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(54) **Title**: MARINE CRAFT FOR PERFORMING SURFACE OPERATIONS

(57) **Abstract**: A marine craft for surface level operation comprises a body, at least one propulsion drive coupled to the body and a controller carried by the body and configured to control operation of the at least one propulsion drive. The marine craft further comprises a wireless transceiver communicably coupled to the controller to facilitate wireless communication between the controller and a remote computing device and at least one coupler to removably couple the craft to a vessel, wherein the marine craft is configured for unmanned surface level operation to couple to the vessel and decouple from the vessel under control of the controller.

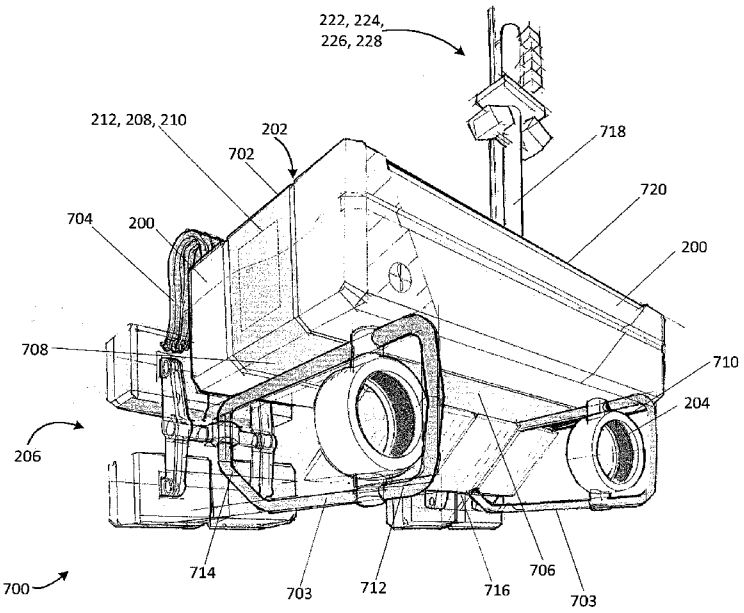

Figure 7

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MARINE CRAFT FOR PERFORMING SURFACE OPERATIONS

Technical Field

[0001] Described embodiments generally relate to marine craft, and in particular, marine craft for performing unmanned surface level operations. Some embodiments relate to marine craft for surface level operation that can be coupled to a vessel to provide greater manoeuvrability to the vessel or to assist in holding the vessel in a given location, while other embodiments relate to a method of controlling operations of the marine craft to perform surface operations.

Background

[0002] Large marine vessels often require assistance with manoeuvring in situations where their propulsion and steering systems do not provide sufficient manoeuvrability, for example when navigating harbours or channels, docking and undocking, or maintaining a position and orientation for loading or unloading. Other such large marine vessels which cannot move by themselves, such as barges and oil rigs, often require assistance for transportation or to maintain a position in open water. Such assistance is conventionally provided by tugboats.

[0003] It is desired to address or ameliorate one or more shortcomings or disadvantages associated with tugboats and such small marine craft for manoeuvring larger marine vessels, or to at least provide a useful alternative thereto.

[0004] Throughout this specification the word "comprise", or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated element, integer or step, or group of elements, integers or steps, but not the exclusion of any other element, integer or step, or group of elements, integers or steps.

[0005] Any discussion of documents, acts, materials, devices, articles or the like which has been included in the present specification is not to be taken as an admission that any or all of these matters form part of the prior art base or were common general knowledge in the field relevant to the present disclosure as it existed before the priority date of each claim of this application.

Summary

[0006] Described embodiments relate to a marine craft for surface level operation, comprising: a body; at least one propulsion drive coupled to the body; a controller carried by the body and configured to control operation of the at least one propulsion drive; a wireless transceiver communicably coupled to the controller to facilitate wireless communication between the controller and a remote computing device; and at least one coupler to removably couple the craft to a vessel; wherein the marine craft is configured for unmanned surface level operation to couple to the vessel and decouple from the vessel under control of the controller.

[0007] In some embodiments, the marine craft may be configured for unmanned surface level operation to couple to the vessel and decouple from the vessel under control of the remote computing device.

[0008] The at least one propulsion drive may comprise a plurality of propulsion drives. For example, the plurality of propulsion drives may comprise four propulsion drives. The at least one propulsion drive may comprise at least one azimuth thruster.

[0009] In some embodiments, the at least one coupler comprises at least one magnetic coupling mechanism. For example, the at least one magnetic coupling mechanism may comprise a plurality of rare earth magnets. The at least one coupler may comprise a decoupling mechanism to cause the at least one magnetic coupling to release from the vessel. The at least one decoupling mechanism may comprise a pneumatic retractor. In some embodiments, the at least one coupler may comprise at least one suction coupling mechanism. The at least one coupler comprises at least one movable arm to position the at least one coupling mechanism.

[0010] In some embodiments, the body may be free of deck structure to accommodate a passenger.

[0011] In some embodiments, the craft may comprise at least one electrical power source for powering the at least one propulsion drive.

[0012] In some embodiments, the craft may be of a size and weight to be carried by another vehicle. For example, the vehicle is a ship or an aircraft.

[0013] In some embodiments, the coupling mechanism may be capable of removably coupling the craft to a hull of a marine vessel.

[0014] In some embodiments, the controller may comprise a memory for storing operation instructions for the marine craft. The operation instructions may comprise at least one of propulsion drive operating instructions and coupling mechanism instructions.

[0015] In some embodiments, the memory may include a control module comprising program code which when executed by a processor of the controller may be configured to cause the controller to control operations of the at least one propulsion drive.

[0016] In some embodiments, the memory may include a control module comprising program code which when executed by a processor of the controller is configured to cause the controller to control operations of the at least one coupling mechanism.

[0017] In some embodiments, the controller may be configured to control operations of the at least one coupling mechanism based on data received from the remote computing device. For example, the data received from the remote computing device comprises at least one of operation instructions, vessel data and weather data.

[0018] In some embodiments, the craft may further comprise at least one sensor device, the controller being coupled to the at least one sensor device to receive sensor data from the at least one sensor device. The sensor data may comprise positioning information indicative of a position of the craft and/or the at least one coupler with respect to the vessel. For example, the sensor may comprise at least an orientation sensor, a motion sensor, a proximity sensor and a camera. In some embodiments, the sensor data may comprise one or more of water depth, wave and water movements, tidal range and flow, current flow as well as wind and temperature data. In some embodiments, the sensor data may comprise data on the topology of the sea bed.

[0019] In some embodiments, the controller may be configured to update operation instructions based on the sensor data. The controller may be configured to transmit sensor data to the remote computing device. The controller may be configured to receive updated operation instructions from the remote computing device based on the sensor data.

[0020] In some embodiments, the craft further may comprise a positioning system to determine a location of the craft with respect to the vessel, wherein the positioning system may be coupled to and provides location data to the controller.

[0021] The remote computing device may be at least one of a controller of another marine craft, a control tower server, a server carried by the vessel, and a handheld computing device.

[0022] Some embodiments relate to a system comprising: the marine craft as described above; and a remote computing device.

[0023] In some embodiments, the system may comprise a plurality of the marine craft, each of the marine craft in communication with and controlled by the remote computing device.

[0024] Some embodiments relate to a computer implemented method of controlling a marine craft to perform an unmanned surface level operation, the method operable by a controller of the marine craft, the method comprising: determining that a task is to be performed by the craft to assist a vessel including identifying a location of the vessel; determining operation instructions for the craft, wherein the operating instructions comprise operation instructions for at least one propulsion drive of the marine craft and for at least one coupling mechanism of the marine craft; activating the at least one propulsion drive to drive the marine craft towards the location of the vessel in accordance with the operation instructions; coupling the at least one coupler to the vessel in accordance with the operation instructions; performing the task; and decoupling the at least one coupling mechanism from the vessel in accordance with the operation instructions.

[0025] In some embodiments, determining that a task is to be performed may comprise receiving a request to assist the vessel from at least one remote computing device over a wireless communications network, wherein request may comprise location identifier for the vessel.

[0026] In some embodiments determining that a task is to be performed may comprise detecting by a sensor device coupled to the controller the vessel within a predefined zone.

[0027] In some embodiments, determining operation instructions may comprise receiving data from at least one remote computing device over a wireless communications network, wherein the operation instructions may be based on the data.

[0028] In some embodiments, determining operation instructions may comprise retrieving data from a memory of the controller.

[0029] In some embodiments, activating the at least one propulsion drive may comprise a processor of the controller executing program code associated with the operation instructions for the at least one propulsion drive to cause the controller to control a supply of power from a power source to the at least one propulsion drive.

[0030] In some embodiments, coupling the at least one coupler to the vessel may comprise a processor of the controller executing program code associated with the operation instructions for the at least one coupler to cause the controller to deploy the at least one coupler.

[0031] In some embodiments, coupling the at least one coupler to the vessel may comprise the controller executing program code associated with the operation instructions for the at least one coupler to cause the controller to activate the at least one coupler to couple to the vessel.

[0032] In some embodiments, decoupling the at least one coupler from the vessel may comprise the controller executing program code associated with the operation instructions for the at least one coupler to cause the controller to deactivate the at least one coupler to decouple the craft from the vessel.

[0033] The method may further comprise receiving data from the remote computing device over a wireless communications network and updating the operation instructions based on the received data.

[0034] The method may further comprise receiving from a sensor device provided on the marine craft sensor data comprising positioning information. For example, the positioning information may be indicative of a position of the craft and/or the at least one coupler with respect to the vessel.

[0035] The method may further comprise receiving from a sensor device provided on the marine craft sensor data comprising one or more of wave and water movements, tidal range and flow, current flow, wind data, temperature data and water depth. The method may further comprise receiving from a sensor device provided on the marine craft sensor data comprising data on the topology of the sea bed.

[0036] The method may further comprise updating the operation instructions based on the sensor data. In some embodiments, the method may further comprise transmitting the sensor data to the remote computing device and receiving from the remote computing device via the communications network updated operation instructions based on the sensor data.

[0037] In some embodiments, the method may further comprise cooperating with other marine craft of a group assigned to perform the task including receiving data from a controller of at least one other marine craft and updating the operation instructions based on the data.

