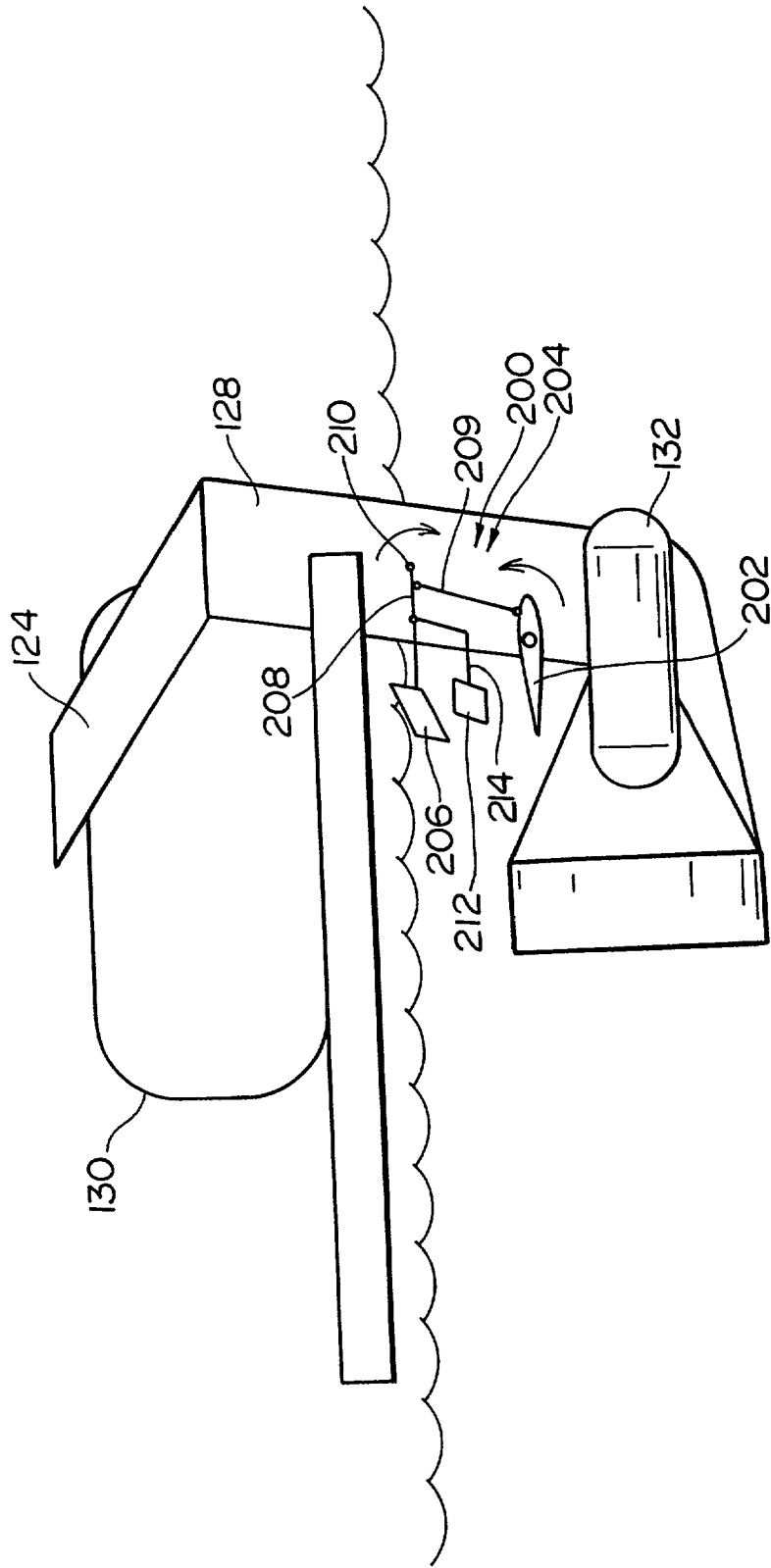


FIG. 10



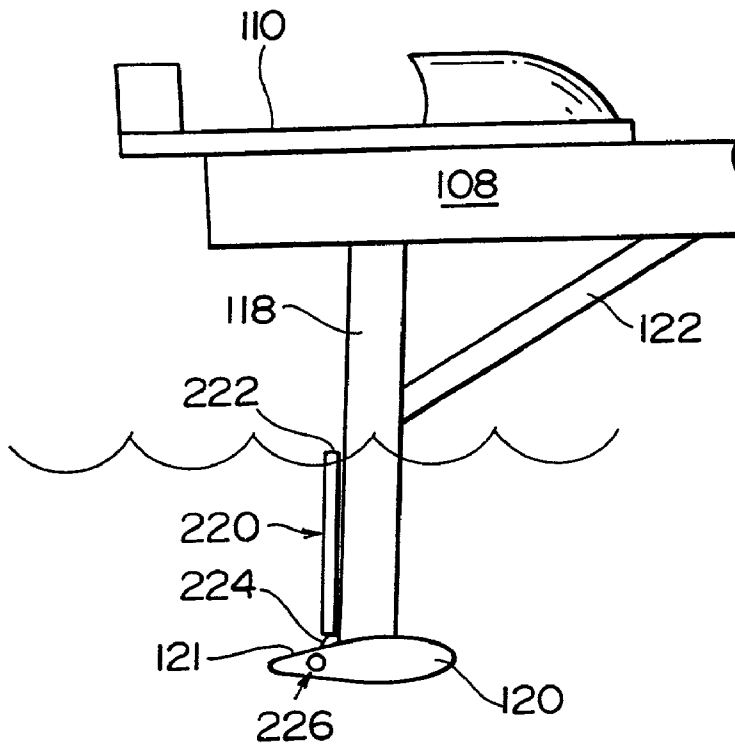


FIG. 11

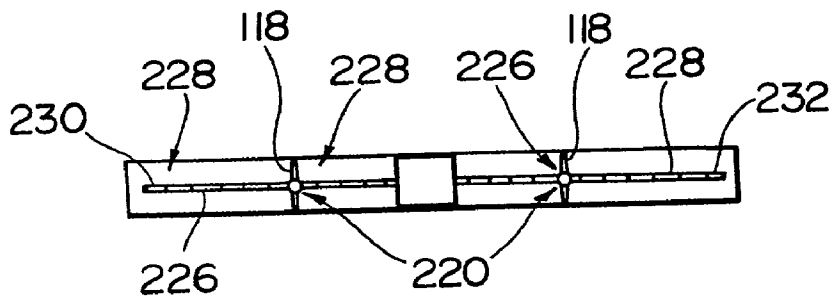


FIG. 12

FIG. 13A

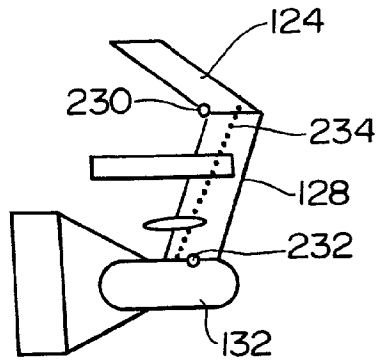


FIG. 13B

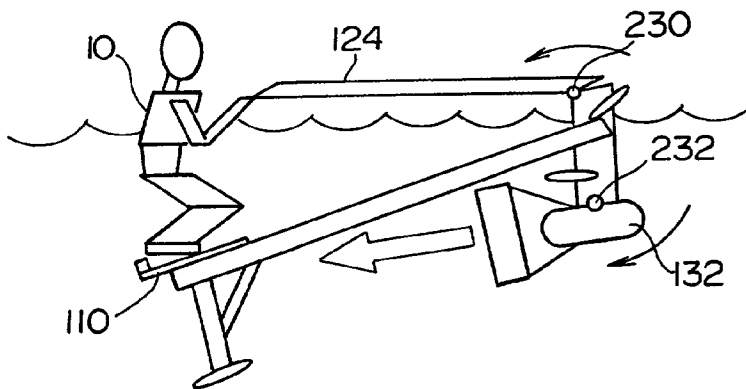
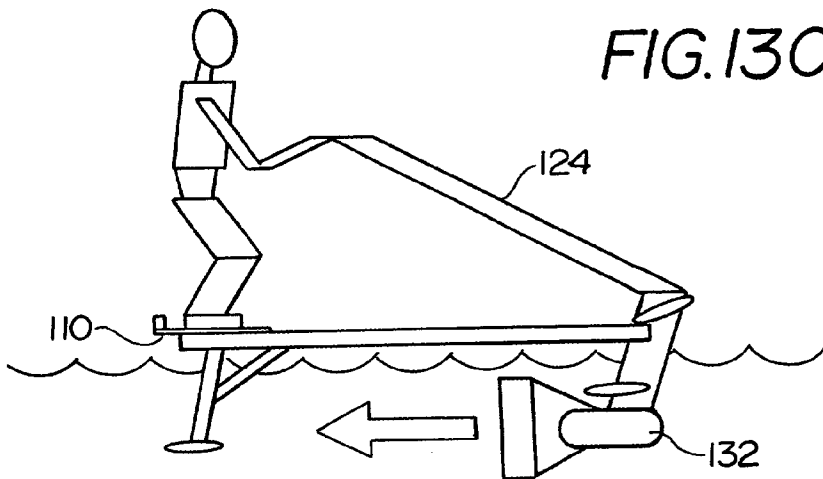