[0038] In some embodiments, the method may further comprise cooperating with other marine craft of a group assigned to perform the task including transmitting sensor data to a controller of at least one other marine craft.

[0039] Some embodiments relate to a computer implemented method of controlling a marine craft to perform an unmanned surface level operation, the method operable by a computing device remote from the marine craft, the method comprising: transmitting a request over a wireless communications network to a controller of at least one marine craft to perform a task, the request including an identification of a vessel associated with the task; determining operating instructions for the at least one marine craft; transmitting operating instructions to

the controller of the at least one marine craft to cause the marine craft to perform the task; and monitoring operations of the at least one marine craft until the task is completed.

[0040] In some embodiments, the method further comprises receiving a request for assistance from a server of the vessel over the wireless communications network.

[0041] In some embodiments, determining operating instructions may comprise determining operating instructions for at least one of the at least one propulsion drive and the at least one coupler.

[0042] The method may further comprise assigning at least two marine craft to perform the task as a group.

[0043] In some embodiments, determining operating instructions may comprise determining a formation for the group of the marine craft and configuring operation instructions specific to each of the marine craft to achieve the formation when coupling to the vessel.

[0044] In some embodiments, monitoring operations of the at least one marine craft may comprise receiving an indication from at least one of the controller of the at least one marine craft and a server of the vessel that the task has been completed.

[0045] The method may further comprise receiving data from the at least one of the controller of the at least one marine craft and a server of the vessel.

[0046] In some embodiments, the method may further comprise updating the operation instructions based on the received data and transmitting the updated operation instructions to at least one of the at least one marine craft.

[0047] In some embodiments, the method may further comprise transmitting instructions to the controller of the at least one marine craft to cause the marine craft to depart from the vessel.

[0048] Some embodiments relate to a computer program product comprising a computer readable medium encoded with computer executable instructions, which when executed in a

computer system, is effective to cause the computer system to carry out the method described above.

[0049] In some embodiments, the computer readable medium may be a non-transitory computer readable medium.

[0050] Some embodiments relate to a system configured to perform the method described above.

Brief Description of Drawings

[0051] Embodiments are described in further detail by way of reference to the accompanying drawings, in which:

[0052] Figure 1 is a schematic illustration of a harbour showing a plurality of marine craft for surface level operations according to some embodiments;

[0053] Figure 2 is a block diagram of the marine craft of Figure 1;

[0054] Figure 3 is a block diagram of a communications system comprising a controller of the marine craft of Figure 1, a marine vessel server and a control tower server according to some embodiments;

[0055] Figure 4A is a perspective view of a marine craft in an operating state according to some embodiments;

[0056] Figure 4B is a front elevation view of the marine craft of Figure 4A;

[0057] Figure 4C is a side elevation view of the marine craft of Figure 4A;

[0058] Figure 5A is a perspective view of the marine craft of Figure 4A in a retracted state;

[0059] Figure 5B is front elevation view of the marine craft of Figure 5A;

[0060] Figure 6A is a plan view of the marine craft of Figure 4A in an operating state according to some embodiments;

[0061] Figure 6B is a plan view of the marine craft of Figure 4A in an operating state according to some embodiments;

[0062] Figure 6C is a plan view of the marine craft of Figure 4A in a retracted state;

[0063] Figure 7 is a perspective view of a marine craft according to some embodiments;

[0064] Figure 8A is a plan view of a marine craft according to some embodiments;

[0065] Figure 8B is a side elevation view of section A-A of the marine craft of Figure 8A;

[0066] Figure 9A is a cross-sectional view of a coupler of a marine craft according to some embodiments;

[0067] Figure 9B is a cross-sectional view of the coupler of the marine craft of Figure 9A in an alternative configuration;

[0068] Figure 10A is a cross-sectional view of a propulsion device of a marine craft according to some embodiments;

[0069] Figure 10B is a cross-sectional view of the propulsion device of the marine craft of Figure 10B in an alternative configuration;

[0070] Figure 11A is cross-sectional view of an attachment member of a marine craft according to some embodiments;

[0071] Figure 11B is cross-sectional view of an attachment member of a marine craft according to some embodiments;

[0072] Figure 12A is cross-sectional view of an attachment member of a marine craft according to some embodiments;

[0073] Figure 12B is cross-sectional view of the attachment member of Figure 12A in one configuration;

[0074] Figure 13A is cross-sectional view of an attachment member of a marine craft according to some embodiments;

[0075] Figure 13B is cross-sectional view of the attachment member of Figure 13A in one configuration;

[0076] Figure 14 is a flow diagram depicting a method of operating a marine craft according to some embodiments; and

[0077] Figure 15 is a flow diagram depicting a method of operating marine craft according to some embodiments.

Detailed Description

[0078] Described embodiments generally relate to marine craft, and in particular, marine craft for performing unmanned surface level operations. Some embodiments relate to unmanned marine craft for surface level operations that can be coupled to a vessel to provide greater manoeuvrability to the vessel or to assist in holding the vessel in a given location,

while other embodiments relate to a method of controlling operations of the marine craft to perform surface operations.

[0079] Some embodiments relate to marine craft configured to operate automatically. For example, the marine craft may be configured to operate by executing operating instructions independent of human intervention or input. Some embodiments relate to remotely controlled marine craft. For example, the marine craft may be configured to operate in response to instructions received from a remote computing device. In some embodiments, the remote computing device may be configured to receive user input. Some embodiments relate to marine craft configured to operate autonomously. For example, the marine craft may be configured to operate in accordance with a pre-programmed set of operating instructions. Some embodiments relate to marine craft configured to operate semi-autonomously. For example, the marine craft may be configured to operate in accordance with a pre-programmed set of operating instructions and also in response to instructions received from a remote computing device.

[0080] In some embodiments, a group of such marine craft may be arranged to operate cooperatively as a fleet or swarm. For example, marine craft may be configured to cooperate with at least some of other marine craft of a group or fleet. Alternatively, the marine craft may be configured to act independently of other marine craft in a group or fleet. The marine craft may be configured to cooperate with one or more manned or unmanned vessels such as conventional tugboats, for example, or other equipment.

[0081] Figure 1 is a schematic illustration of a harbour 100 including a control tower 102 provided at a port 104 of the harbour 100 for monitoring and controlling navigation of vessels 106 within or in a vicinity of the harbour 100.

[0082] A plurality of marine craft 108 for performing surface level operations may be deployed within the harbour 100. The marine craft 108 may be operable to assist the vessel 106, for example to guide the vessel 106, such as a relatively large marine vessel or a barge, through the harbour 100, or to assist in holding the vessel at a given location. For example, when a vessel 106 requires assistance, at least some of the marine craft 108 may be controlled remotely from the control tower 102 and/or from the vessel 106 to travel to the vessel 106, to

couple to a hull of the vessel 106 and to guide the vessel 106 through the harbour 100 and/or to assist in holding the vessel at a location. In some embodiments, the marine craft 108 may be configured to operate autonomously or semi-autonomously to couple to a hull of the vessel 106 and to guide the vessel 106 through the harbour 100. The marine craft 108 may be controlled or configured to be positioned around the vessel 106 in a configuration or formation suitable for controlling the attitude/orientation and position of the vessel 106.

[0083] In some embodiments, when not in use, the marine craft 108 may be located or parked at or about a parking station 110, such as a floating pontoon or jetty provided in or close to the harbour 100. For example, the marine craft 108 may be associated with or may park at any one of a plurality of parking station 110 deployed in or near the harbour 100. In some embodiments, the marine craft 108 may assume a sleep state when parked at the parking station 110 to conserve power consumption. In some embodiments, the marine craft 108 may be recharged or refuelled while at the parking station 110.

[0084] In other embodiments, the marine craft 108 may be employed to assist other marine objects or floating marine objects, such as barges and oil rigs, to manoeuvre the marine objects to a location or to hold or maintain the marine objects at given location. For example, the vessel 106 may comprise offshore plants, refineries, ships, barges, oil rigs, floating plant, floating cranes, floating processing units, cruise liners, ferries, research vessels, and/ or research equipment. The marine craft 108 may also be carried on board a vessel, air craft or other vehicle to be deployed from the vessel, aircraft or other vehicle. For example, the marine craft 108 may be transported by aircraft to a vessel in distress to provide assistance.

[0085] Referring to Figure 2, there is illustrated a block diagram of a marine craft 108 according to some embodiments. The marine craft 108 may comprise a floatation mechanism 200, such as one or more buoyancy tanks or other closed or open vessels, to provide positive buoyancy enabling the marine craft 108 to float at or near the surface of a body of water. The floatation mechanism 200 may be sufficiently buoyant to counteract the total weight of the marine craft 108 and maintain it at or near the surface of a body of water. In some embodiments, the marine craft 108 may be semi-submerged. For example, for a marine craft 108 having a total height of 3000mm, approximately 300mm or about 10% of the marine craft

108 may remain above the water in use. In some embodiments, the floatation mechanism 200 may be configured to selectively adjust the percentage of the marine craft 108 that remains submerged in use. For example, the floatation mechanism 200 may be configured to cause the marine craft 108 to be semi-submerged in use, such that waves may pass over the marine craft 108 and any interference to the movement of the marine craft 108 as a result of the force of waves may be mitigated.

[0086] In some embodiments, the marine craft 108 may comprise a chassis or frame structure 202 to which the floatation mechanism 200 may be coupled. In other embodiments, the floatation mechanism 200 may form a chassis or frame structure of the marine craft 108.

[0087] The marine craft 108 may comprise one or more propulsion drives or devices 204, such as thrusters, to allow the marine craft 108 to move through the water. The one or more propulsion devices 204 may be connected to the floatation mechanism 200 and/or the chassis 202. In some embodiments, the propulsion devices 204 may be rotated to generate thrust in any selected direction, or a range of rotation of the propulsion devices 204 may be restricted. For example, the range of rotation may be limited to a substantially horizontal plane during operation of the marine craft 108 such that the propulsion devices 204 act as azimuth thrusters. Alternatively, the propulsion devices may be fixedly connected or mounted to the marine craft 108. The propulsion devices 204 may have a thrust sufficient to contribute significantly to guide a vessel 106 to which the marine craft 108 attaches. For example, the magnitude of thrust of the propulsion devices 204 may be determined based on a number of marine craft 108 to be used for a particular vessel 106 and the thrust required to manoeuvre the vessel 106. The propulsion devices 204 may be operated independently of one another, may be operated independently as groups of two of more or may be operated collectively or in unison.

[0088] The marine craft 108 may comprise one or more couplers 206, such as attachment members or pads, to couple the marine craft 108 to a vessel 106, such as a hull of the vessel 106, so that the vessel 106 may be manoeuvred or held at a location or in position by the marine craft 108 when the propulsion devices 204 are activated. The coupler(s) 206, when coupled to the vessel 106, may provide a coupling or attachment force of sufficient strength to withstand expected differential forces between the marine craft 108 and the vessel 106 during

operations.

[0089] In some embodiments, the coupler(s) 206 may be mechanically coupled to the propulsion device(s) 204 to allow a transfer force from the propulsion device(s) 204 to the coupler(s) 206. For example, the coupler(s) 206 and propulsion device(s) 204 may be mechanically coupled together via the chassis 202, or alternatively may be joined directly and independently of the chassis 202. In some embodiments, the coupler(s) 206 may be rigidly coupled to the propulsion device(s) 204.

[0090] The marine craft 108 may include a power source 208 for supplying power to the propulsion devices 204 to drive or propel the marine craft 108. The power source 208 may be coupled to floatation mechanism 200 or the chassis 202. For example, the power source 208 may comprise an energy storage device 210, such as a rechargeable battery, fuel cell or fuel tank. In some embodiments, the power source 208 may comprise an internal combustion engine, solar or wind energy harvester, or other energy generation means.

[0091] The marine craft 108 may comprise a controller 212 for controlling operations of the marine craft 108. The controller 212 may include one or a plurality of processors 214 which may operate together (referred to for convenience as "processor 214") and a memory 216. The memory 216 may comprise a combination of volatile and non-volatile computer readable storage and may have sufficient capacity to store program code executable by processor 214 in order to perform appropriate processing functions as described herein. In some embodiments, the memory 216 may include a control module 218 comprising program code, which when executed by the processor 214, may be arranged to cause the controller 212 to control operations of the marine craft 108. For example, the control module 218 may comprise program code, which when executed by the processor 214, may be arranged to cause the controller 212 to control operations of the propulsion devices 204 and/or to control operations of the couplers 206, including the coupling and decoupling of the couplers 206 to the vessel 106. In some embodiments, the control module 218 may comprise program code, which when executed by the processor 214, may be arranged to cause the controller 212 to send and receive wireless transmissions via a communications system 222 coupled to the controller 212.

[0092] The controller 212 may be connected to and powered by the power source 208. Alternatively, or in addition, the controller 212 may include a separate power source independent of the power source 208. For example, the controller 212 may include a battery 220, such as a long-life or lithium battery or a replaceable battery. In some embodiments, the energy storage device 210 may include a sensor 221 to monitor fuel or energy stored in the energy storage device 210, and to transmit a signal, wirelessly or via a direct connection, to the controller 212, indicative of the level of fuel or energy available. The sensor 221 may be powered by the battery 220 and/or the power source 208.

[0093] The marine craft 108 may comprise a communications system 222 coupled to the controller 212 to enable the controller 212 to communicate with remote computing devices across a wireless communications network 300, as illustrated in Figure 3. The communications system 222 may comprise a transceiver, a transponder, such as a short or long range radio transponder, and/or other wireless communication devices. In some embodiments, the communications system may comprise one or more antennae 224 to enhance the reception and transmission of signals. The communications system 222 may comprise additional components and/or circuitry (not shown) as judged by a person of ordinary skill in the art to be necessary or desirable in order to carry out the functions described herein.

[0094] In some embodiments, the marine craft 108 may comprise a positioning system 226 to determine the location of the marine craft 108 with respect to other fixed or moving objects and provide location data to the controller 212. For example, the positioning system 226 may make use of electronic or inertial navigation techniques to determine the location of the marine craft 108, and may for example, comprise one or more: compasses; mechanical, electrical or optical gyroscopes; momentum wheels; accelerometers; radio transponders; or GPS transponders or other satellite based positioning systems (GNSS) such as GLONASS, Galileo and SBAS. In some embodiments, the location or position of the marine craft 108 may be compared with or plotted on a map (not shown) stored in the marine craft memory 216 and/or control tower memory 310. The map may include information about the environment in which the marine craft 108 is configured to operate, for example, such as known obstacles, permanent or temporary structures, sea levels, etc. The marine craft 108 may be configured to automatically avoid obstacles and/or stay within designated zones based on a comparison of

the location or position of the marine craft 108 with the map.

[0095] In some embodiments, the positioning system 226 may be arranged to implement real time kinematic satellite navigation or carrier-phase enhancement to improve the accuracy and precision of the location information. For example, the positioning system 226 may analyse the phase of the carrier wave of the transponder signal and compare it with that of a transponder at a fixed location to make relative position measurements. In some embodiments, the positioning system 226 may be arranged to implement time corrections based on the known location of the fixed transponder to further enhance the precision and accuracy of the location data. For example, the positioning system 226 may comprise a high performance GPS receiver platform such as the "piksi" GPS receiver made by "Swift Navigation".

[0096] In some embodiments, instead of or in addition to an independent position system 226, the memory 216 may comprise code, which when executed by the processor 214 may cause the controller 212 to implement navigation techniques, such as dead reckoning or inertial navigation. For example, the controller 212 may employ initial location data of the marine craft 108, i.e., the known location from where the marine craft set off, and may be configured to update a current location of the marine craft 108 based on measurements of the movements of the marine craft 108 at various time intervals.

[0097] In some embodiments, the controller 212 may be configured to employ the communications system 222 to receive and compare signals sent to and from a network of fixed transponders (not shown) in a vicinity of the marine craft 108 to triangulate the position of the marine craft 108. For example, an object detection system (not shown) may be provided at a fixed location in the vicinity of the harbour 100, which may be configured to detect the position of the marine craft 108 in relation to its own location and transmit that position data to the controller 212 of the marine craft 108.

[0098] The marine craft 108 may comprise a sensor 228, such as a proximity sensor, to detect an object in a vicinity of the marine craft 108. For example, the sensor 228 may be configured to detect a relative location of an object to the marine craft 108. In some embodiments, the sensor 228 may comprise lights, cameras, lidar, radar, a laser scanner, sonar and ultrasonic detection/imaging systems or another object detection or imaging systems. In

some embodiments, the sensor 228 may be arranged to provide real time data to the controller 212. In some embodiments, the sensor 228 may be arranged to provide data to the controller 212 such as one or more of water depth, wave and water movements, tidal range and flow, current flow as well as wind and temperature data. In some embodiments, the sensor 228 may be arranged to provide data to the controller 212 on the topology of the sea bed, which can change depending on a variety of factors including weather conditions and any dredging or silting of the sea bed.

[0099] In some embodiments, the control module 218 may comprise program code, which when executed by the processor 214, may be arranged to cause the controller 212 to control the sensor 228 and to receive and process data determined by the sensor 228. For example, data determined by the sensor 228 and provided to the controller 212 may be employed to determine control operations of the propulsion devices 204 and/or to determine control operations and/or positioning of the couplers 206.

[0100] In some embodiments, the sensor 228 may contribute data to the positioning system 226, for example, by detecting various objects and/or landmarks which may be compared against stored data giving the location of landmarks on a map to determine a location or relative position of the marine craft 108, or to determine a location or relative position of the marine craft 108 relative to a moving object such as a vessel 106. The sensor 228 may contribute information for determining the location, orientation, velocity and/or acceleration of the marine craft 108 and/or other stationary or moving objects or vessels 106.

[0101] Referring to Figure 3, there is illustrated a plurality marine craft 108 each including a controller 212 arranged to communicate across a wireless communications network 300 with controllers 212 of other marine craft 108, a control tower server 302 of the control tower 102 and/or a vessel server 304 of the vessel 106. The wireless communications network 300 may comprise a local area network, a wireless data network, the Internet or combinations of such networks.

[0102] The control tower server 302 and the vessel server 304 may each be a single physical server or multiple physical servers arranged to operate as a distributed system. In some embodiments, the control tower server 302 and/or the vessel server 304 may be virtual

servers having distributed functions. For example, the control tower server 302 and/or the vessel server 304 may comprise a set of virtualised servers configured to adapt dynamically to demand and may be effectively provided as on-demand computing services.

[0103] The control tower 102 may comprise a communications system 306, for example, a communications system similar to communications system 222, to enable the control tower server 302 to communicate with the marine craft 108 and vessel 106 across the communications network 300.

[0104] The control tower server 302 may comprise one or a plurality of processors 308 which may operate together (referred to for convenience as "processor 308") connected to a memory 310. The memory 310 may be a non-transitory computer readable medium, such as a hard drive, a solid state disk or CD-ROM. Software, that is executable instructions or program code, such as program code grouped into code modules, may be stored on the memory 310, and may, when executed by the processor 308, cause the control tower server 302 to perform functions such as communicating with the marine craft 108 and vessel 106 over the communications network 300. In some embodiments, the memory 310 may include software, which when executed by the processor 308, cause the control tower server 302 to remotely control operations of the marine craft 108.

[0105] In some embodiments, the control tower 102 may comprise a user interface 312 to enable the control tower server 302 to receive information from a user and/or display information. In other embodiments, the may be isolated from direct user interaction. In some embodiments the control tower server 302 may comprise a portable or handheld device.

[0106] The vessel 106 may comprise a communications system 314, for example, a communications system similar to communications system 222 or 306, to enable the vessel server 304 to communicate with the marine craft 108 and control tower server 302 across the communications network 300.

[0107] The vessel server 304 may comprise one or a plurality of processors 316 which may operate together (referred to for convenience as "processor 316") connected to a memory 318. The memory 318 may be a non-transitory computer readable medium, such as a hard

drive, a solid state disk or CD-ROM. Software, that is executable instructions or program code, such as program code grouped into code modules, may be stored on the memory 318, and may, when executed by the processor 308, cause the vessel server 304 to perform functions such as communicating with the marine craft 108 and control tower 102 over the communications network 300. In some embodiments, the memory 318 may include software, which when executed by the processor 316, cause the vessel server 304 to remotely control operations of the marine craft 108.