FIG. 13C



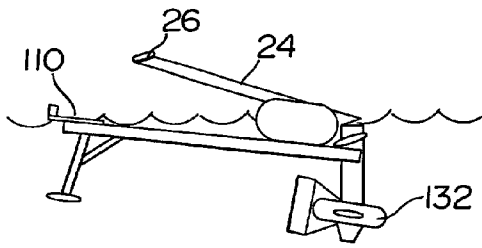


FIG. 14A

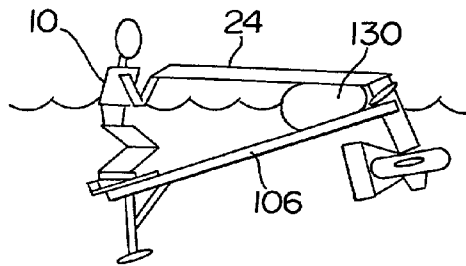


FIG. 14B

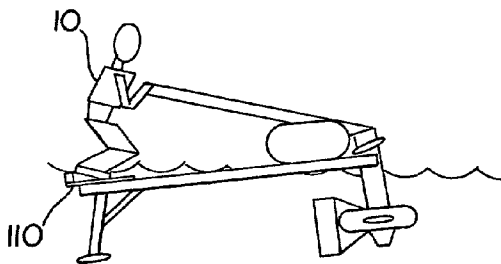


FIG. 14C

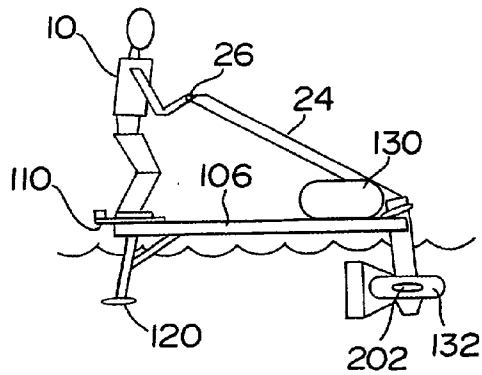


FIG. 14D

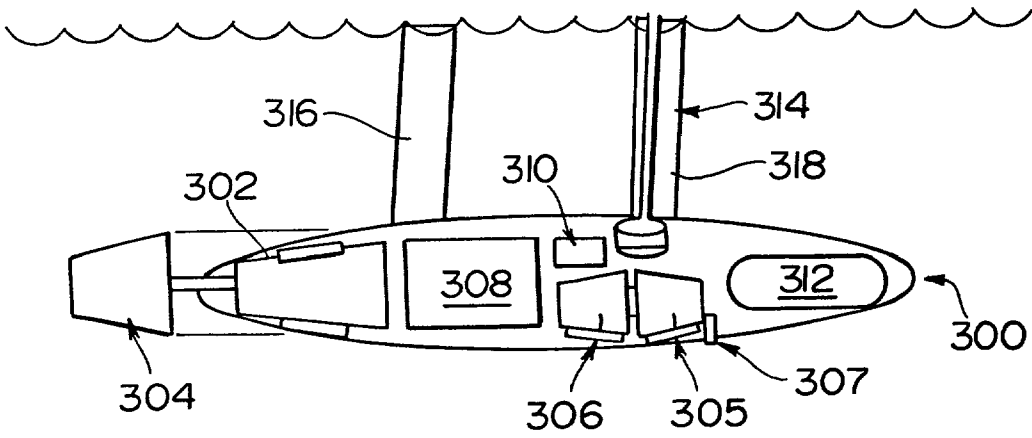


FIG. 15

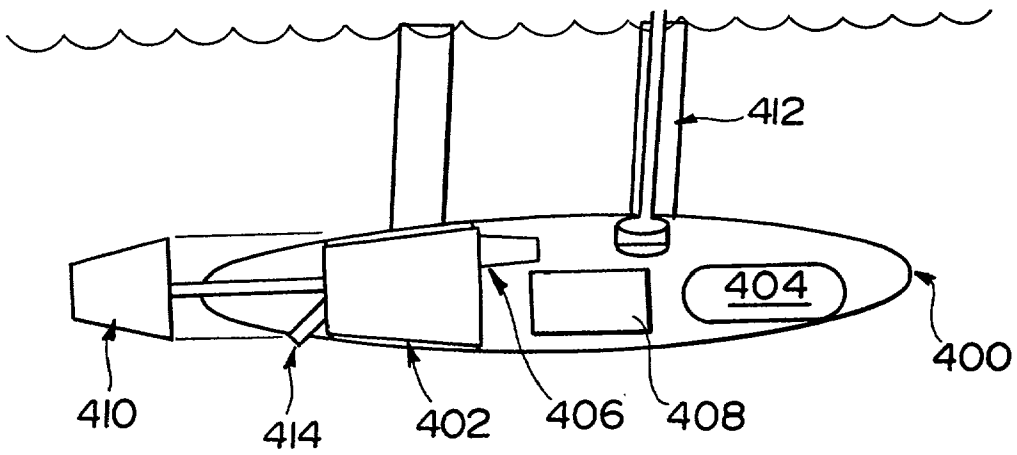


FIG. 16

FIG. 17

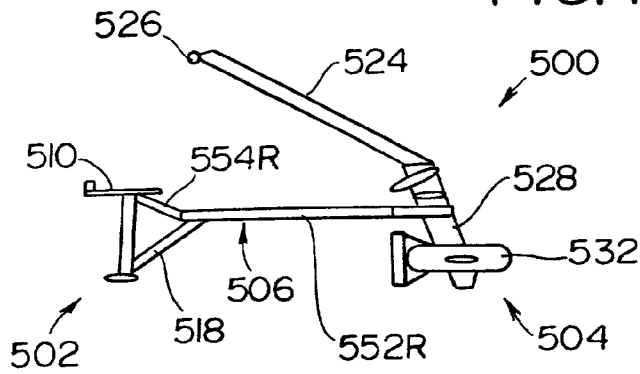


FIG. 18

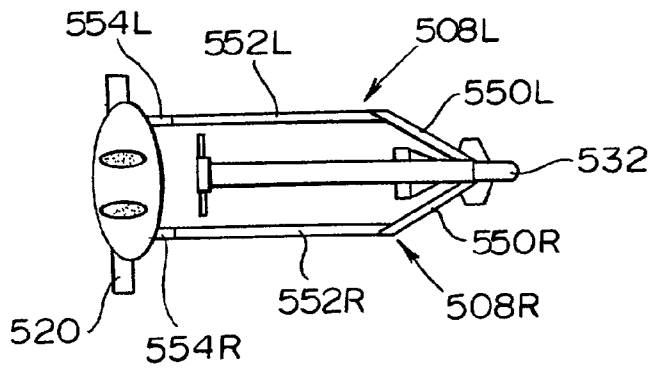


FIG. 19

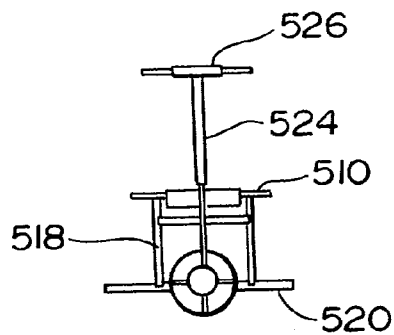
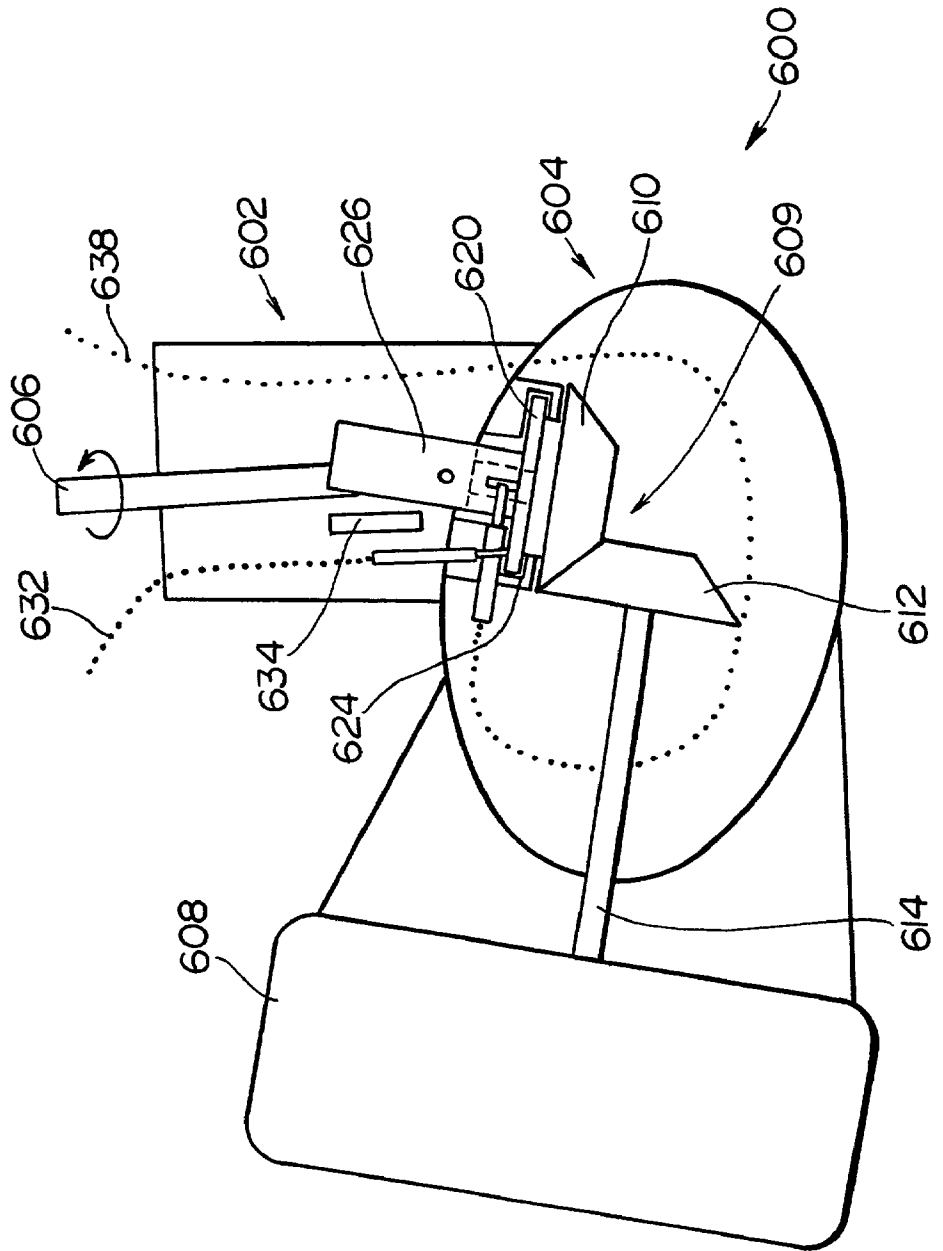


FIG. 21



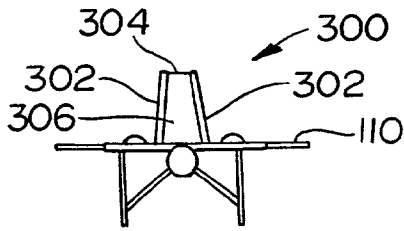


FIG. 23

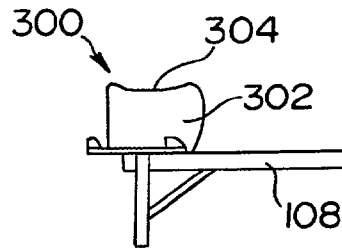


FIG. 24

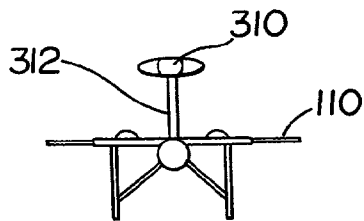


FIG. 25

FIG. 26

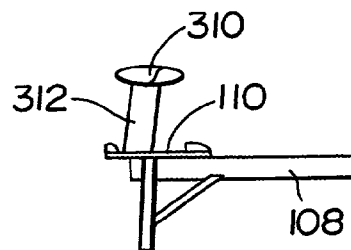


FIG. 27

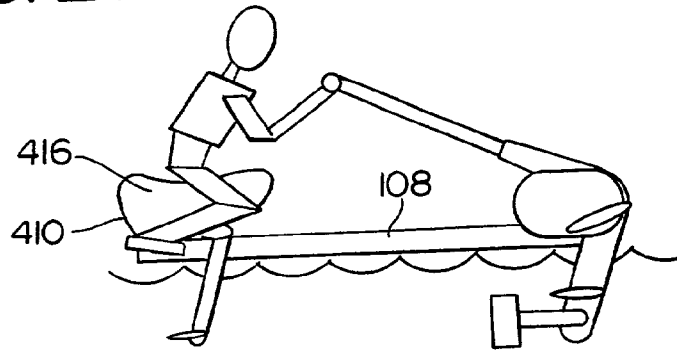


FIG. 28

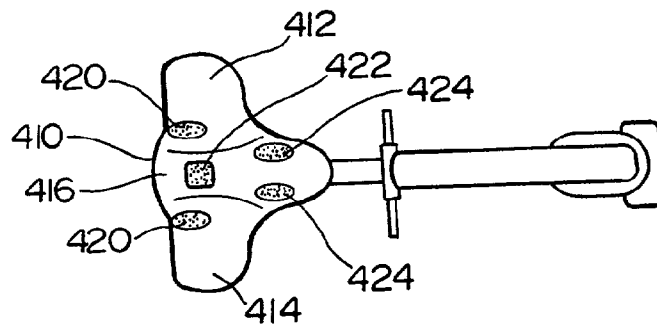


FIG. 29

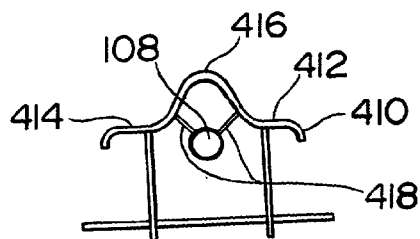


FIG. 30

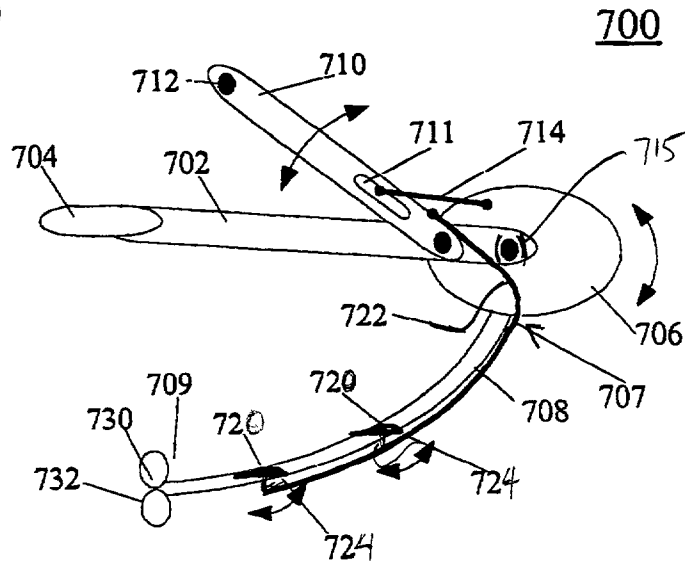


FIG. 31

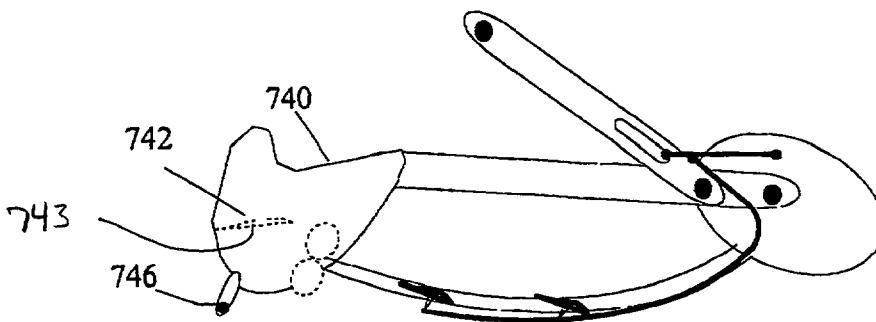


FIG. 32

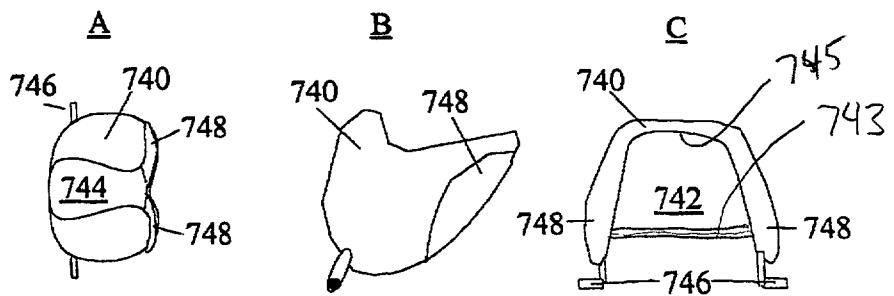


FIG. 33

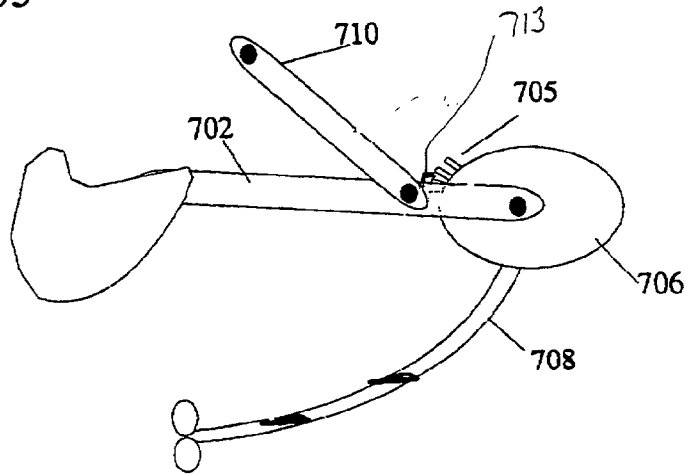


FIG. 34

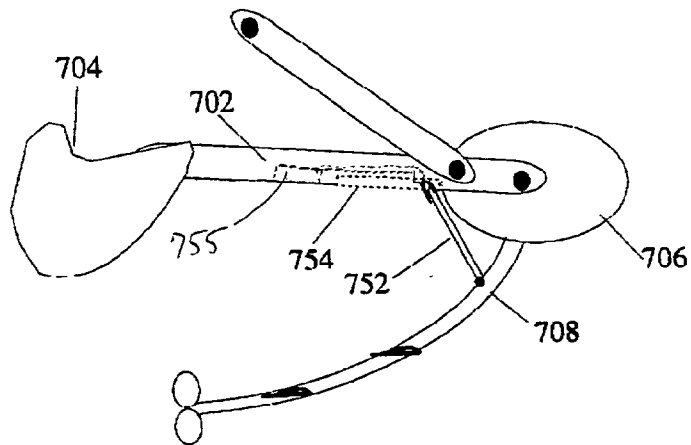


FIG. 35

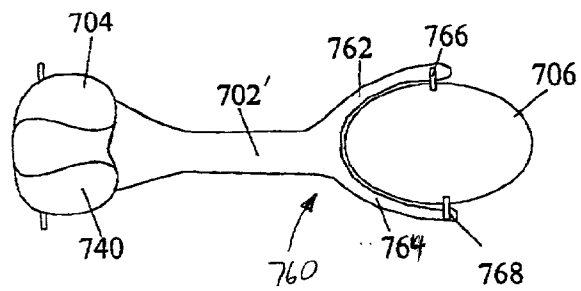


FIG. 36

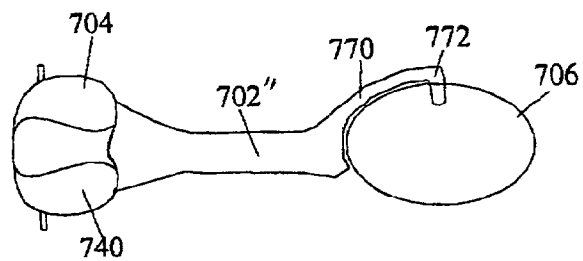


FIG. 37

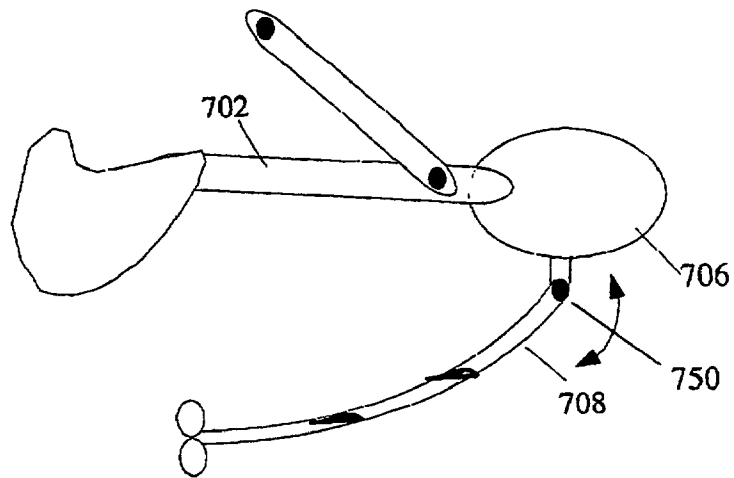


FIG. 38

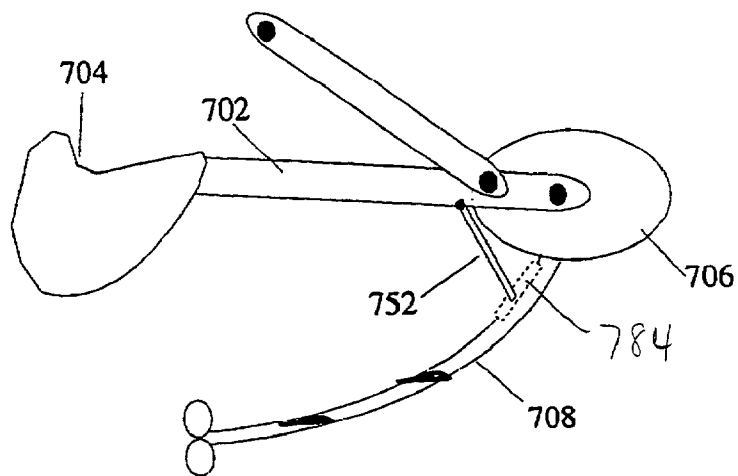


FIG. 39

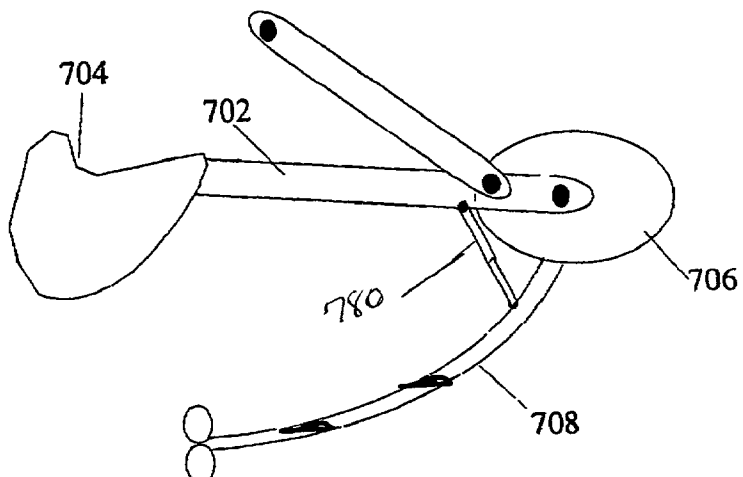


FIG. 40

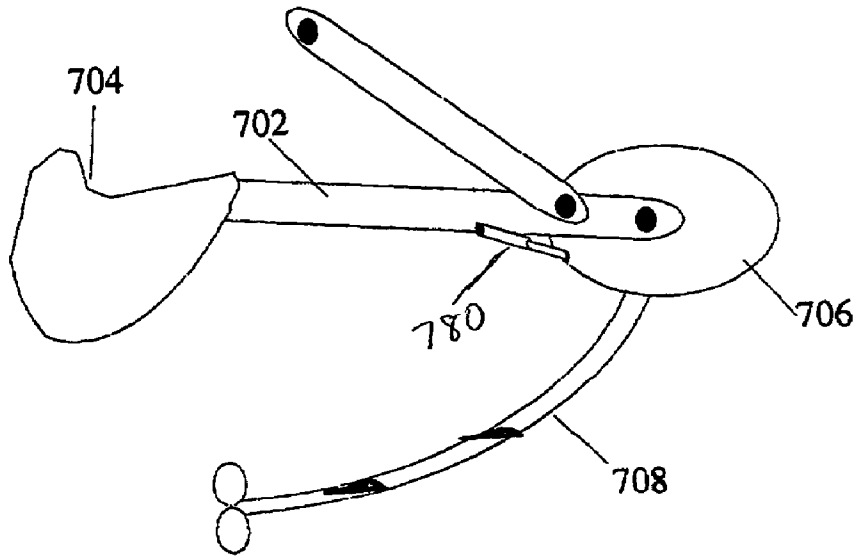
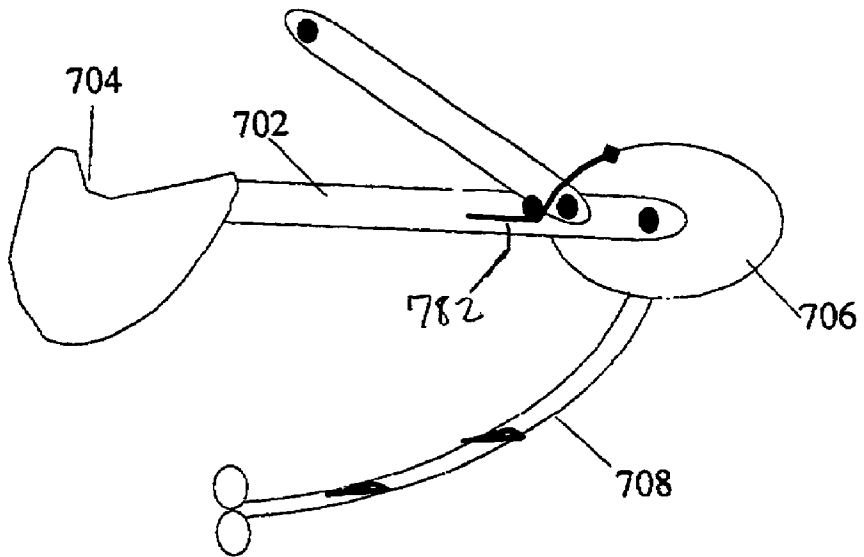


FIG. 41



PERSONAL HYDROFOIL WATER CRAFT

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation-in-part of application Ser. No. 09/771,656, filed Jan. 30, 2001, which is a continuation of application Ser. No. 09/177,622, filed Oct. 23, 1998, now U.S. Pat. No. 6,178,905.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention is directed to a watercraft for personal recreational use, in which the watercraft employs a hydrofoil lift system.

[0004] 2. Description of Related Art

[0005] Personal water craft (PWC) vehicles have enjoyed immense popularity in recent years. PWCs generally allow one, two or more riders to sit, kneel or stand on the craft and to ride across the surface of a body of water. The popularity of PWCs is also attributable to the considerations that they are less expensive than traditional power boats, are more easily transported over land by smaller trailers, and storage and maintenance of the PWCs is generally simpler than with full size power boats.

[0006] The popularity of such craft, and their operational characteristics, has led to several significant problems. The sheer number of such craft on some popular bodies of water has led to congestion, which adversely impacts safety. More significantly, existing PWC designs generate substantial noise, water, wake and air pollution. These PWCs have disproportionately large engines, with current models having 110+ horsepower engines, and, in the quest for increased speed, the power plants are only likely to become more powerful, in the absence of regulation. The hull form of current PWCs generates substantial wakes, which are a disturbance and a nuisance to other users of the waterways, and can adversely affect the safety of operating craft, both PWCs and boats.

[0007] Planing hulls are used in most recreational water craft, including PWCs. The planing hull design has been popularized due to its ability to permit craft operation at speeds in excess of the craft's natural hull speed. These hulls produce a downward reaction in the water by impacting the surface of the water with a low aspect ratio wedge, which produces large wakes.

[0008] The problems and costs associated with wake generation cannot be underestimated. The U.S. Coast Guard regulates speed, and holds operators of water craft responsible for damage due to wakes. Enforcement of the regulations is problematic, as wakes from motor boats can travel large distances before being encountered and causing damage, and identification of the offending vessel is often difficult. Wakes can also impair the operation and control of other water craft, with resulting detrimental impacts on safety. Wakes further can cause damage to docks and docked water craft.

[0009] The prevalent PWCs employ a water jet as the propulsion means. Water jets are prone to generating large amounts of noise pollution, in that, due to wave action and the presence of wakes, the PWC frequently lifts from the

water sufficiently to break the intake suction of the jet. Noise volume and pitch increase as a result, due to the jet ingesting and expelling air.

[0010] Various other water recreation devices have been employed over the years, most notably water skis. Many other towed devices, ranging from inflated tubes to bicycle style devices employing hydrofoil lift have been used or proposed for use. U.S. Pat. No. 3,105,249, discloses a device meeting the latter description. All such devices suffer from the drawback that a motor boat must be used to propel (pull) the device. The motor boat, like the PWCs discussed above, is noisy, uses a planing hull which creates substantial wakes, and pollutes the water.