[0108] In some embodiments, the vessel 106 may include a user interface 320 to enable the vessel server 304 to receive information from a user and/or to display information. In other embodiments, the vessel server 304 may be isolated from direct user interaction. In some embodiments the vessel server 304 may comprise a portable or handheld device.

[0109] Referring now to Figures 4A, 4B and 4C, there is illustrated a marine craft 400, according to some embodiments. The marine craft 400 may comprise similar components and elements to marine craft 108 described in connection with Figures 1 to 3, and where indicated in Figures 4A, 4B and 4C, those similar components and elements are denoted like numerals.

[0110] The chassis 202 of marine craft 400 may be of a generally elongate form, having a body portion 402 and first and second end portions 404, 406. The first and second end portions 404, 406 may be tapered with respect to the body portion 402 and extend from respective ends of the body portion 402. The chassis 202 may comprise one or more coupling points (not shown) to allow the marine craft 108 to be coupled to one or more cables and lifted by a crane or aircraft.

[0111] The chassis 202 may include a floatation mechanism (not shown) such as one or more buoyancy tanks, or other closed or open vessels, to provide positive buoyancy enabling the marine craft 400 to float at or near the surface of a body of water. In some embodiments, the chassis 202 and/or floatation mechanism may be hydrodynamically shaped for efficient movement through water.

[0112] The marine craft 400 may comprise at least one propulsion device or drive 204, such as a thruster, to allow the marine craft 400 to move through the water. For example, the

propulsion device(s) 204 may comprise "Voith Inline Thrusters/Propulsors" or any other suitable thrusters, such as jet thrusters, tunnel thrusters, rim-driven thrusters or conventional propellers. The propulsion device(s) 204 may comprise an electric drive unit integral with a thruster duct allowing any connecting structures connecting the thrusters to the marine craft 108 to be positioned away from the flow entrance and flow exit of the thrusters, thereby avoiding flow interference. Thrusters such as the "Voith Inline Thrusters/Propulsors" may not require drive shafts, gearboxes or external drive units and may be more easily repositioned relative to the marine craft 108.

[0113] In some embodiments, the propulsion device(s) 204 may be connected or mounted to a first side 408 of the chassis 402, for example, a longitudinal side of an elongate chassis 402. For example, at least one propulsion device 204 may be connected to the first side 408 towards the first end portion 404 and at least one propulsion device 204 may be connected to the first side 408 towards the second end portion 406. In another embodiment, as depicted in Figures 4A, 4B and 4C, a first pair of propulsion devices 204 may be disposed toward the first end portion 404 of the first side 408 and a second pair of propulsion devices 204 may be disposed toward the second end portion 406 of the first side 408. For example, each of the pairs of propulsion devices 204 may be configured such that the propulsion devices 204 are aligned in register with one another and/or arranged in a stacked configuration.

[0114] The marine craft 400 may comprise at least one arm member 410 to connect or mount the propulsion device(s) 204 to the chassis 202. In some embodiments, the arm member(s) 410 is pivotally mounted to the marine craft 400 and/or the propulsion device(s) 204. For example, the propulsion device(s) 204 may be rotatable about a pivot mount to enable the propulsion device(s) 204 to be extended outward from and retracted inward toward the marine craft 400. For example, the propulsion device(s) 204 may be azimuthally connected to the marine craft 400 such that they operate as azimuth thrusters. In some embodiments, during operation, the arm member(s) 410 and/or the propulsion device(s) 204 may be rotatable about the vertical and horizontal axes relative to the marine craft 108 to selectively position the propulsion device(s) 204 to mitigate flow interference between the propulsion device(s) 410, the marine craft 108, and/or the vessel 106.

[0115] The marine craft 400 may transition between an operating or deployed state, as depicted in Figures 4A, 4B and 4C, and a retracted state, as depicted in Figures 5A and 5B. For example, the marine craft 400 may assume the operating or deployed state when assisting a vessel 106 and the marine craft 400 may assume the retracted state when the marine craft 400 is travelling to and from a vessel 106 or is at the parking station 110.

[0116] When the marine craft 400 assumes the operating state, the arm member(s) 410 may extend outwardly from the chassis 202 to position the propulsion device(s) 204 away from the chassis 202 of the marine craft 400, as depicted in Figures 4A, 4B and 4C. When the marine craft 400 transitions to the retracted state, the arm member(s) 410 may be retracted towards the chassis 202 to position the propulsion device(s) 204 at or in close proximity to the chassis 202 of the marine craft 400, as depicted in Figures 5A and 5B. For example, the arm member(s) 410 and the propulsion device(s) 204 may be rotated with respect to the chassis 202 to retract the arm member(s) 410 and the propulsion device(s) 204 towards the chassis 202. In some embodiments, when the marine craft 400 assumes the retracted state, the arm member(s) 410 may extend in a direction substantially parallel to the longitudinal axis of the marine craft 400. In some embodiments, the arm member(s) 410 may be configured in use to position one or more propulsion devices 204 at a lower depth or deeper level than the chassis 202, relative to the surface of the water during operation, in order to mitigate flow interference.

[0117] As discussed in connection with Figure 2, the propulsion device(s) 204 of the marine craft 400 may be powered by the power source 208 and may be configured to operate in accordance with instructions received from the controller 212. In some embodiments, each of the propulsion device(s) 204 may be controlled and driven by the controller 212 independently of each other and/or may be paired together and controlled and driven by the controller as a single unit, as will be discussed below in more detail with reference to Figure 6.

[0118] As discussed with reference to Figure 2, the marine craft 400 may comprise at least one coupler 206, to couple the marine craft 400 to a vessel 106 and allow the marine craft 400 to remain coupled or attached to the vessel 106 during operations as required. In some embodiments, the coupler(s) 206 may comprise at least one attachment member or attachment

pad 416. For example, and as depicted in Figures 4A, 4B, and 4C, each coupler 206 may comprise four attachment members 416 arranged in a symmetric configuration.

[0119] In some embodiments, the coupler(s) 206 may be connected to a second side 412 of the chassis 402, opposite to the first side 408. For example, at least one coupler 206 may be connected to the second side 412 of the chassis 202 towards the first end portion 404 and at least one coupler 206 may be connected to the second side 412 towards the second end portion 406. In another embodiment, as depicted in Figures 4A, 4B and 4C, at least one coupler 206, or, for example, a pair of couplers 206, may be connected to the first end portion 404 of the chassis 202 and at least one coupler 206, or, for example, a pair of couplers 206, may be connected the second end portion 406 of the chassis 202. In some embodiments, the pair of couplers 206 may be configured such that each of the pair of couplers 204 is aligned in register with one another and/or arranged in a stacked configuration.

[0120] The marine craft 400 may comprise at least one coupler arm member 414 to connect or mount the coupler(s) 206 to the chassis 202. In some embodiments, the arm member(s) 414 may be adjustably mounted to the marine craft 400 and/or to the coupler(s) 206 to enable adjustment of a position of the coupler(s) 206 with respect to the chassis 202 and allow for selective adjustment and positioning of the coupler(s) 206 to a surface of the vessel 106, independent of the movement of the marine craft 400. In some embodiments, the coupler arm member(s) 414 may comprise an electronic, pneumatic and/or hydraulic actuator. During operation, the coupler arm member(s) 414 may be rotatable about the vertical and horizontal axes relative to the marine craft 108 to allow repositioning of the coupler(s) 206 in order to accommodate different vessel hull shapes.

[0121] As discussed above, the marine craft 400 may transition between an operating state, as depicted in Figures 4A, 4B and 4C, and a retracted state, as depicted in Figures 5A and 5B. When the marine craft 400 assumes the operating state, the coupler arm member(s) 414 may extend outwardly from the second side 412 of the chassis 202 to position the coupler(s) 206 away from the chassis 202 of the marine craft 400, as depicted in Figures 4A, 4B and 4C. When the marine craft 400 transitions to the retracted state, and the coupler arm member(s) 414 may be retracted towards the chassis 202 position the coupler(s) 206 at or in

close proximity to the chassis 202 of the marine craft 400, as depicted in Figures 5A and 5B. In some embodiments, when the marine craft 400 assumes the retracted state, the coupler arm member(s) 414 may be retracted towards the ends 404, 406 of the chassis 202 such that an outward facing surface of the coupler 206 is substantially flush with a surface of the second side 412 of the chassis 202 of the marine craft 400.

[0122] As discussed above, the processor 214 may be arranged to execute program code to cause the controller 212 to control the operations of the marine craft 400 and to transition the marine craft 400 between the operating state and the retracted state by controlling operations of the propulsion devices 204 and/or the couplers 206, including the coupling and decoupling of the couplers 206 to a hull of the vessel 106. Figures 6A and 6B depict plan views of the marine craft 400 configured in the operating state. Figure 6C depicts a plan view of the marine craft 400 configured in the retracted state which may provide for improved or streamlined motion through water.

[0123] As illustrated in Figure 6A, the processor 214 may be arranged to execute program code to cause the controller 212 to cause the arm member(s) 414 to extend from the chassis 202, thereby positioning the couplers 206 for coupling to or attaching to the vessel 106. The processor 214 may be arranged to execute program code to cause the controller 212 to cause the arm member(s) 410 of the propulsion device(s) 204 to extend outwardly from the chassis 202 at an angle to the first side 408 to position the propulsion device(s) 204 away from the chassis 202 of the marine craft 400. In one embodiment, the arm member(s) 410 of the propulsion device(s) 204 disposed toward the first end portion 404 and the arm member(s) 410 of the propulsion device(s) 204 disposed toward the second end portion 406 are caused to extend away from each other, outwardly at an obtuse angle to the first side 408.

[0124] The processor 214 may be arranged to execute program code to cause the controller to cause power to be supplied to the propulsion device(s) 204 from the power source 208 to cause the propulsion device(s) 204 to generate a manoeuvring force in a direction substantially perpendicular to a longitudinal axis of a hull of the vessel 106 to allow the marine craft 400 to move towards the vessel 106 and enable the couplers 206 to couple or attach to the vessel 106, for example, to a hull of the vessel 106.

[0125] In some embodiments, the processor 214 may be arranged to execute program code to cause the controller to control and drive at least one of the propulsion device(s) 204 independently of other propulsion device(s) 204 and/or to control and drive pairs or groups of propulsion device(s) 204 together as a single unit.