[0011] Other water going vehicles have been proposed which employ hydrofoils as part of the lift or control system of a water craft in excess of speeds efficiently attainable with conventional hull forms. Often, hydrofoils have been proposed for use with hulled craft, whereby the craft will travel at low speeds using the displacement of the hull, and, at higher speeds, lifted partially or completely out of the water on a hydrofoil.

[0012] The high speeds attainable with hydrofoils are accomplished in that a hydrofoil provides a more efficient means of providing the lift necessary to float or ride on the water. Conventional displacement hulls simply displace a volume of water equal to the weight of the vehicle. Planing hulls displace water at lower speeds, and, at higher speeds, provide a crude form of lift by impacting the water downwardly, elevating the craft from the water and permitting higher speeds.

[0013] There continues to exist a need for an efficiently operating personal water craft (PWC) vehicle that avoids or minimizes the environmental impacts resulting from the widespread use of planing hulled craft. Further, efforts are ongoing to improve the recreational experience of such craft, which, in the conventional, planing hull PWC design, can largely be achieved only through increasingly powerful engines to provide increased speed.

[0014] A principal object of the present invention is thus to provide a PWC design which provides many, if not all, of the benefits of existing PWC designs, but which eliminates or significantly reduces the noise, water, air and wake pollution associated with the operation of conventional PWCs, principally through the elimination of the hull structure and the reliance on the use of hydrofoil lift for the craft.

[0015] It is a further principal object of the present invention to provide a PWC design that is more efficient in operation and has much lower power requirements, for equivalent on-water performance, as compared with conventional PWC designs.

[0016] It is an additional important object of the present invention to provide a fast and dynamic vehicle that may operate legally in waterways in which other, larger powered water craft have been or may be restricted by laws or regulations limiting the available motor power.

[0017] It is a further object of the present invention to provide a PWC design which is convenient and enjoyable to use, and is easy to maintain and transport.

SUMMARY OF THE INVENTION

[0018] The above and other objects of the present invention are achieved by providing a water craft which uses a hydrofoil or a plurality of hydrofoils as the sole means of suspending the craft operator above the surface of the water, such that the craft or vehicle can operate with dramatically less power than comparable water craft, such as conventional PWCs. The hydrofoil-based personal water craft of the present invention will thus operate with considerably less air, water, and noise pollution, and will generate far less wake than do hulled craft. The water craft further employs an operator platform designed with a suitable aspect ratio to provide hydrodynamic lift at startup, to aid in transitioning the craft from its startup position to its running position.

[0019] The hydrofoil craft of the present invention includes a main hydrofoil subassembly including an operator platform on which the operator will stand, sit, or kneel, and a hydrofoil extending from below the platform. This subassembly is coupled to a propulsion system which is disposed forwardly of the hydrofoil subassembly. The hydrofoil craft is steered and/or controlled by a handlebar-type assembly that extends rearwardly from a position adjacent to the propulsion system, placing the handlebars in position to be held by the operator when the operator is kneeling or standing. The propulsion system itself may be either an axial flow impeller type, or a ducted propeller type system, and the handlebar controls for power and steering will be tailored to the specific type of propulsion unit provided.

[0020] A strut assembly is used to couple the main foil assembly to the propulsion and steering systems, and the craft thus has no hull. Floatation devices may optionally be secured to the strut assembly, and/or to the operator platform, to give the craft sufficient buoyancy to prevent full submersion of the craft when the craft is idle or stationary.

[0021] The operator platform is designed with a suitable aspect ratio such that, at low speeds, it can function as a larger foil to aid in lifting the platform out of the water to achieve running configuration. After providing hydrodynamic lift, as the platform emerges from the water with an increase in vehicle speed, the platform will temporarily function as a planing surface, until it clears the surface of the water and becomes completely foil-borne.

[0022] The upper surface of the platform preferably includes a non-slip surface, in order to provide increased traction for the operator's feet, and also includes small toe and heel (front and rear) cups or chocks to allow the operator to brace his or her feet against the flow of water crossing the platform.

[0023] The forward-mounted propulsion system may incorporate one or more hydrofoils, in order to provide lift to the propulsion system when in operation. The forward portion of the craft, namely where the forward end of the handlebar column is coupled to the propulsion system, also includes hydrofoils to control the depth of, or the elevation of, the front end and propulsion system while operating at low speeds and at full speed.

[0024] In another embodiment of the personal water craft of the present invention, a main strut couples a motor housing at a forward portion of the strut and an operator platform at a rearward portion of the struts, and the motor

housing or forward portion of the strut has a foil-bearing strut depending downwardly therefrom, wherein the foil-bearing strut is pivotable relative to the main strut to allow the distance between the main strut and foil-bearing strut to be varied.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] These and other features, aspects and advantages of the present invention will become better understood when the following detailed description is read with reference to the accompanying drawings, wherein:

[0026] FIG. 1 is a substantially schematic side elevation view of the hydrofoil water craft in accordance with a preferred embodiment of the present invention.

[0027] FIG. 2 is a substantially schematic top plan view of the hydrofoil water craft in accordance with a preferred embodiment of the present invention.

[0028] FIG. 3 is a substantially schematic front elevation view of the hydrofoil water craft in accordance with a preferred embodiment of the present invention.

[0029] FIG. 4 is a substantially schematic front elevation view of a main hydrofoil subassembly in accordance with a preferred embodiment of the present invention.

[0030] FIG. 5 is a substantially schematic front elevation view of a main hydrofoil subassembly in accordance with an alternative preferred embodiment of the present invention.

[0031] FIG. 6 is a substantially schematic front elevation view of a main hydrofoil subassembly in accordance with a further alternative preferred embodiment of the present invention.

[0032] FIG. 7 is a substantially schematic view of a propulsion system and the arrangement of the components thereof in accordance with a preferred embodiment of the present invention.

[0033] FIG. 8 is a substantially schematic view of a propulsion system and the arrangement of the components thereof in accordance with another preferred embodiment of the present invention.

[0034] FIG. 9 is a substantially schematic view of a propulsion system and the arrangement of the components thereof in accordance with a further preferred embodiment of the present invention.

[0035] FIG. 10 is a substantially schematic side view of a forward end of the hydrofoil water craft of the present invention, showing details of a preferred forward depth control system for the propulsion system.

[0036] FIG. 11 is a substantially schematic side elevation view of the main hydrofoil subassembly illustrating details of a depth control system for the hydrofoil subassembly.

[0037] FIG. 12 is a top plan view of a foil to be employed in the main hydrofoil subassembly in accordance with a preferred embodiment of the present invention.

[0038] FIGS. 13A-C are substantially schematic side elevation views of the hydrofoil water craft of the present invention, illustrating operational details of the pivoting propulsion subassembly.

[0039] FIGS. 14A-D are substantially schematic side elevation views of the hydrofoil water craft of the present invention, illustrating the position of the craft and the operator during a typical take-off sequence.

[0040] FIG. 15 is a substantially schematic view of a propulsion system and the arrangement of the components thereof in accordance with an alternative preferred embodiment of the present invention.

[0041] FIG. 16 is a substantially schematic view of a propulsion system and the arrangement of the components thereof in accordance with an alternative preferred embodiment of the present invention.

[0042] FIG. 17 is a substantially schematic side elevation view of the hydrofoil water craft in accordance with an alternative preferred embodiment of the present invention.

[0043] FIG. 18 is a substantially schematic top plan view of the hydrofoil water craft in accordance with an alternative preferred embodiment of the present invention.

[0044] FIG. 19 is a substantially schematic front elevation view of the hydrofoil water craft in accordance with an alternative preferred embodiment of the present invention.

[0045] FIG. 20 is a substantially schematic view of a propulsion system and an arrangement of the components thereof in accordance with an alternative preferred embodiment of the present invention.

[0046] FIG. 21 is a substantially schematic view of the propulsion system of FIG. 20 illustrating the manner in which the system rocks the propulsor.

[0047] FIG. 22 is a front elevation view of internal components of the propulsion system illustrated in FIG. 20.

[0048] FIG. 23 is a substantially schematic front elevation view of an alternative preferred embodiment of the operator platform in accordance with the present invention.

[0049] FIG. 24 is a substantially schematic side view of the operator platform of FIG. 23.

[0050] FIG. 25 is a substantially schematic front elevation view of an alternative preferred embodiment of the operator platform in accordance with the present invention.

[0051] FIG. 26 is a substantially schematic side view of the operator platform of FIG. 25.

[0052] FIG. 27 is a substantially schematic side elevation view of the hydrofoil water craft in accordance with a preferred embodiment of the present invention.

[0053] FIG. 28 is a substantially schematic top plan view of the hydrofoil water craft in accordance with a preferred embodiment of the present invention.

[0054] FIG. 29 is a substantially schematic rear elevation view of the hydrofoil water craft in accordance with a preferred embodiment of the present invention.

[0055] FIG. 30 is a substantially schematic side elevation view of an alternative preferred embodiment of the hydrofoil water craft of the present invention.

[0056] FIG. 31 is a substantially schematic side elevation view of the craft illustrated in FIG. 30, with the foil strut shown in a retracted position.

[0057] FIGS. 32A-C are schematic top plan, side elevation and front elevation views of a saddle-type operator platform according to an alternative preferred embodiment of the hydrofoil water craft of the present invention.

[0058] FIG. 33 is a substantially schematic side elevation view of an alternative preferred embodiment of the hydrofoil water craft of the present invention.

[0059] FIG. 34 is a substantially schematic side elevation view of an alternative preferred embodiment of the hydrofoil water craft of the present invention.

[0060] FIG. 35 is a top plan view according to an alternative preferred embodiment of the hydrofoil water craft of the present invention.

[0061] FIG. 36 is a top plan view according to an alternative preferred embodiment of the hydrofoil water craft of the present invention.

[0062] FIG. 37 is a substantially schematic side elevation view of an alternative preferred embodiment of the hydrofoil water craft of the present invention.

[0063] FIG. 38 is a substantially schematic side elevation view of an alternative preferred embodiment of the hydrofoil water craft of the present invention.

[0064] FIG. 39 is a substantially schematic side elevation view of an alternative preferred embodiment of the hydrofoil water craft of the present invention.

[0065] FIG. 40 is a substantially schematic side elevation view of an alternative preferred embodiment of the hydrofoil water craft of the present invention.

[0066] FIG. 41 is a substantially schematic side elevation view of an alternative preferred embodiment of the hydrofoil water craft of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0067] Referring initially to FIGS. 1-3, a water craft 100 employing hydrofoil lift in accordance with a preferred embodiment of the present invention is illustrated. Craft 100 includes a main or rear hydrofoil subassembly 102, and a forward steering and propulsion subassembly 104, and a strut assembly 106 connected to and extending between the forward and rear subassemblies.

[0068] In accordance with the present invention, the water craft is defined as being hull-less. The term hull-less water craft, as used herein, means a craft having at least one normal operating position for the rider in which an adult person, when in such operating position, and while the craft is at rest in calm water, will necessarily be in contact with the water.

[0069] The strut assembly illustrated in FIGS. 1-3 is a single strut 108, preferably a hollow tube having a circular cross-sectional shape. The strut may preferably be on the order of four inches (4") in diameter, and made of aluminum or other high-strength, lightweight material which is resistant to corrosion in fresh water and in seawater. Plain carbon steel tubing with a corrosion-resistant paint or coating could alternatively be employed, as could a fiber-reinforced plastic or other engineering thermoplastic.

[0070] The rear or main hydrofoil subassembly 102 includes an operator platform 110 which is sized to accommodate the feet of the operator (10, FIG. 14B-D), and to permit the operator to kneel comfortably thereon. The platform 110 preferably has a high traction, non-slip surface 112, at least at the central portions where the operator's feet will normally be placed, although the entire upper surface could be made of a non-slip material, if desired. Platform 110 preferably has front and back footing cleats 114, 116, respectively, secured thereto, with the front cleats 114 provided to break the flow of water to minimize the force of any water flowing across the upper surface of the platform on the operator's feet. The back cleats 116 are provided to aid in preventing the operator's feet from slipping off the platform. The cleats are illustrated in FIG. 1, but are omitted from FIG. 2, in order to show, in FIG. 2, the non-slip surface 112.

[0071] The platform 110 provides several important functions in addition to providing a footing surface. The platform will have on the order of thirty pounds (30 lbs.) of buoyancy, by virtue of its displacement in the water, which serves to maintain the rear hydrofoil assembly in a position close to the surface of the water when the craft 100 is not being propelled through the water. Also, due to the length A and width B of the platform, preferably on the order of about 40 inches or less, and 18 inches or less, respectively, and the thin cross-section thereof, the platform 110 will act as a hydrofoil, providing lift during the initial take-off of the craft, as will be discussed in greater detail later.

[0072] The aspect ratio of the operator platform is desirably about 1 to 2 (2) or greater, in order that sufficient lift is generated during take-off. Even more preferably, an aspect ratio of 1 (1 to 1) or greater is desired in order to aid in readily and quickly lifting the operator platform to the surface of the water.