[0126] As illustrated in Figure 6B, the processor 214 may be arranged to execute program code to cause the controller 212 to cause the arm member(s) 410 of the propulsion device(s) 204 disposed towards one of the first end portion 404 or second end portion 406 to retract towards the chassis 202 to position the propulsion device(s) 204 at or in close proximity to the chassis 202 of the marine craft 400. The processor 214 may be arranged to execute program code to cause the controller to cause power to be supplied to the propulsion device(s) 204 from the power source 208 to cause the propulsion device(s) 204 to generate a manoeuvring force in a direction substantially parallel to the longitudinal axis of the hull of the vessel 106 to allow the marine craft 400 to move the vessel 106.

[0127] As illustrated in Figure 6C, the processor 214 may be arranged to execute program code to cause the controller 212 to cause the coupler arm member(s) 414 to be retracted towards the chassis 202 to position the coupler(s) 206 at or in close proximity to the chassis 202 of the marine craft 400. The processor 214 may be arranged to execute program code to cause the controller 212 to cause the arm member(s) 410 of the propulsion device(s) to retract towards the chassis 202 to position the propulsion device(s) 204 at or in close proximity to the chassis 202 of the marine craft 400. The processor 214 may be arranged to execute program code to cause the controller 212 to cause the power to be supplied to the propulsion device(s) 204 from the power source 208 to cause the propulsion device(s) 204 to generate a manoeuvring force in a direction of intended movement.

[0128] Referring now to Figure 7, there is depicted a perspective view of a marine craft 700 according to some embodiments. The marine craft 700 may comprise similar components and elements to marine craft 108 described in connection with Figures 1 to 3, and/or marine craft 400 described in connection with Figures 4 to 6C, and where indicated in Figure 7, those similar components and elements are denoted like numerals.

[0129] As illustrated, in some embodiments, the marine craft 700 may comprise a chassis

202 having a substantially rectangular shaped body portion 702 and first and second floatation mechanisms 200 disposed alongside or mounted to first and second longitudinal sides (not shown), respectively, of the body portion 702. The body portion 702 may be arranged to house components of the marine craft, such as the controller 212, the power source 208 and energy store 210.

[0130] At least one propulsion device 204 and at least one coupler 206 may be coupled to the chassis 202. In some embodiments, the coupler(s) 206 may be connected to the controller 212 and/or the power source 208 by an electrical connector 704.

[0131] In some embodiments, at least one bracket 703 may be connected to and extend from a major surface 706 of the chassis 202. The propulsion device(s) 204 and the coupler(s) 206 may be coupled to the bracket(s) 703. In some embodiments, a first bracket 703 may be connected toward a first end 708 of the major surface 706 of the chassis 202 and a second bracket 703 may be connected toward a second end 710 of the major surface 706 of the chassis 202.

[0132] In some embodiments, the bracket(s) 703 may extend substantially along the width of the chassis 202. The propulsion device(s) 204 may be coupled to the bracket 703 toward a first end 712 of the bracket 703 and the coupler(s) 206 may be coupled to the bracket 703 toward a second end 714 of the bracket 703. In some embodiments, the propulsion device(s) 204 may be pivotally mounted to the bracket(s) 703 and may be capable of being rotated about an axis perpendicular to the longitudinal axis of the body portion 702.

[0133] In some embodiments, a flow diverter 716 may be mounted to and extend along a length of the major surface 706 of the chassis. For example, flow diverter 716 may extend outwardly from the major surface 706 and between the propulsion device(s) 204 and the coupler(s) 206 to mitigate flow interference from the propulsion device(s) 204.

[0134] In some embodiments, the marine craft 700 may comprise a mast 718 extending from a major surface 720, opposite or reverse to major surface 706, of the chassis 202. A communication system 222, antenna 224, positioning system 226, sensor 228, such as an orientation sensor, motion sensor, proximity sensor, and/or a camera (not shown) may be

mounted to, accommodated or housed by the mast 718 and electrically connected to the controller 212.

[0135] Referring now to Figures 8A and 8B, a marine craft 800 is illustrated according to some embodiments. The marine craft 800 may comprise similar components and elements to marine craft 108 described in connection with Figures 1 to 3, and/or marine craft 400 described in connection with Figures 4 to 6C, and/or marine craft 700 described in connection with Figures 7 and where indicated in Figures 8A and 8B, those similar components and elements are denoted like numerals.

[0136] Figure 8A is a top view of the marine craft 800 and Figure 8B is a side elevation of section A-A. The marine craft 800 comprises a substantially elongate body portion 802 substantially symmetrical about a longitudinal axis which may allow for efficient manoeuvring through the water.

[0137] The body portion 802 may include a floatation mechanism 200. In some embodiments, the floatation mechanism 200 may be integrally formed with or comprise the body portion 802. The marine craft 800 may comprise one or more propulsion devices 204, such as thrusters. In some embodiments, marine craft 800 may include at least one propulsion devices 204 disposed at or near opposing ends of the marine craft 800.

[0138] The marine craft 800 may include a power source 208, energy/fuel supply 210 and controller 212. In some embodiments, the power source 208, energy/fuel supply 210 and/or controller 212 may be located toward a centre of the marine craft 800, for example, towards a base of the marine craft 800 and may act as stabilising ballast and mitigate rolling moments. In some embodiments, the power source 208, energy/fuel supply 210 and/or controller 212 may be housed within a housing (not shown). A mast 718 may extend from the body portion 802 and maybe arranged to receive or support components such as a communication system 222, antenna 224, positioning system 226, sensor 228, such as an orientation sensor, motion sensor, proximity sensor, and/or a camera (not shown). Such components may be electrically connected to the controller 212 and/or the power source 208.

[0139] An elongate aperture or slot 804 may be provided or disposed in the body portion

802 and may be arranged to receive a coupler arm member 414. The coupler arm member 414 may be rotatably connected or recessed within the slot 804 to enable the coupler arm member 414 to be rotated about an axis substantially parallel to the longitudinal axis of the body portion 802. In some embodiments, the coupler arm member 414 may be configured to extend outward of and retract at least partially within the slot 804. The coupler 206 may be pivotally connected to the coupler arm member 414 to allow the coupler 206 to rotate about a connection point 805 connecting the coupler 206 to the coupler arm member 414. In some embodiments, a plurality of slots 804 may be disposed in the body portion 802 of the marine craft 800 to accommodate a plurality of coupler(s) 206.

[0140] For example, when the marine craft 800 assumes a retracted state, such as for travelling uncoupled to a vessel, the coupler arm members 414 may be at least partially retracted within the slots 804 and rotated about the axis substantially parallel to the longitudinal axis of the body portion 802 such that the couplers 206 extend from a major surface or deck 26 806 of the body portion 802 and the hydrodynamic efficiency of the marine craft 800 may be enhanced. When the marine craft 800 assumes an operating state, the coupler arm members 414 may be rotated about the axis substantially parallel to the longitudinal axis of the body portion 802 such that the couplers 206 extend from the slots 804 outward from a side wall 808 of the marine craft 800. The coupler arm members 414 may extend at least partially from the slots 804 and the couplers 206 may be pivotally moved to assist in attaching the couplers 206 to a vessel.

[0141] Referring to Figures 9A and 9B, there is illustrated a marine craft 900 according to some embodiments. The marine craft 900 may comprise similar components and elements to marine craft 108 described in connection with Figures 1 to 3, and/or marine craft 400 described in connection with Figures 4 to 6C, and/or marine craft 700 described in connection with Figures 7 and/or marine craft 800 described in connection with Figures 8A and 8B and, where indicated in Figures 9A and 9B, those similar components and elements are denoted like numerals.

[0142] The marine craft 900 may comprise at least one recessed region or nacelle 902 disposed in the side wall 808 of the marine craft 900 and providing access to the slot(s) 804.

The nacelle(s) 902 may be configured to accommodate the coupler(s) 206. For example, nacelle(s) 902 may be configured to partially or completely receive the coupler(s) 206 when the coupler arm member(s) 414 is retracted or partially retracted within the slot(s)804.

[0143] In some embodiments, the nacelle(s) 902 may comprise a cover or flap 904 to selectively cover the nacelle 902 when the coupler(s) is retracted within the nacelle(s) 902. For example, when the flap 904 is closed, an outer surface of the flap 904 may be substantially flush with an outer surface of the marine craft 900 and may reduce drag when the marine craft 900 is travelling through water. When a marine craft 108 is required to couple to the hull of a vessel 106, the flap 904 may be opened to allow the coupler(s) 206 to extend from the nacelle 902, as illustrated in Figure 9B. In some embodiments, the processor 214 may be arranged to execute program code to cause the controller 212 to selectively open and close the flaps 904 in accordance with operating instructions for the marine craft 900.

[0144] Referring to Figures 10A and 10B, there is illustrated a side view of a marine craft 1000 according to some embodiments. The marine craft 1000 may comprise similar components and elements to marine craft 108 described in connection with Figures 1 to 3, 27 and/or marine craft 400 described in connection with Figures 4 to 6C, and/or marine craft 700 described in connection with Figures 7 and/or marine craft 800 described in connection with Figures 8A and 8B and/or marine craft 900 described in connection with Figures 9A and 9B and, where indicated in Figures 10A and 10B, those similar components and elements are denoted like numerals.

[0145] As depicted in Figures 10A and 10B, the marine craft 1000 may have a recess 1002 provided in an outer surface of a hull 1004 of the marine craft 1000 and which may be configured to receive the arm member(s) 410 of the propulsion device(s) 204. For example, recess 1002 may be configured to partially or completely receive arm member(s) 410 of the propulsion device(s) 204 when the arm member(s) 410 is retracted and the marine craft assumes the retracted state, as depicted in Figure 10A. In some embodiments, by enabling the arm member(s) 410 of the propulsion device(s) 204 to be received within or partially within the recess 1002, drag contributions from the arm member(s) 410 may be mitigated when the marine craft 108 is travelling.

[0146] As depicted in Figure 10B, the arm member(s) 410 may comprise first and second connected beam members 1006, such as elongate beam members. In some embodiments, the first and second beams members 1006 may be hingeably connected to rotatable swivel joints allowing the two beam members 1006 to rotate with two degrees of freedom relative to the marine craft 1000, the propulsion device(s) 204, and each other.