[0073] The hydrofoil subassembly further has a pair of foil struts 118 secured to the underside of the platform 110, and depending downwardly therefrom. A main foil 120 is secured at the lower ends of the foil struts. Rounded ends 119 of the foil struts extend a short distance below the main foil 120, in order to reduce vehicle drag when transporting the vehicle across land, and in order to minimize the possibility that the foil will ground itself against the bottom of the body of water.

[0074] The main foil 120 is preferably somewhat greater in length C (on the order of 48 inches or less) and smaller in width D (on the order of 4 inches or less) than platform 110, and the cross-sectional shape thereof is designed to provide lift. The length of the foil struts may preferably be on the order of thirty inches (30"), thus spacing the main foil 120 from the operator platform at that distance.

[0075] The operator platform 110, foil struts 118 and main foil making up the rear foil subassembly may be made from aluminum, and, in this instance the struts may be joined to the platform and to the main foil by welding. Other materials can optionally be employed, including composite materials, injection molded plastics, rotomolded plastics, and even different materials may be employed for the platform, foil struts, and main foil, i.e., materials selection for the components is not seen as being critical to the construction of a craft 100 in accordance with the invention. Where other or dissimilar materials are used, other conventional joining or fastening means, including, for example, riveting, threaded

connections, or adhesives, will be readily recognized as being possible candidates for use.

[0076] The main or rear foil subassembly 102 is secured to strut 108, as by welding, if all aluminum components are employed, or by other suitable connectors or fastening means. Strut 108 defines a centerline of the craft 100, as it is connected to the platform 110 at a centerline of the platform. Foil struts 118 are laterally spaced equidistantly from strut 108, and the main foil 120 is centered on the craft as well. The connection of the main foil subassembly 102 to strut assembly 106 is reinforced by the provision of a pair of angled support bars 122 rigidly fastened between strut 108 and the foil struts 118.

[0077] FIGS. 4, 5 and 6 illustrate, in substantially schematic form, alternative preferred configurations for the rear or main hydrofoil subassembly 102. FIG. 4 shows the subassembly 102 in the configuration shown in FIG. 1, with the operator platform 110, front foot cleats 114, foil struts 118, main foil 120, and also showing the rearward portion of strut assembly 106, strut 108 and angled support bars 122.

[0078] FIG. 5 illustrates an alternative configuration in which the only difference is that the main foil actually comprises a pair of spaced apart foils 120a and 120b attached to foil struts 118. FIG. 6 illustrates a single foil construction, but with a centrally disposed support bar 122' connected between strut 108 and the main foil 120. As can readily be envisioned from viewing FIG. 6, the centrally disposed support bar 122' may be used as a single foil strut, which construction would eliminate the need for side foil struts 118. These various embodiments are shown to illustrate that the connections and supports between the main body strut 108 and the main hydrofoil subassembly 102 are not seen as being critical to proper operation of the craft 100, nor is the specific foil configuration.

[0079] Returning to FIGS. 1-3, the strut assembly 106 has a steering or control subassembly and a propulsion subassembly 104 disposed at the forward end of strut 108. While the illustrated embodiments all depict the propulsion subassembly 104 being located at or near the front end of the craft, it is to be recognized that the propulsion may be provided at essentially any position along the length of the craft. Thus, while it is presently believed that providing both the propulsion subassembly and the steering or control subassembly at the forward end of the craft should provide the best overall performance, it is not seen as being critical that the propulsion subassembly be so located. Certain advantages in stability and maneuverability are obtained, however, by having the steering or control subassembly at or near the forward end of the craft.

[0080] Shown schematically in FIGS. 1-3 are a control column 124, having a handlebar 126 at a distal end thereof, and being operatively coupled to a control housing 128 at a proximal end thereof. A motor housing 130 is disposed rearwardly of control housing 128, and underneath control column 124, and is secured to strut 108 by suitable mounting hardware or welding. A propulsor housing 132 is disposed at a lower end of control housing 128. Details of the construction and operation of, and the components contained within, these housings will be discussed in greater detail in the discussion of other drawing figures presented. An anti-dive plate 134 is preferably provided on control housing 128, which has a flat surface area oriented such that, when the

forward end of the craft begins to dive, the plate will impact the surface of the water with a positive angle of attack, which will prevent or greatly dampen any further diving motion.

[0081] It can further be seen in FIG. 1 that the control housing 128 is angled toward the rear of the craft, and that the control housing 128 and the propulsor housing present a swept-back, rounded nose at the lower extent of the forward end of the craft. This design aids in preventing the craft from becoming grounded in shallow water and aids in transporting the craft over land.

[0082] The invention described thus far is a hull-less water craft which is capable of floating in a partially submerged condition when not in motion, and which, in operation, is lifted in the water by a hydrofoil assembly disposed underneath an operator platform, wherein the hydrofoil assembly bears the weight of the operator and the rear portion of the craft. The propulsion subassembly propels the hydrofoil, platform and operator through the water, and the craft is controlled by the operator by a handlebar control extending rearwardly toward the operator platform from the forward control subassembly. Overall, the craft operates as a self-propelled sled.

[0083] FIG. 7 illustrates, in substantially schematic form, a preferred arrangement or embodiment of a propulsion subassembly 134 and other associated components. The illustrated subassembly is referred to as a split propulsion system, in that certain components are housed in motor housing 130, and other components are housed in propulsor housing 132. A split system has the advantage of reducing the size of the housing (propulsor housing 132) that will remain submerged at full operating speed. This yields a lower cross-section presented to the water, thus lowering the form and wetted area drag of the propulsion system.

[0084] The selection of which components are positioned in the motor housing 130 and in the propulsor housing 132 generally follows a logical division of the components required to be submerged in operation, and those that are not. In FIG. 7, the motor housing 130, which will travel above the water surface at operating speeds, has a reciprocating motor 136, a generator 138 driven by the reciprocating motor, and a fuel tank 140 supplying to the reciprocating motor, disposed therein.

[0085] The motor housing optionally has an induction fan 142 in fluid communication with the outside environment, which is used to maintain a positive pressure in the motor housing 130. It may also be desirable to fluidly couple the propulsor housing 132 to the motor housing 130, in order to maintain a positive pressure throughout both housings. Maintaining this positive pressure will provide a moderate boost in engine performance and will make the propulsion system less susceptible to small leaks, and provides a means of continuously draining sump 166 through valve 168.

[0086] Mounting the reciprocating motor 136 in an upper motor housing 130 positioned above (as illustrated) or alongside (not shown) the strut assembly 106 desirably allows the interior of strut 108 to house an exhaust system 144, which can include an exhaust resonator 146, a muffler 148, and tubing runs 150 connecting the motor exhaust chamber or manifold to the exhaust resonator and connecting the resonator to the muffler. In this preferred embodi-

ment, the strut 108 is left open at the rear end 109 thereof, as well as at its front end, such that the strut 108 is free flooding, and so that the exhaust gases will advantageously exit the vehicle at the rear thereof. It is estimated that, due to the ability to provide a long, linear muffler 148 in the strut 108, the above-water exhaust system would achieve approximately the same level of noise reduction as would a submerged exhaust port. When the strut 108 is used to house the exhaust system, the motor housing 130 and the strut 108 will be joined such that a passage or opening is provided between the two components to allow the connection of the tubing run 150 between the motor 136 and exhaust resonator 146.

[0087] Generator 138 is electrically connected by cable or wiring 152 to a controller 154, which controls operation of electric drive motor 156, and the distribution of power to the motor 156 and battery 158. In this way, the generator supplies power to the motor 156 through controller 154, and also supplies power to battery 158. Battery 158 provides the charge for ignition, and may also be employed to intermittently provide power in initial takeoff and acceleration modes. The controller 154, battery 158 and drive motor 156 are housed within propulsor housing 132 in the FIG. 7 embodiment.

[0088] Drive motor 156 has an output shaft 160 which extends through the rear of the propulsor housing, and the shaft 160 is operatively coupled to a propulsor means 162, shown schematically in FIG. 7. The propulsor means 162 is preferably a ducted propeller or an axial flow impeller, both of which are available in the market, and both of which are relatively safe and efficient for use in this particular service.

[0089] Drive motor 156 may be jacketed so as to be conduction cooled. Small openings 164 are provided in a lower portion of control housing 128 to function as a water inlet, which water is to be collected and directed to the reciprocating motor 136 and to exhaust system 144 (through the open front end of strut 108), for cooling those components while the craft is foil-borne.

[0090] Propulsor housing 132 may preferably be provided with a sump 166 at the lower extent of the housing, with a popette valve or another selectively openable means. The sump will collect water that enters the housing, and the water may be drained or forced out through valve 168.

[0091] As shown in this FIG. 7 embodiment, the propulsor housing is coupled to the craft by a plate 170 that is secured to a lower end of a control rod 172. Control rod 172 is mounted inside control housing 128 and is rotatable about its longitudinal axis. Control rod 172 is itself coupled by a universal joint (shown schematically at reference numeral 174), to a steering bar 176 extending within control column 124. Steering bar 176 is coupled to handlebar 126 in a manner such that, when the handle bar is pivoted, the steering bar will rotate about its longitudinal axis, and, through universal joint 174, will cause control rod 172 and plate 170 to rotate. Steering is thus effected in this embodiment by rotating the handlebar 126, which, through the described linkage, rotates propulsor housing 132 to a desired angle relative to the longitudinal axis of the craft.

[0092] FIG. 8 depicts another preferred arrangement for the propulsion subassembly. This arrangement resembles, to some extent, the configuration of an outboard motor. This

embodiment may preferably employ the same exhaust system 144 as in the FIG. 7 embodiment.

[0093] In this embodiment, the pressurized motor housing 130 encloses a fuel tank 140 and a motor 136. The output of the motor 136 powers a drive shaft assembly 180, which drives the propeller 162 or other propulsor means. A swept-back, rounded, drive shaft housing 182 encloses a majority of the submersed portion of the drive shaft assembly, and the housing 182 is pivotably or rotatably coupled at the underside of the control housing 128.

[0094] Control rod 172 in this embodiment is coupled to a rotatable motor mount 184, by a steering coupling 186, illustrated as a pair of pulleys 188, 190 and a belt 192 extending between the pulleys. Steering is effected by rotating the handlebar 126, as in the FIG. 7 embodiment, which causes control rod 172, and pulley 188 connected thereto, to rotate. Through belt 192, the second pulley 190 is rotated, which rotates the drive shaft housing 182, drive shaft assembly 180 and propeller 162.

[0095] A further preferred propulsion subassembly configuration is illustrated in FIG. 9. This configuration replaces the rigid, geared drive shaft assembly 180 shown in FIG. 8 with a flexible drive cable or shaft 196. The use of the flexible drive shaft 196 enables the use of the simpler steering system shown in FIG. 7. In this embodiment, drive shaft housing 182 is coupled to a control rod 172 at a lower plate 170 attached thereto. Rotation of the drive shaft housing 182 and propeller 162 to effect steering takes place in a manner similar to the manner in which propulsor housing 132 is rotated in the FIG. 7 embodiment.

[0096] FIG. 10 illustrates a preferred embodiment of a forward end propulsion system depth control system 200. The depth control system 200 employs one or more pivotable foils 202 (one shown) extending laterally from opposite sides of control housing 128. The foil or foils 202 are preferably pivoted at their center of lift, and the pivot means can be a pin or pins extending from the foils 202 through the walls of control housing 128. The angle of attack of the foils 202 is controlled by sensor 204, which includes a large, inclined sensor plate 206 attached to an arm 208 pivotably secured to control housing 128. Arm 208 is connected to one or both of the foils 202.

[0097] As shown, in a preferred embodiment, the plate 206 and arm 208, and the foils 202, are in a substantially neutral position, i.e., substantially parallel to the surface of the water, when the propulsor housing and the front of the craft are traveling stably at approximately the desired depth. Plate 206 is designed such that it will substantially skim the surface of the water. Thus, as the front end of the vehicle begins rising farther out of the water, plate 206 will descend, pushing downwardly on the front of the foils 202, by action of the pivoting arm 208, to position the foils to have a negative angle of attack. The foils thus impart a downward force on propulsor housing 132, substantially preventing it from rising any higher in the water. The ability to generate the negative angle of attack is an important and significant feature, in that the operator on platform 110 may have a tendency to lean back and/or pull back on handlebars 126, both of which will tend to cause the craft to attempt to raise the front end thereof. The depth control system will, in all conceivable instances, be capable of retaining the front end in the water.

[0098] When the front end of the vehicle begins to descend past the desired neutral position, plate 206 pivots upwardly, causing arm 208 to pull upwardly on the front of foils 202, thus providing a desired positive angle of attack to substantially prevent further descent of the front end, and to urge the front end back to the neutral position.

[0099] A damper foil 212 and arm 214 may preferably be secured to arm 208 at the side of pivot point 210 to which plate 206 is attached. The damper foil 210 will be positioned to remain submerged during normal operation, and will damp or stiffen the sensor 204, making it less sensitive to wave action or other water surface level transients.