[0147] In some embodiments, the marine craft 800 comprises the nacelle(s) 902 and coupler(s) 206 and/or flap 904 configuration of the marine craft 900 of Figures 9A and 9B and the recess 1002 and the arm member(s) 410 configuration of the marine craft 1000 of Figures 10A and 10B. For example, such an embodiment may provide for efficient movement of the marine craft 108 through the water when travelling uncoupled to a vessel 106, with the coupler(s) 206 raised up out of the water and the arm member(s) 410 of the propulsion device(s) 204 retracted into the recess 1002 of the marine craft.

[0148] Some embodiments of the attachment members 416 will now be described with reference to Figures 11A, 11B, 12A, 12B and 13A and 13B. The attachment member(s) 416 may comprise a backing layer or support structure 1100 for supporting or carrying a coupling mechanism 1102. The attachment member(s) 416 may include an outward facing surface 1104 for coupling or attaching to a vessel 106, such as to the hull of a vessel, to couple the marine 28 craft 108, 400, 700, 800, 900, 1000 to the vessel 106. The coupling mechanism 1102 may be arranged to provide sufficient strength and stiffness to withstand forces acting on the attachment members 416 during operation. In some embodiments, the attachment member(s) 416 may be composed at least partially of a material or have a surface layer disposed thereon such the surface 1104 has or exhibits a relatively high coefficient of friction when coupled to a surface of the vessel 106, to thereby mitigate shear separation or sliding between the marine craft 108 and the vessel 106.

[0149] Each attachment member 416 may be connected directly to the chassis 202 or body portion 402, 702, 802, 902 of the marine craft 108, 400, 700, 800, 900, 1000 or to the coupler arm member 414. For example, the attachment member 416 may comprise an arm element 1106 and a joint 1108. The joint 1108 may be fixed, or may allow the attachment member 416 to move in one or more rotational degrees of freedom with respect to the marine

craft 108, 400, 700, 800, 900, 1000. For example, the joint 1108 may comprise a universal joint, a spherical joint, a revolute joint, a pivot joint, a spring loaded joint. In some embodiments, the joint 1108 may include an actuator (not shown) linked to the controller 212 such that the orientation of the attachment member 416 may be adjusted by the controller 212.

[0150] In some embodiments, the attachment member(s) 416 may comprise a protective layer 1110. The protective layer 1110 may be composed or formed of a relatively soft material (relative to typical hull or vessel material) such as rubber, and may prevent or mitigate the attachment members 416 from causing damage to a vessel 106 to which they may be attached. The strength of attachment between the coupler(s) 206 and/or attachment member(s) 416 and the vessel may be sufficient to withstand the differential forces between the marine craft 108, 400, 700, 800, 900, 1000 and the vessel 106 during operation.

[0151] In some embodiments, for example as illustrated in Figure 11A, the coupling mechanism 1102 of the attachment member(s) 416 may comprise at least one magnet 1112 to magnetically couple to or attach to a vessel 106. The magnet(s) 1112 may be an electromagnet or a permanent magnet, such as a rare earth magnet. The magnet(s) 1112 may be disposed in close proximity to the outer surface 1104 of the attachment member(s) 416 to provide a relatively strong attractive force. In some embodiments, each attachment member 416 may be independently extendable and retractable with respect to the others so that each of a plurality of attachment members 416 may be removed, one-by-one or a few at a time. In this way, the remaining attached pad(s) 416 may provide a reaction force to separate each attachment member 416 from the vessel 106 until only one or two pads 416 remain attached to the vessel 106. The coupler arm member 414 or the chassis 202 may include a decoupling mechanism (not shown), such as a non-magnetic arm or a pneumatic retractor, configured to extend from the marine craft 108, 400, 700, 800, 900, 1000 to push against the vessel 106 to disconnect or decouple the remaining attached pad(s) 416 from the vessel 106. By providing coupler(s) 206 including a plurality of attachment members 416 and by detaching the attachment members 416 one at a time, in sequence, a lower separation force may be required to decouple the marine craft 108, 400, 700, 800, 900, 1000 from the vessel 106. Alternatively or in addition, the coupler arm members 414 may be capable of being retracted quickly enough to detach the attachment members 416 from a vessel 106 by creating an impulse sufficiently high to break

the attachment or coupling bond.

[0152] In some embodiments, for example as illustrated in Figure 11B, the magnet 1112 may comprise one or more electromagnets 1114 and one or more permanent magnets 1116 to control the coupling and decoupling of the attachment member(s) 416 to a vessel 106. The electromagnets 1114 may be electrically coupled to the controller 212 via a cable or wire 1118. The electromagnets 1114 may be disposed adjacent to the permanent magnets 1116. In some embodiments, the permanent magnets 1116 may be coils disposed adjacent to, about or around the permanent magnets 1116. The electromagnets 1114 may be used to increase a force of attraction of the attachment members 416 to a vessel 106 and aid in the attachment of the permanent magnets 1116 and thereby the coupler(s) 204 to the vessel 106.

[0153] In some embodiments, the controller 212 may be configured to deactivate the electromagnets 1114 while the marine craft 108, 400, 700, 800, 900, 1000 remains coupled or attached to the vessel 106, and may be configured to activate the electromagnets 1114 in a reverse polarity with respect to the permanent magnets 1116 to counteract and neutralise the magnetic field of the permanent magnets 1116, thereby reducing the force of attachment and allowing the marine craft 108, 400, 700, 800, 900, 1000 to more easily detach from the vessel 106 using the propulsion device(s) 204. Attachment members 416 comprising permanent magnets may allow the marine craft 108 to remain coupled to a vessel 106 in a passive mode without expending energy.

[0154] In other embodiments, as illustrated in Figures 12A and 12B, the attachment member(s) 416 may be configured to couple or attach to the vessel 106 by vacuum suction. For example, coupling mechanism 1102 of the attachment member(s) 416 may be a suction coupling mechanism and may comprise a protruding lip or seal 1200 disposed about a perimeter of the outwardly facing surface 1104 to couple or substantially seal the attachment member(s) 412 to a surface of the vessel 106. A hole or aperture 1202 may be disposed or provided in surface 1104 of the attachment member(s) 416 so that suction may be induced via a tube 1204 connected to a pump (not shown) on the marine craft 108, 400, 700, 800, 900, 1000. In some embodiments, the controller is configured to control operations of the pump (not shown) in accordance with operation instructions.

[0155] As illustrated in Figure 12B, by inducing suction at the aperture 1202, a negative pressure difference between the pressure in a region 1206 defined between the coupling mechanism 1102 and the vessel 106, the ambient pressure outside of the seal 1200 may be created, thereby enabling the coupling or holding of the attachment member(s) 416 to a surface of vessel 106. In some embodiments, the seal 1200 may be composed of an elastically deformable material and may deform during attachment to an object or vessel 106 so as to decrease the volume of the region 1206 and may return to its unloaded state after detachment. The attachment member(s) 416 may remain coupled or attached to the vessel 106 until the pressure is released and equalised, allowing the attachment member(s) 416 to decouple or detach from the surface of the vessel 106.

[0156] In some embodiments, for example as illustrated in Figures 13A and 13B, the attachment members 416 may employ both magnetic attraction and suction techniques to couple the coupler(s) 206 to a vessel 106. For example, the coupling mechanism 1102 of the attachment member(s) 416 may comprise a seal 1300 disposed about a perimeter of a perimeter of the surface 1104 of the attachment member(s) 416 and at least one magnet 1302 disposed at or near the contact surface 1104 of the attachment member(s) 416. A hole or aperture 1304 may be disposed or provided in the surface 1104 of the attachment member(s) 416.

[0157] In some embodiments, a thickness of the seal 1300 and/or the magnetic strength of the magnet(s) 1302 may be selected such that the magnet(s) 1302 does not exert a sufficient attracting force to magnetically couple to a vessel 106 when the seal 1300 is brought into abutment or contact with a surface of the vessel 106. Vacuum suction may be applied at the aperture 1304 to reduce the pressure within a region 1306 defined between the coupling mechanism 1102 and the vessel 106, and positive pressure outside the seal 1300 may deform the seal 1300 to bring the attachment member(s) 416 and the magnet(s) 1302 closer to the surface of the vessel 106 so that the magnet(s) 1302 may magnetically couple to or attach to the vessel 106. The attachment member(s) 416 may be decoupled or detached from the vessel 106 by increasing the pressure in the region 1306 to move the attachment member(s) 416 and the magnet(s) 1302 sufficiently far away from the vessel 106 so that the marine craft 108, 400, 700, 800, 900, 1000 is able to detach or decouple from the vessel 106.

[0158] In some embodiments, the seal 1300 may be composed of an elastically deformable material and may deform during attachment to an object or vessel 106 so as to decrease the volume of the region 1306 within the seal 1300 and may return to its unloaded state after detachment.

[0159] Figure 14 is a flow diagram depicting a method of operating a marine craft 108, 400, 700, 800, 900, 1000 according to some embodiments. The method 1400 may be executed by controller 212 of the marine craft 108, 400, 700, 800, 900, 1000.

[0160] At 1405, the marine craft 108, 400, 700, 800, 900, 1000 may determine that an operation or task is to be performed to assist a vessel 106, such as marine vessels, offshore plants, refineries, ships, barges, oil rigs, floating plant, floating cranes, floating processing units, cruise liners, ferries, research vessels, and/ or research equipment.

[0161] Examples of tasks to be performed by the marine craft 108, 400, 700, 800, 900, 1000 may comprise retaining a vessel 106 within a defined safe zone, keeping vessel 106 within a channel or region, guiding a vessel 106 from one location to another, such as through the harbour 100, maintaining a vessel 106 at a given location to facilitate the mooring of the vessel 106 to a fixed structure such as a dock or port 104; assisting with docking and undocking a vessel 106, maintaining a vessel 106 at a particular heading angle and a particular location; providing active or passive dynamic positioning to a vessel 106; moving components or equipment around a shipyard; or dynamically locating or positioning a vessel 106 with respect to a moving object such as another vessel or plant. Such tasks may be performed in any body of water such as a bay, harbour, marina, river, estuary, channel, canal, lock, lake, sea or in open ocean.