[0100] FIGS. 11 and 12 illustrate features that may advantageously be included on the rear foil subassembly 102, in order to provide depth control for the foil and rear portion of the craft. More specifically, these figures show the use of ventilation means provided to reduce the lift of the foil, and thus to regulate the minimum depth (maximum height) attained by the foil in operation.

[0101] In FIG. 11, a ventilation tube 220 is shown extending upwardly from the upper surface 121 of foil 120, alongside foil strut 118. An identical ventilation tube would be similarly positioned on the second foil strut (not shown). The low-pressure region present on the top of the lifting foil 120 is used by tube 220 to induct air from above the surface of the water to the top of the foil. This air induction, also referred to as ventilation, has the effect of dramatically reducing the lift generated by the foil.

[0102] Thus, in the present invention, the ventilation tube 220, when fully submerged, has no substantial ventilating effect, and the lift provided by the foil will raise the foil 120 and the operator platform 110. The length of the ventilation tube 220 is selected such that an upper end 222 thereof breaks the surface of the water when the foil 120 reaches a predetermined level below the surface of the water corresponding to the desired closest distance of approach of the foil to the surface of the water, and the desired elevation of the platform 110 in operation.

[0103] When the upper end of the tube breaks the surface, ventilation commences, thereby dramatically reducing lift. As a result, the foil will remain substantially at that level in the water. At this position, the top of the tube will spend a portion of time exposed to the air and a portion of the time submerged, due to the natural action of crossing even small waves or wakes. This has the effect of providing a smooth transition from the normal to the ventilated condition. The ventilation system becomes more effective at higher craft speeds, due to the increased tendency of the vehicle to climb, with even the minimal lift provided by the ventilated foil.

[0104] The opening at the lower end 224 of the tube is preferably positioned immediately adjacent the upper surface of the foil, and may preferably face laterally toward the side of the craft, or rearwardly, away from the flow of water. This will ensure a reliable low pressure coupling of the opening to the foil.

[0105] FIG. 12 illustrates a further preferred embodiment of the ventilator system. In this figure the ventilator tubes 220 are positioned inside, or are made integral with, foil struts 118. In addition, a ventilator extension tube 226 extends laterally within the interior of foil 120, and has a plurality of orifices 228 extending through the upper surface

121 of the foil, which will bleed air inducted through ventilator tubes 220 to the upper surface of the foil. This configuration is expected to increase the effectiveness of the ventilation.

[0106] The two ventilator tubes 220 could communicate with the entire ventilator extension tube, or, preferably, the ventilator extension tube will comprise two separate tubes 230, 232 and each ventilator tube 220 may be in fluid communication with only the portion of the extension tube 226 on the side of the craft on which the respective ventilator tube 220 is disposed. This arrangement can provide a limited amount of roll control, in addition to or as an enhancement to the depth control, in that, if one side of the craft is raised higher, for example, with the operator leaning considerably to one side, the ventilator on that raised side will operate to decrease lift on the foil on the raised side thereby tending to right the craft, while the ventilator on the lower side will not be significantly decreasing lift on the opposite side.

[0107] FIGS. 13A-C illustrate a further feature of the propulsion and steering system in accordance with a preferred embodiment of the present invention. In these figures, the propulsion and steering system is assembled to the main strut subassembly 106 such that the propulsor housing and propeller can pivot or rock relative to the strut 108, and such that the longitudinal axes of these components will not always be in parallel.

[0108] The main object of providing a rocking propulsion subassembly is to facilitate the initial take-off of the vehicle, as will be discussed in greater detail below. Referring now to FIGS. 14A-D, a typical take-off sequence is illustrated schematically. With no operator onboard, the vehicle or craft 100 is partially buoyant, with portions of the craft extending above and below the surface of the water, as seen in FIG. 14A. The operator 10 mounts or boards the craft 100 preferably by kneeling or crouching on the operator platform 110, as shown in FIG. 14B. In this position, the forward end of the craft remains near the surface of the water, while the operator platform 110 lowers under the weight of the operator.

[0109] The operator 10, using the controls disposed on handlebar 126, starts the craft moving in the water, whereupon the rear foil subassembly and the lift provided by the operator platform 110 cause the rear portion of the craft to rise such that the operator platform breaks the surface of the water, as seen in FIG. 14C. Further increases in craft speed result in a further raising of the operator platform due to the lift provided by foil 120. In full operation (FIG. 14D), the operator platform 110, motor housing 130, and strut assembly 106 travel above the surface of the water, due primarily to the lift provided by main foil 120, with lift also contributed by foils 202 attached to the propulsor housing 132.

[0110] Returning now to FIGS. 13A-C, the components enabling the propulsor housing 132 to be rocked during take-off will be described. Control column 124 is pivotably connected to control housing 128 by a suitable hinged connection 230 (see also FIG. 7) or other means. This pivotable connection is desired even when the rocking propulsor housing is not employed, so that the handlebar 126 can travel between a lowered position and a raised position, to enable the handlebars to be held comfortably when the operator is kneeling or standing, and to accommodate a range of operator heights.

[0111] Where a rocking propulsor is used, the propulsor housing 132 is hingedly connected to the steering mechanism (plate 170 in FIG. 7) by hinge means 232. This connection is made at the rear portion (aft of center) of the propulsor housing. A rod or cable 234, shown schematically in FIG. 13A, is secured to the control column 124 at a point which will pivot upwardly when the handlebar at the end of the control column is pivoted downwardly, or is at a lowered position (FIG. 13B). The opposite end of rod or cable 234 is secured to the propulsor housing 132 at a point rearward of the hinged connection. Thus, when the handlebar is lowered, the rod or cable pulls the rear portion of the propulsor housing upwardly, and, when the handlebar 126 is raised, the propulsor housing is able to pivot back into its normal orientation or position. The propulsor housing preferably would have a biasing means to retain it in contact with plate 170 in the absence of a substantial downward force being applied to the handlebar 126 and control column 124.

[0112] The rocking propulsor housing facilitates an easier and potentially quicker take-off for the craft. In the at-rest position (FIG. 13B), the vehicle, with an operator or rider 10 in place, is pitched upwardly. While this has the benefit of angling the foils to better generate lift, the propulsor housing 132, if not pivotable, would also be similarly upwardly pitched. This would cause the propulsor subassembly to have a tendency to broach the surface of the water, which can cause the propeller 162 to ventilate with air, and thereby lose thrust and efficiency.

[0113] Maintaining the handlebar 126 and control column in the lowered position will raise the back end (and lower the front end) of the propulsor housing, as seen in FIG. 13B. This will decrease the relative pitch of the propulsion system to the surface of the water, and will direct the thrust generated by the propeller directly at the underside of the operator platform 110. In the take-off sequence, operator platform 110 provides lift while emerging from the water, and the propulsion thrust thus boosts the lifting forces acting on the platform. This results in the operator and platforms being more easily lifted prior to the craft's achieving higher speeds. Since less of the operator will be in the water creating drag, the vehicle can be propelled forward with less power. Finally, the thrust of the propeller will be more closely in line with the desired direction of motion, thereby maximizing the use of the thrust to propel the craft forward.

[0114] The propulsor section would preferably be able to pivot on the order of about 10-20 degrees from its normal position, but this can be varied to accommodate specific geometries of the craft.

[0115] FIGS. 15 and 16 illustrate two alternative preferred arrangements of a fully submersed propulsion subassembly, which could be employed in place of the partially submersed or split systems illustrated in FIGS. 7-9. The principal differences between the two embodiments in FIGS. 15 and 16 are the type of drive motor and auxiliary equipment employed.

[0116] In FIG. 15, a pressurized propulsion enclosure 300 is provided. In this configuration, an electric motor 302 is used to power a ducted propulsor 304. Electric motor 302 is, in turn, powered by a gas-powered motor/generator combination 305, 306. The motor 305 has an exhaust port 307 extending through the wall of the enclosure. The generator

output can drive the electric motor directly and/or can be stored in battery 308 under the control of charge controller 310. Fuel for the gas-powered motor is stored in fuel cell 312.

[0117] The use of this power plant configuration provides high efficiency, lower gas motor power requirements, allowing use of a smaller gas motor, and a built-in thrust reverse capability. The craft may also be operated on battery power alone intermittently, allowing extremely quiet operation, and limited "get home" operation in the event of a gas motor failure.

[0118] The propulsion enclosure 300 may also be provided with a snorkel tube 314 to allow air to be inducted into the enclosure by the motor, thereby allowing the enclosure to operate as a compressed air plenum for supercharging the gas motor. Enclosure 300 may be mounted to the underside of the strut subassembly by a pair of propulsion support struts 316, 318.

[0119] The FIG. 16 embodiment is a gas engine powered system. Propulsion enclosure 400 contains a gas engine/motor 402, a fuel cell 404, a starter motor 406 and battery 408 used to power the starter motor. The motor output is used to power the propulsor 410. As in the FIG. 15 embodiment, the propulsion enclosure has a snorkel tube 412, and an engine exhaust port 414. While this configuration may be somewhat less efficient than that illustrated in FIG. 15, it may be less expensive to construct. Overall, submersing the entire propulsion system in either of these arrangements offers the benefits of better sound isolation, lower foil lift requirements, and greater inherent stability.

[0120] FIGS. 17-19 illustrate an alternative preferred configuration of the personal water craft 500 of the present invention. The principal difference between this embodiment and the embodiment illustrated in FIGS. 1-3 is the construction of the strut subassembly 506. In this embodiment, the craft still has a forward propulsor housing 532, a control housing 528, control column 524, handlebar 526, rear operator platform 510 and rear foil assembly 502, including main foil 520.

[0121] Strut subassembly 506 in this embodiment comprises a pair of laterally spaced struts 508L, 508R (FIGS. 18, 19) that connect the propulsor subassembly 104 to the foil subassembly 102. Each of struts 508L and 508R is made up of strut sections, a forward section 550L,R which connects to the control housing 528, and branches to the left or right, respectively, a middle longitudinal section 552L,R, connected to and extending from the forward sections to rear sections 554L,R. Rear sections 554L,R connect to the rearward end of middle sections 552L,R, and to the underside of operator platform 510, at the point where foil struts 518 connect. Auxiliary foil struts 522 also connect to the rearward end of middle sections 552L,R, and to a lower end of foil struts 518.

[0122] The craft of the present invention is on the order of ten (10) feet in overall length, and the height from the main foil 120 to the operator platform 110 may be on the order of about 30 inches or less. The span of the main foil 120 is preferably 48 inches or less, with the operator platform preferably being several inches less in span than the main foil. The craft thus is of a manageable size for a single user, and can readily be trailered in a manner similar to the current trailering of the hulled personal water craft now on the market.

[0123] FIGS. 20 and 21 illustrate a further preferred embodiment of the propulsion subassembly of the present invention. FIG. 22 is a front elevation view of certain internal components of the propulsion subassembly.

[0124] This propulsor subassembly 600 includes a control housing or strut 602 and a propulsor housing or gear housing 604 which is positioned below the control housing. Control housing or strut 602 is secured to the forward end of the craft (not shown in FIGS. 20, 21) and depends downwardly therefrom.

[0125] Extending through control housing 602 is a drive shaft 606, coupled at its upper end to an output of a motor. Drive shaft 606 is operatively coupled to ducted propulsor 608 by a bevel gear pair 609, which comprises drive gear 610 and driven gear 612. Drive shaft 606 may include a universal joint or a flexible coupling (shown schematically in FIG. 22 at reference numeral 611) connecting it to bevel gear 610, so that the drive shaft can continue to drive the gear pair when the propulsor housing is rocked or pitched, relative to the drive shaft. The driven gear 612 of the gear pair is connected to the propulsor 608 by a driven gear shaft 614, which is connected to driven gear 612 and extends from the interior to the exterior of propulsor housing 604.

[0126] The propulsor housing or gear housing 604 is coupled to the control housing or strut 602 by means of a control disc 620 captured in a channel 622 of a bracket 624, the bracket being secured to an upper inner wall of the propulsor or gear housing 604. Control disc 620 is circular (actually, a short cylinder), and has a pair of spaced fork members 626 extending perpendicularly upwardly from an upper surface 628 of the disc. The fork members 626 are connected by pins 630 to the control housing 602, which allows the fork members to pivot relative to the control housing, thereby pivotably securing the propulsor or gear housing 604 thereto.

[0127] A rocking control cable 632, illustrated as a sleeved control cable, is connected to the control disc 620 at a point to the aft of the fork members 626. The rocking control cable can be operated by push/pull control rods or arms (not shown), and can move the propulsor or gear housing from a normal, non-rotated axial orientation (FIG. 20) to a rotated orientation (FIG. 21), by pulling upwardly on the rear of the control disc 620. The control disc 620, in turn, rotates bracket 624 in which it is captured, thereby rotating the propulsor or gear housing 604 and propulsor 608. It is expected that it will be undesirable to allow the propulsor housing to be rocked or rotated in the opposite direction, i.e., with the propulsor 608 oriented to provide upward thrust, and, in that case, a stop element 634 may be mounted to the inner wall of control housing 602 as schematically illustrated in FIGS. 20 and 21, with the stop 634 preventing the fork members 626 from moving rearwardly past the upright or vertical orientation.

[0128] This propulsor subassembly also provides for steering control, by providing a tang or flange 636 projecting upwardly from the upper surface 628 of the control disc 620. A steering control cable 638 may preferably be attached to tang 636, and, when the cable is manipulated by the rider, the tang is pushed or pulled, thereby causing the control disc 620 and propulsor or gear housing 604 to rotate from side to side.

[0129] The controls for the rocking and steering of the propulsor or gear housing need not be sleeved cables of the

push/pull type, but instead may comprise hydraulic controls or other suitable control means.

[0130] FIGS. 23 and 24 are front and side views, respectively, of an operator platform in accordance with an alternative preferred embodiment of the present invention. In this embodiment, platform 110 is equipped with a saddle-type seat 300, made up of two side panels 302 and an upper, contoured seat panel 304. In this embodiment, an operator would have the option of standing, crouching, or being seated while operating the craft.

[0131] The saddle-type seat in the illustrated embodiment has a channel 306 extending therethrough to permit water to pass through when the platform 110 is not completely elevated out of the water.

[0132] FIGS. 25 and 26 are front and side views, respectively, of an operator platform in accordance with another alternative preferred embodiment of the present invention. In this embodiment, platform 110 is equipped with a bicycle seat 310 elevated above platform 110 and supported by seat strut 312. Both the saddle-type seat and the bicycle seat configurations are perceived as being desirable primarily as a function of customer preference, and the addition of either seat to the operator platform is not seen as having any dramatic impact on the operation of the craft.

[0133] FIGS. 27-29 are side, top and rear views of a further preferred embodiment of the craft of the present invention. In this embodiment, the operator platform 410 is not entirely substantially planar, but rather has two wing sections 412, 414, and a raised central saddle section 416.

[0134] As can be seen by comparing this embodiment to the FIG. 23 embodiment, which adds a saddle seat to the planar operator platform 110, the embodiment shown in FIGS. 27-29 simply forms the footing elements (wing sections 412, 414) integrally with the saddle portion (saddle section 416). In making this a unitary component, it can be seen, in FIG. 29, that a central planar portion of the operator platform 110 may be omitted, and the operator platform 410 may be secured to strut 108 by one more platform struts 418 (two shown).

[0135] It can be seen in FIG. 28 that the operator platform 410 is provided with several areas of non-skid surfaces, including footing surfaces 420, seating surface 422, and crouching surfaces 424. The crouching surfaces are positioned to engage the inside of the knee, thigh and/or calf, of the rider. The non-skid surfaces provide traction and increased stability for the rider, in the available operating positions, which primarily include standing, sitting and crouching/kneeling. A saddle-type operator platform will allow the rider to closely conform his or her body to the operator platform (see FIG. 27), thereby streamlining the body and reducing drag during the takeoff sequence.

[0136] As noted previously, the operator platform of the present invention preferably has an aspect ratio of at least about 2, and more preferably at least about one (1). In the FIGS. 27-29 configuration, the aspect ratio would be measured using the dimensions of the wing sections 412, 414 extending laterally from the saddle section 416, as the wing sections will primarily be responsible for the lift provided by the operator platform during startup. By comparison, the aspect ratio of a planar platform, such as platform 110, will be measured using the overall dimensions of the platform.

[0137] An alternative preferred embodiment illustrated in FIGS. 30-36, provides several improved characteristics over the preferred embodiments discussed above. In the previously discussed preferred embodiments, the overall height of the vehicle is substantial, because the foils project below the water craft a considerable distance, in order to operate efficiently. When a saddle-type operator platform is employed, this platform extends upwardly to approximately half the height of the operator, resulting in an overall craft height of approximately five (5) feet. Such a configuration can limit the ability to routinely and easily beach the vehicle, and may increase the chances that the vehicle will become damaged in use, or may result in increased chances of loss of control of the vehicle or injury, in the event that the craft strikes an obstruction.

[0138] In addition, the drag and propulsion efficiency of the foregoing embodiments during takeoff can be improved upon. These factors are very important in sizing a power plant for the craft, and can affect the relative size and pitch of the propulsor to be used on the craft. A configuration that reduces drag and increases propulsion efficiency at takeoff can employ a smaller power plant, and the propulsion system overall can be optimized for fuel economy, increased top speed, or other operating parameters.

[0139] The preferred embodiments of FIGS. 30-36, address these design considerations and provide improvements over the previously discussed embodiments in these respects. The provision of a foil strut that is capable of pivoting or rotating upwardly toward a main strut addresses the situation presented by having the foil or foils fixed in position at a considerable distance below the operator platform. The pivoting strut is expected to reduce the potential for loss of control of the vehicle or injury to the operator or others in the vicinity of the craft.

[0140] Turning first to FIG. 30, the hydrofoil water craft 700 of this alternate preferred embodiment is shown in substantially schematic form. The craft 700 has a main strut assembly comprising a main strut 702 and a motor housing 706, wherein the main strut operatively couples an operator platform 704 at a rearward portion of the main strut 702 to the motor housing 706 at a forward portion of the strut.

[0141] As illustrated, motor housing 706 is coupled to main strut 702 such that the motor housing can rotate or pivot about a horizontal axis which is perpendicular to an axial extent of the craft. This coupling may be effected in any known manner, including the use of pins extending laterally from the sides of the motor housing into bores or bearing structures provided on main strut 702.

[0142] Foil strut 708 is coupled to, and extends downwardly and rearwardly from, motor housing 706. In the embodiment illustrated in FIG. 30, foil strut 708 is substantially rigidly secured to motor housing 706, and will thus pivot or rotate relative to main strut 702 when motor housing 706 so pivots or rotates. In an alternative embodiment (see, e.g., FIG. 37), motor housing 706 may remain fixed relative to the main strut, with the foil strut being pivotably mounted to a pivoting means 750, shown here in the form of a short leg 750 extending downwardly from the fixed motor housing, as will be readily recognized by those of ordinary skill in the art.

[0143] The craft 700 in FIG. 30 further has a control column 710 with handlebars 712 protruding therefrom. As

illustrated, a brace **714** is shown as being attached to the control column **710** and to the motor housing **706**, thereby operatively linking these members together. Brace **714** allows the operator to control the position of the motor housing **706** and foil strut **708** relative to main strut **702** by raising or lowering the control column **710**, which is itself pivotably mounted to main strut in the illustration of **FIG. 30**.

[**0144**] The control column is mounted at a forward portion of the main strut **702**, but rearwardly of the position at which the motor housing **706** is mounted to main strut **702**. The control column **710** may preferably have a slot **711** which brace **714** engages, which provides for a predetermined range of rotation or pivoting of control column **710** without an attendant movement of housing **706**. This allows the positioning of foils **720** using the control cables **722** without releasing the clutch.

[**0145**] Brace **714** allows the operator to optionally deploy (lower) or stow (raise) the foil strut by rotating the motor enclosure to which it is attached. In a preferred embodiment, the mechanism of slot **711** would function to release a clutch, shown schematically at **715**, holding the position of motor enclosure **706** fixed in relation to the main strut **702** by preventing the rotation of the axle or bearings between main strut **702** and motor housing **706**.

[**0146**] Thus, it can be seen that the interaction of the brace **714** and slot **711** provides a range of motion for control column **710** in which the foil position control **722** will be active, but the foil strut control **714** is not releasing the clutch, and the motor housing will thus not rotate. This gives the operator the freedom to control the elevation of the vehicle over the water while in operation, including the possibility of executing jumps.

[**0147**] When the brace **714** travels to the ends of slot **711**, the mechanism will trigger a release of the clutch, possibly by the use of switches or sensors, and allow control column **710** to be used to rotate the motor housing. The clutching mechanism may also preferably be designed so that, upon experiencing a sudden and excessive load, e.g. the foil strut **708** striking an object, the clutch will automatically release and allow the foil strut to rotate, thereby minimizing the disruptive effect of the impact.

[**0148**] The foil strut **708** of craft **700** is preferably in the form of a tube having a passage extending therethrough. At least one, and preferably more than one, lift foils **720** are pivotably mounted on the foil strut **708** at spaced apart locations. The lift foils **720** extend laterally of the foil strut, and are sized to present a desired aspect ratio.

[**0149**] The positioning or orientation of the lift foils **720**, in the illustrated preferred embodiment, is controlled by a control cable **722** having one end secured to a lower portion of control column **710**, and having other portions secured to foil control members **724** at the appropriate locations along the length of the cable. Movement of the control column will thus push or pull the control cable **722**, depending upon the direction of movement thereby pivoting the foils allowing the operator to control the elevation of the vehicle over the water.

[**0150**] Also, it can be seen in **FIG. 30** that the control column **710** can be manipulated by the operator, who would be standing, kneeling or sitting on the operator platform **704**,

to raise or lower the foil strut **708** and to pivot foils **720**, as desired. This facilitates handling the craft near a shoreline or other shallow water areas, for example. The operator, in anticipation of bringing the craft **700** into shore, or beaching the craft, can push upwardly on the handlebars **712** and control column **710** to cause clutch to release, and the motor housing to tilt forward, which in turn causes the foil strut to rotate upwardly toward the main strut **702**. Moving the foil strut **708** upwardly in this manner allows the craft to clear submerged obstacles or to more closely approach dry land before the foil strut contacts the sand or earth underlying the water at the shoreline.

[**0151**] **FIG. 30** also shows, in substantially schematic form, a propulsion means **730** disposed at the end of foil strut **708** opposite the end of the foil strut which is operatively connected to motor housing **706**. As a shorthand notation, the end of the foil strut **708** connected to the motor housing will be termed a proximal end **707**, and the end at which the propulsion means **730** is disposed will be termed a distal end **709**. The propulsion means may be a propeller **732** (as shown schematically in **FIG. 30**), a propulsor, as described elsewhere in this specification, or other suitable means for providing thrust to move the craft forward.

[**0152**] The propulsion means is powered by a motor (not shown) housed within the motor housing **706**. A propulsion transmission means operatively couples the motor output to the propulsion means **730**, and may preferably be integral to the foil strut **708**, for example, by use of a drive shaft housed within the foil strut. Alternatively, where a propulsor is used in lieu of a propeller as the propulsion means **730**, the motor output may preferably be used to pump water through the foil strut **708** to the propulsor.

[**0153**] Turning to **FIG. 31**, the water craft **700** is shown in an alternative preferred configuration. This configuration employs an operator platform **704** that is formed as a saddle seat **740**. **FIGS. 32A and B** show top plan and side elevation views, respectively, of an exemplary saddle seat **740**. A saddle seat is seen as providing several significant advantages when used in combination with the movable or rotatable foil strut **708**. It can be seen in **FIG. 31** that the foil strut can be sized such that, as it rotates toward the main strut **702**, the propulsion means **730** mounted at the distal end **709** of the strut travels into a recess **742** formed under the saddle seat **740**. This has the effect of shielding the propulsion means, which can aid in protecting the operator and possibly swimmers in the water, should the operator accidentally come upon a swimmer while riding the water craft.

[**0154**] Optionally mounted on the operator platform within recess **742** is foil **743**, which has the purpose of providing additional lift when the propulsion means **730** is recessed. This lift is generated by the impingement of the ejected water from the propulsion means **730** on the foil **743**. An additional feature of foil **743** is to further enclose the propulsion means **730** while it is in its retracted position. The lift generated by foil **743** may be useful in other alternative embodiments of the invention, for example, one which includes motorized deployment of foil strut **708** while the vehicle is in motion, particularly during takeoff. The additional lift will lift the operator partially from the water, greatly reducing drag during takeoff. Once sufficient speed has been gathered, the foil strut **708** could then be deployed (lowered) using a small motor or other mechanical assist

device. One approach to effecting this would be the provision of foil strut position controller, shown schematically at 755 (FIG. 34), which preferably would be a small jack screw motor, recessed within slot 754, which would move brace 752 (FIG. 34) forward to deploy the foil strut 708. A hydraulic ram could be provided in place of the jack screw motor as the foil strut position controller 755, to provide the same function.

[0155] The saddle seat 740 forms the recess underneath by using a molded or formed hollow shell-like construction which provides an upper seating surface 744 (FIG. 32A) and an essentially arched interior surface 745 (FIG. 32C). Preferably, footrests 746 are secured to, and extend downwardly and outwardly from the saddle seat 740.

[0156] FIG. 33 schematically illustrates an alternative approach to controlling the rotation of the motor housing and foil strut. This figure shows that a ratchet-type latching mechanism can be employed, such that a plurality of pre-set orientations of the motor housing 706/foil strut 708 may be selected by the operator of the craft, by way of engagement of teeth or cogs 705 protruding from the surface of motor housing 706, with a latch or pawl 713 disposed on control column 710. It will be appreciated that this latching mechanism will preferably be designed such that the latching mechanism will disengage or release to allow the foil strut 708 to pivot toward the main strut 702, in the event that the foil strut 708 strikes or impacts a submerged object.

[0157] It will also be readily appreciated that other forms of operator control of the orientation of the motor housing/foil strut may also be used. Examples include geared mechanisms and friction brakes.