[0162] In some embodiments, the controller 212 may determine that an operation or task is to be performed by processing instructions received from a remote computing device or server across the communications network 300 via the communications system 222 coupled to the controller 212. For example, the instructions may be received from the control tower server 302, the vessel server 304, or any other computing system, such as an unmanned aerial vehicle (UAV) or drone. In some embodiments, the instructions provide information regarding an identification code of the vessel 106, a location of the vessel 106 and/or a task to be

performed, such as manoeuvring the vessel or holding or positioning the vessel at a given location.

[0163] For example, the vessel server 304 of a vessel 106 requiring assistance may communicate via vessel communications system 314 over the communications network 300 with the tower server 302 and/or to the controller 212 of the marine craft 108, 400, 700, 800, 900, 1000 to request assistance and/or to transmit information about the vessel 106 and/or weather information local to the vessel 106.

[0164] In some embodiments, the controller 212 may determine that an operation or task is to be performed by processing instructions received from the positioning system 226 and/or sensor 228. For example, the controller 212 may determine that it is required to perform a task by sensing a vessel 106, such as a marine vessel or floating plant, within a predetermined operations or task zone. In some embodiments, coordinates or other information designating specific locations or zones are stored in the memory 216 as operations or task zone. The control module 218 may comprise code which when executed by the processor 214, may cause the controller 212 to compare the location of the detected vessel 106 received from the positioning system 226 and/or sensor 228 with the stored locations of operations or task zone in the memory 216 in order to determine whether the vessel 106 is within an operations or task zone and whether an operation or task is to be performed by the marine craft 108, 400, 700, 800, 900, 1000. In some embodiments, types of tasks to be performed may be associated with operation or task zones and stored in the memory 216. For example, if a vessel is detected in a specific task zone, the controller 212 may determine from the memory 216 the type of task to be performed.

[0165] At 1410, the controller 212 may determine the operation instructions for the marine craft 108, 400, 700, 800, 900, 1000 to perform the task. The operation instructions comprise operating instructions for the propulsion device(s) 202 and the coupler(s) 206.

[0166] The operating instructions may depend on operating factors such as the task to be performed; the type, size, mass, hull shape and/or draught of the vessel 106 to be assisted; the distribution and density of the cargo of the vessel 106 to be assisted; the position, orientation, velocity and/or acceleration of the vessel 106 to be assisted; a target position on a vessel to

which the coupler(s) 206 are to couple; weather information, such as the current weather information and forecasted weather information, for example, one or more of expected magnitude and direction of winds, waves and currents in the area of operation during the period of operation; sensor data, for example, one or more of water depth, data on the topology of the sea bed, air and water temperature; tidal information, a number and location of other marine craft 108, 400, 700, 800, 900, 1000 available and assigned, recruited or configured to assist in performing the task; fuel and/or energy available to the marine craft and any of the other marine craft 108, 400, 700, 800, 900, 1000 expected to assist in performing the task; fuel and/or energy expected to complete the task; the time expected to complete the task; and/or locations of fixed and/or floating obstacles, restricted zones, lanes or channels.

[0167] In some embodiments, at least some of the operating factors on which the operating instructions depend and/or at least some of the operating instructions may be stored locally in the memory 216 of the marine craft 108, 400, 700, 800, 900, 1000 and/or may be stored at a remote database (not shown) in communication with the controller 212 across communications network 300. In some embodiments, the controller 212 may be configured to store and/or transmit to the remote database (not shown) data relating to operating factors and/or operating instructions for a given or specific type of vessel 106. The operating factors and/or operating instructions for the given or specific type of vessel 106 may be accessible to and retrievable from the memory 216 of the controller 212 and/or the remote database (not shown) by a controller 212 of another marine craft 108, 400, 700, 800, 900, 1000 which may subsequently be required to perform a task for the vessel 106.

[0168] The operating instructions for the propulsion device(s) 202 may include information such as a direction or course of travel to be taken, operating speeds for the propulsion device(s) 202 at various stages while travelling to the vessel, a minimum distance for the marine craft to maintain from the vessel 106, from any other marine craft 108, 400, 700, 800, 900, 1000, or any other surrounding objects or structures. The operating instructions for the coupler(s) 206 may include information such as operating distances, coupling forces, position and orientation of the attachment members.

[0169] In some embodiments, the operating instructions for a task may be received from a

remote server across the communications network 300 via the communications system 222 coupled to the controller 212. For example, the operating instructions may be received from the control tower server 302, the vessel server 304, or any other computing system, such as an unmanned aerial vehicle (UAV) or drone, or a controller 212 of another marine craft 108, 400, 700, 800, 900, 1000 assigned or configured to assist in performing the task or may be retrieved from a remote database (not shown).

[0170] In some embodiments, the operating instructions for a task may be preconfigured and/or may be stored or pre-programmed in or derived from information stored in the memory 216. For example, the memory 216 may comprise operating instructions including operating instructions for the propulsion device(s) 204 and/or the coupler(s) 206 which take into account a range of factors, such as those discussed above, on which the operating instructions may depend.

[0171] In some embodiments, the operating instructions may be determined from information derived from the positioning system 226, sensor(s) 228 and/or sensor 221. For example, information derived from the positioning system 226, sensor(s) 228 and/or sensor 221 may be employed by the controller 212 to determine the operating instructions. In some embodiments, information derived from the positioning system 226, sensor(s) 228 and/or sensor 221 may be transmitted to the control tower server 302 and/or the vessel server 304, periodically or continuously (or sufficiently regular as to be effectively continuous), and may be employed the control tower server 302 and/or the vessel server 304 to modify or update or generate operating instructions for transmitting to the controller 212 of the marine craft 108, 400, 700, 800, 900, 1000.

[0172] In some embodiments, the operating instructions for a task may comprise operating instructions received from the control tower server 302, the vessel server 304, and/or any other computing system, such as a controller 212 of another marine craft 108, 400, 700, 800, 900, 1000 assigned or configured to assist in performing the task; operating instructions stored in or derived from information stored in the memory 216; and/or operating instructions may be determined from information derived from the positioning system 226, sensor(s) 228 and/or sensor 221.

[0173] The operating instructions may comprise or rely on static information and/or dynamic information. For example, in the case where the operating instructions comprise or rely on dynamic information, the operating instructions may be updated during the period for which the marine craft has been assigned to or configured to perform the task.

[0174] At 1415, the processor 214 may execute program code of the control module 218 to cause the controller 212 to activate the propulsion device(s) 204 and to propel the marine craft 108, 400, 700, 800, 900, 1000. The controller may employ the operating instructions and information derived from the sensors 228, the positioning system 226 and/or the communications system 222 to direct the marine craft 108, 400, 700, 800, 900, 1000 to the vessel 106.

[0175] In some embodiments, the controller 212 may communicate via communications system 222 with the controllers 212 of other marine craft 108, 400, 700, 800, 900, 1000 assigned or configured to assist in performing the task to effectively locate or position the marine craft 108, 400, 700, 800, 900, 1000 about the vessel 106 with respect to the other marine craft 108, 400, 700, 800, 900, 1000.

[0176] At 1420, the processor 214 may execute program code of the control module 218 to cause the controller 212 to transition or reconfigure the marine craft 108, 400, 700, 800, 900, 1000 from the retracted state to the operating state. For example, the processor 214 may execute program code of the control module 218 to cause the controller 212 to extend the arm members 410 of the propulsion device(s) and the coupler arm member(s) 414 so that the marine craft 108, 400, 700, 800, 900, 1000 assumed the operating state as discussed above with reference to Figures 4A, 4B and 4C.

[0177] At 1425, the processor 214 may execute program code of the control module 218 to cause the controller 212 to activate the coupler(s) 206 to couple to the vessel 106. In some embodiments, the controller 212 may communicate via communications system 222 with the controllers 212 of other marine craft 108, 400, 700, 800, 900, 1000 assigned or configured to assist in performing the task to effectively or appropriately locate or position the coupler(s) 206 with respect to the coupler(s) 206 of the other marine craft 108, 400, 700, 800, 900, 1000.

[0178] At 1430, the processor 214 may execute program code of the control module 218 to cause the controller 212 to control the propulsion device(s) 204 and/or coupler(s) 206 to perform the task. For example, if the task involves manoeuvring the vessel 106 to a specific location, the controller 212 may cause the propulsion device(s) 204 to be positioned and activated so that they operate as required to propel the marine craft and the vessel 106 to which it is coupled to the location, as illustrated in Figure 6B.

[0179] At 1435, once the task has been performed and/or the marine craft is to decouple from the vessel, the processor 214 may execute program code of the control module 218 to cause the controller 212 to decouple or detach the coupler(s) 206 from the vessel 106. In some embodiments, the controller 212 may transmit a signal to the vessel server 304 and/or the control tower server 302 indicating that the operation has been completed.

[0180] At 1440, the processor 214 may execute program code of the control module 218 to cause the controller 212 to transition or reconfigure the marine craft 108, 400, 700, 800, 900, 1000 from the operating state to the retracted state. For example, the processor 214 may execute program code of the control module 218 to cause the controller 212 to retract the arm members 410 of the propulsion device(s) and the coupler arm member(s) 414 so that the marine craft 108, 400, 700, 800, 900, 1000 assumes the retracted state as discussed above with reference to Figures 5A and 5B.

[0181] At 1445, the processor 214 may execute program code of the control module 218 to cause the controller 212 to activate the propulsion device(s) 204 to propel the marine craft 108, 400, 700, 800, 900, 1000 from the vessel 106. The controller 212 may employ the operating instructions and information derived from the sensors 228, the positioning system 226 and/or the communications system 222 to direct the marine craft 108, 400, 700, 800, 900, 1000 from the vessel 106, and for example, toward the parking station 110.

[0182] In some embodiments, steps 1405 to 1445 of method 1400 may be conducted in a different order than that depicted in Figure 14 and furthermore, not all of the steps may be required to perform the method.

[0183] Figure 15 is a flow diagram depicting a method 1500 of operating marine craft

108, 400, 700, 800, 900, 1000 according to some embodiments. The method 1500 may be executed the tower server 302. For example, program code stored on the memory 310, may, when executed by the processor 308, cause the control tower server 302 to carry out the method 1500 of operating a plurality of marine craft 108, 400, 700, 800, 900, 1000.