[0158] Some alternatives to manual control of the foil strut rotation depicted in FIG. 30 are illustrated in FIGS. 38-41. In FIG. 39, a hydraulic ram 780 is attached to main strut 702 and to foil strut 708. In FIG. 40, the hydraulic ram 780 is connected to the main strut 702 and a pivotable motor housing 706. The hydraulic ram extends and contracts to change the position of the foil strut 708 relative to the main strut 702 and operator platform 704.

[0159] FIG. 41 illustrates an alternative preferred embodiment in which the motor housing 706 and foil strut 708 are constructed such that they are biased, as by counterbalancing or a spring or springs, into the retracted or raised position (closest position to the main strut 702). The foil strut position may then be controlled via a cabling arrangement 782, wherein the cable counteracts and overcomes the initial biasing force, such that the foil strut may be deployed or lowered to a desired position. Reverting back to FIG. 33, the cogs 705 could be engaged by a motor driven worm gear to raise and lower the foil strut.

[0160] In each of the embodiments shown in FIGS. 38-41, the operator interface will present to the operator controls for the actuators to operate these assist devices. The controls may be switches or buttons mounted on control column 710, or the handlebar 712, or elsewhere on the craft, preferably in a position or positions where the operator will have convenient access.

[0161] FIG. 37 illustrates a further variant of this alternative preferred embodiment. In this configuration, motor housing 706 is secured in a substantially fixed position relative to main strut 702 on the main strut assembly. The

foil strut 708 is, on the other hand, coupled to motor housing 706 in such a manner that it is pivotable between an extended position spaced below the operator platform 704 and main strut 702, and a retracted position in which the foil strut has moved upwardly toward the operator platform and main strut.

[0162] The foil strut may be pivoted, as in the previous configuration, upon contacting an object located below the waterline, or by operator control. Although various coupling configurations will readily come to mind, FIG. 37 shows that foil strut 708 may be mounted pivoting means, which, in FIG. 37, is illustrated as a short leg fixed to and depending downwardly from motor housing 706 using a pivoting connection, such as a pin rotatably retained in bores, or through the use of bearings and a transverse pin or axle. A hinge-like device, a U-joint type device, or any other coupling that permits pivoting of the foil strut about a transverse axis could readily be used as an alternative construction.

[0163] Turning to FIG. 34, the foil strut 708 may preferably be supported by a linkage to main strut 702, in which a link 752 is pivotably connected to foil strut 708 at one end of the link 752, and is slidably received and retained in a recess 754 disposed at an underside of the main strut 702. The recess may be sized such that it will dictate the range of travel of the foil strut 708. It can be seen in FIG. 34 that, as foil strut travels to its extended position, link 752 is brought toward the front of the main strut 702, where motor housing 706 is disposed. The recess 754 will preferably present an obstacle to further forward movement of the upper end of link 752, thereby preventing further extension or pivoting of foil strut 708 in a direction away from main strut 702 and operator platform 704.

[0164] As noted previously, the control of the position of the foil strut relative to the main strut can be achieved by linkages to the control column, or by more automated means, such as the use of the jack screw motor 755.

[0165] Similarly, as foil strut 708 moves to its retracted position, the upper end of link 752 travels toward the rear of the main strut 702. Preferably, the recess presents an obstacle to further rearward movement, which thus limits the range of travel of the foil strut 708 in the direction toward the main strut 702. This range of travel may preferably permit the foil strut to closely approach the main strut, but it is preferable that the foil strut, and particularly the propulsion means 730, be kept from contacting the main strut 702 and/or the operator platform 704.

[0166] Alternative configurations for linkages between main strut 702 and foil strut 708 are depicted in FIGS. 38 and 39. In FIG. 38, the linkage 752 is pivotably connected to main strut 702, and slidably engages slot or slide element 784 disposed on the foil strut 708. This is essentially a reversal of the linkage shown in FIG. 34, however, the linkage will function in the same basic manner. In FIG. 39, a hydraulic ram 780 is provided in lieu of the linkage 752 and slot or slide 754. Either of these actuators or control elements can be employed in both of the basic configurations shown in FIGS. 34 and 37. In FIG. 34, the foil strut is fixed to the motor housing, and the motor housing may rotate relative to the main strut 702. In FIG. 37, the foil strut 708 pivots, and the motor housing remains stationary relative to the main strut.

[0167] FIGS. 35 and 36 are top plan views of two alternative preferred configurations of the main strut 72 of

the present invention. **FIG. 35** illustrates that the main strut **702'** may have a front fork **760**, with arms **762**, **764** extending around opposing sides of motor housing **706**. The arms may preferably have pins **766**, **768** held in bearings (not shown) mounted on or through the arms **762**, **764**, which extend into or attach to motor housing **706**, whereby motor housing **706** may rotate relative to the main strut **706** about a transverse axis.

[0168] **FIG. 36** illustrates a variant on the main strut of **FIG. 35**, wherein the main strut **702''** has only a single arm **770** extending to one side of the motor housing **706**. The arm **770** may have a transverse pin extension **772** which is rotatably secured to motor housing **706**, as shown schematically.

[0169] Either of these configurations is feasible from a technical standpoint. The important consideration is that the mounting of the motor housing **706** to the main strut **702**, in combination with the control mechanism for changing the orientation of the foil strut **708** relative to the main strut, will allow a rapid release and rotation of the foil strut under either operator command or as a consequence of an impact.

[0170] Reverting back to **FIGS. 32A-C**, the saddle-type operator platform illustrated in those figures shows a further enhancement in the design of the operator platform.

[0171] The saddle-type platform **740** in this embodiment is provided with rigid or semi-rigid chap-like extensions **748** around the leading edge of the saddle seat **740**. The chaps **748** provide smooth, hydrodynamic flow around the legs of the operator, which will be positioned behind the chaps. The chaps will aid in shielding the operator from the water striking those areas during all phases of operation of the craft. The chaps **748** will also aid in bracing the operator in position on the vehicle, should a portion of the saddle strike the surface of the water, for example, when executing highly banked turns. In all, the chaps **748** reduce the overall drag of the vehicle, and reduce drag-induced stress on the operator, leading to more efficient and enjoyable operation of the craft.

[0172] In general, it is anticipated that electronic and computer driven controls and actuators may be used to either supplement or replace the various mechanical linkages illustrated in the various drawing figures. Specific examples include the use of an electromechanical actuation of clutch **715**, using switches to detect brace **714** encountering the ends of slot **711**. As noted previously, a small motor and screw jack assembly or hydraulic ram could be used to move brace **752** to position the foil strut. The cog **705** and pawl **713** arrangement in **FIG. 33** could employ a small motor and screw to actuate the cogs **705**. The pivoting of the motor housing or foil strut in the various embodiments could further be accomplished and controlled by hydraulic means, or by cables under tension.

[0173] It is to be understood that the foregoing description of the preferred embodiments of the present invention is for illustrative purposes, and many variations or modifications may become apparent, upon reading this disclosure, to those of ordinary skill in the art. In particular, while the strut assembly, the operator platform, the main foil assembly, the control subassembly and the propulsion subassembly have been described as separate units that are joined together, it is envisioned that any two or more of these subassemblies or

components, and even the entire craft, may be formed as an integral or unitary assembly. Such embodiments are regarded as being within the spirit and scope of the present invention. Those and other such variations and modifications are intended to fall within the spirit and scope of the present invention, and the scope of the invention is to be determined by reference to the appended claims.

What is claimed is:

1. A hull-less personal water craft comprising:

a main strut assembly having a forward end and a rearward end, said main strut assembly including a motor housing disposed at said forward end;

an operator platform positioned at said rearward end of said main strut assembly, said operator platform being so constructed and arranged to be capable of providing hydrodynamic lift in a fluid medium;

a motor provided in said motor housing;

a foil strut operatively coupled to said forward end of said main strut assembly and extending downwardly and rearwardly therefrom;

at least one foil operatively coupled to said foil strut;

a control column having a proximal end operatively coupled to said main strut assembly, and a distal end having an operator interface thereon; and

a propulsion system.

2. A hull-less personal water craft as recited in claim 1, wherein said foil strut is rotatable about a transverse horizontal axis relative to said main strut assembly.

3. A hull-less personal water craft as recited in claim 2 wherein said foil strut is coupled to said motor housing in a substantially fixed relation, and wherein said motor housing is rotatable about a horizontal axis relative to a remainder of said main strut assembly.

4. A hull-less personal water craft as recited in claim 2, wherein said control column is pivotably connected to said main strut assembly, and wherein said control column is operatively coupled to said foil strut in such a manner that a pivoting of said control column controls the rotation of said foil strut.

5. A hull-less personal water craft as recited in claim 4, wherein said at least one foil is pivotably connected to said foil strut, and said control column and said at least one foil are operatively coupled such that an attitude of said at least one foil is controlled by said control column.

6. A hull-less personal water craft as recited in claim 3, wherein said main strut assembly further comprises a forked strut having two arms extending forwardly to form a yoke around said motor enclosure, and wherein said motor enclosure is pivotably mounted to said two arms.

7. A hull-less personal water craft as recited in claim 3, wherein said main strut assembly further comprises a forked strut having a single arm extending forwardly to form a half-yoke at one side of said motor enclosure, and wherein said motor enclosure is pivotably mounted to said single arm.

8. A hull-less personal water craft as recited in claim 2, wherein said motor housing is maintained in a substantially fixed position relative to a remainder of said main strut

assembly, and wherein said foil strut is pivotably coupled to said motor housing, so as to be rotatable relative to said main strut assembly.

9. A hull-less personal water craft as recited in claim 8, wherein said control column is pivotably connected to said main strut assembly, and wherein said control column is operatively coupled to said foil strut in such a manner that a pivoting of said control column controls the rotation of said foil strut.

10. A hull-less personal water craft as recited in claim 9, wherein said at least one foil is pivotably connected to said foil strut, and said control column and said at least one foil are operatively coupled such that an attitude of said at least one foil is controlled by said control column.

11. A hull-less personal water craft as recited in claim 1, wherein said at least one foil is pivotably connected to said foil strut, and is operatively coupled to said control column such that an attitude of said at least one foil is controlled from said control column.

12. A hull-less personal water craft as recited in claim 2, wherein said operator platform is substantially saddle-shaped, and wherein said foil strut is sized such that, when pivoted upwardly toward said main strut assembly, said distal end of said foil strut rotates into a cavity formed at an underside of said operator platform.

13. A hull-less personal water craft as recited in claim 12, wherein said operator platform has a foil mounted across a rearward end of said cavity.

14. A hull-less personal water craft as recited in claim 12, wherein said operator platform has two integral chap extensions at a forward end of said operator platform.

15. A hull-less personal water craft as recited in claim 1, wherein said operator platform is substantially saddle-shaped and has two integral chap extensions at a forward end of said operator platform.

16. A hull-less personal water craft as recited in claim 1, wherein said propulsion system includes a propeller shaft contained within said foil strut, said propeller shaft being operatively coupled to said motor.

17. A hull-less personal water craft as recited in claim 16, wherein said propulsion system further comprises an open propeller operatively coupled to said propeller shaft, and disposed at said distal end of said foil strut.

18. A hull-less personal water craft as recited in claim 17, wherein said propulsion system comprises an enclosed propulsor operatively coupled to said propeller shaft, and disposed at said distal end of said foil strut.

19. A hull-less personal water craft as recited in claim 1, wherein said propulsion system comprises a duct for pumping water through said foil strut, and a nozzle positioned on the foil strut for discharging the water from the foil strut.

20. A hull-less personal water craft as recited in claim 2 further comprising a foil strut positioning device.

21. A hull-less personal water craft as recited in claim 20, wherein said foil strut positioning device comprises a link element pivotably coupled to said foil strut and operatively coupled to said main strut assembly in a manner permitting said link element to move forwardly and rearwardly along a portion of said main strut assembly.

22. A hull-less personal water craft as recited in claim 20, wherein said foil strut positioning device comprises a link element pivotably coupled to said main strut assembly and operatively coupled to said foil strut in a manner permitting said link element to move along a portion of said foil strut.

23. A hull-less personal water craft as recited in claim 20, wherein said foil strut positioning device comprises a hydraulic ram operatively coupled to said foil strut and to said main strut.

24. A hull-less personal water craft as recited in claim 3, further comprising a foil strut positioning device.

25. A hull-less personal water craft as recited in claim 24, wherein said foil strut positioning device comprises a brace attached at one end to said motor housing, and at the other end to said control column.

26. A hull-less personal water craft as recited in claim 25, wherein said brace slidingly engages a slot provided in said control column, whereby said control column may be moved within a predetermined range of movement without moving said motor housing, and wherein, upon said brace traveling to an end of said slot, said control column is operable to rotate said motor housing.

27. A hull-less personal water craft as recited in claim 24 wherein said foil strut positioning means comprises a plurality of gear teeth coupled to said motor housing, and means for engaging and moving said gear teeth.

28. A hull-less personal water craft as recited in claim 24, wherein said foil strut and said motor housing are biased to an initial retracted position, and said foil strut positioning means comprises a cable assembly connected to said motor housing, and being so constructed and arranged to overcome said initial bias to move said foil strut away from said retracted position.

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