[0184] At 1505, the server 302 may determine that a vessel 106 requires assistance.

[0185] In some embodiments, the server 302 may receive a request over the communications network 300 from a vessel server 304 of a vessel requiring assistance or the server 302 may receive a signal or message over the communications network 300 from the controller 212 of a marine craft 108, 400, 700, 800, 900, 1000 identifying a vessel requiring assistance. The request or message may include an indication of a task required to assist the vessel 106 and/or a location of the vessel 106. In some embodiments, the server 302 determines that a vessel 106 requires assistance, a task required to assist the vessel 106 and/or a location of the vessel, from information received from a user via the user interface 312 or from other monitoring systems connected to or in communication with the communications system 306 of the control tower 102.

[0186] At 1505, the server 302 may recruit or allocate at least one marine craft 108, 400, 700, 800, 900, 1000 to perform the task or operation to assist the vessel 102. In some embodiments, the recruited at least one marine craft forms a fleet or swarm to perform the task.

[0187] At 1510, the server 302 may determine operation instructions for each marine craft 108, 400, 700, 800, 900, 1000 to assist the vessel 106. The operation instructions may comprise operating instructions for the propulsion device(s) 204 and the coupler(s) 206 as discussed above in connection with method 1400.

[0188] The operating instructions may depend on the operating factors identified above in respect of method 1400. For example, the operating instructions for each of the marine craft 108, 400, 700, 800, 900, 1000 may depend on the number of marine craft 108, 400, 700, 800, 900, 1000 in the fleet and the proximity of the marine craft to one another and the vessel 106.

[0189] The server 302 may determine specific operating instructions for each of the

marine craft 108, 400, 700, 800, 900, 1000 in the fleet. The server 302 may determine a formation or arrangement for the fleet of the marine craft 108, 400, 700, 800, 900, 1000 to adopt or assume in order to assist the vessel 106 and may assign each marine craft 108, 400, 700, 800, 900, 1000 specific operating instructions to achieve the formation.

[0190] In some embodiments, the server 302 may receive information from the vessel server 304 and/or the controllers 212 of the marine craft 108, 400, 700, 800, 900, 1000 and may employ the information to determine the operating instructions for each of the marine craft 108, 400, 700, 800, 900, 1000.

[0191] At 1515, the server 302 may transmit operating instructions to the controllers 212 of the marine craft 108, 400, 700, 800, 900, 1000.

[0192] At 1520, the server 302 may monitor the operations of the marine craft 108, 400, 700, 800, 900, 1000 to determine whether operation has been completed. For example, determining whether the operation has been completed may include determining that the marine craft are coupled to the vessel, the operation is performed and/or the marine craft are decoupled from the vessel.

[0193] For example, in some embodiments, once the marine craft 108, 400, 700, 800, 900, 1000 are coupled to the vessel 106, the operation has been performed, and/or the marine craft 108, 400, 700, 800, 900, 1000 coupled to the vessel 106 have decoupled from the vessel, server 304 and/or at least one controller 212 of the marine craft 108, 400, 700, 800, 900, 1000 may send a signal to the server 302 to indicate that successful coupling, operations and/or decoupling have been achieved. In other embodiments, the server 302 may determine from information received from the vessel server 304 and/or the controllers 212 that successful coupling, operations and/or decoupling have been achieved or from a user input received through user interface 312.

[0194] If the operation has not been completed, the server 302 may determine whether information has been received from the vessel server 304 and/or the controllers 212 and/or any other source, for example, from a drone or a user at user interface 312 and may determine whether operating instructions should be generated or updated based on the information, at

1525.

[0195] If information is received and operating instructions are to be generated or updated, the server 302 may generate or update the operating instructions, at 1530 and transmit the generated or updated operating instructions to the controllers 212 of the relevant marine craft 212, at 1515.

[0196] For example, as the fleet of marine craft 108, 400, 700, 800, 900, 1000 move toward the vessel 106, the server 302 may receive updated position and velocity information from the 39 vessel 106 and update a predicted intercept location. The updated intercept location may be employed to generate or modify operating instructions for transmitting to the controllers 212 of at least some of the marine craft 108, 400, 700, 800, 900, 1000 so they can correct their course accordingly. Similarly, once the marine craft have arrived at the location of the vessel 106, the server 302 may receive feedback information regarding the location and positioning of the coupler(s) 206 from the vessel 106 and/or the controllers 212 and may update coupler 206 and/or propulsion device 204 operating instructions based on the feedback information to assist with the coupling operation.

[0197] At 1535, the processor 308 may execute program code of the memory 310 to cause the control tower server 302 to instruct or direct the controller(s) 212 of the marine craft 108, 400, 700, 800, 900, 1000 to travel from the vessel 106 and for example, to return to the parking station 110. For example, information derived from the user via user interface 312, the sensors 228 and/or the positioning system 226 of the marine craft 108, 400, 700, 800, 900, 1000, and/or the vessel server 304 received via the control tower communications system 306 may employed by the control tower server 302 to generate instructions for transmitting to the marine craft 108, 400, 700, 800, 900, 1000 to remotely control or direct the marine craft 108, 400, 700, 800, 900, 1000 from the vessel 106, and for example, toward the parking station 110.

[0198] In some embodiments, steps 1505 to 1535 of method 1500 may be conducted in a different order than that depicted in Figure 15 and furthermore, not all of the steps may be required to perform the method.

[0199] In some embodiments, the method 1500 may be performed by the vessel server 304. For example, program code stored on the memory 318, may, when executed by the processor 316, cause the vessel server 304 to carry out the method 1500 of operating a plurality of marine craft 108, 400, 700, 800, 900, 1000.

[0200] In some embodiments, the method 1500 may be performed cooperatively by the control tower server 302 and the vessel server 304. For example, the control tower server 302 may remotely control the dispatching of the marine craft 108, 400, 700, 800, 900, 1000 to and from the vessel 106 and the vessel server 304 may remotely control the operations of the marine craft 108, 400, 700, 800, 900, 1000 when performing the task or operation, such as controlling the coupling and decoupling of the coupler(s) 206 and the operations of the propulsion device(s) 204 while the task is being performed. In such an embodiment, the 40 control tower server 302 or the vessel server 304 may remotely control the transforming of the marine craft from the retracted state to the operating state.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A marine craft for surface level operation, comprising:

a body;

at least one propulsion drive coupled to the body;

a controller carried by the body and configured to control operation of the at least one propulsion drive;

a wireless transceiver communicably coupled to the controller to facilitate wireless communication between the controller and a remote computing device; and

at least one coupler to removably couple the craft to a vessel;

wherein the marine craft is configured for unmanned surface level operation to couple to the vessel and decouple from the vessel under control of the controller.

2. The craft of claim 1, wherein the marine craft is configured for unmanned surface level operation to couple to the vessel and decouple from the vessel under control of the remote computing device.

3. The craft of any one of claims 1 or 2, wherein the at least one propulsion drive comprises a plurality of propulsion drives.

4. The craft of any preceding claim, wherein the plurality of propulsion drives comprises four propulsion drives.

5. The craft of any preceding claim, wherein the at least one propulsion drive comprises at least one azimuth thruster.

6. The craft of any preceding claim, wherein the at least one coupler comprises at least one magnetic coupling mechanism.

7. The craft of claim 6, wherein the at least one magnetic coupling mechanism comprises a plurality of rare earth magnets.

8. The craft of any preceding claim, wherein the at least one coupler comprises a decoupling mechanism to cause the at least one magnetic coupling to release from the vessel.

9. The craft of claim 8, wherein the at least one decoupling mechanism comprises a pneumatic retractor.

10. The craft of any preceding claim, wherein the at least one coupler comprises at least one suction coupling mechanism.

11. The craft of any preceding claim, wherein the at least one coupler comprises at least one movable arm to position the at least one coupling mechanism.

12. The craft of any preceding claim, wherein the body is free of deck structure to accommodate a passenger.

13. The craft of any preceding claim, further comprising at least one electrical power source for powering the at least one propulsion drive.

14. The craft of any preceding claim, wherein the craft is of a size and weight to be carried by another vehicle.

15. The craft of any preceding claim, wherein the vehicle is a ship or an aircraft.

16. The craft of any preceding claim, wherein the coupling mechanism is capable of removably coupling the craft to a hull of a marine vessel.

17. The craft of any preceding claim, wherein the controller comprises a memory for storing operation instructions for the marine craft.

18. The craft of claim 17, wherein the operation instructions comprise at least one of propulsion drive operating instructions and coupling mechanism instructions.

19. The craft of any preceding claim, wherein the memory includes a control module comprising program code which when executed by a processor of the controller is configured to cause the controller to control operations of the at least one propulsion drive.

20. The craft of any preceding claim, wherein the memory includes a control module comprising program code which when executed by a processor of the controller is configured to cause the controller to control operations of the at least one coupling mechanism.

21. The craft of any preceding claim, wherein the controller is configured to control operations of the at least one coupling mechanism based on data received from the remote computing device.

22. The craft of any preceding claim, wherein the data received from the remote computing device comprises at least one of operation instructions, vessel data and weather data.

23. The craft of any preceding claim, wherein the craft further comprises at least one sensor device, the controller being coupled to the at least one sensor device to receive sensor data from the at least one sensor device.

24. The craft of claim 23, wherein the sensor data comprises positioning information indicative of a position of the craft and/or the at least one coupler with respect to the vessel.

25. The craft of claim 23 or 24, wherein the sensor data comprises one or more of wave and water movements, tidal range and flow, current flow, wind data, temperature data and water depth.

26. The craft of any one of claims 23 to 25, wherein the sensor data comprises data on the topology of the sea bed.

27. The craft of any one of claims 23 to 26 , wherein the sensor comprises at least an orientation sensor, a motion sensor, a proximity sensor and a camera.

28. The craft of any one of claims 23 to 27, wherein the controller is configured to update operation instructions based on the sensor data.

29. The craft of any one of claims 23 to 28, wherein the controller is configured to transmit sensor data to the remote computing device.

30. The craft of claim 29, wherein the controller is configured to receive updated operation instructions from the remote computing device based on the sensor data.

31. The craft of any preceding claim, wherein the craft further comprises a positioning system to determine a location of the craft with respect to the vessel, wherein the positioning

system is coupled to and provides location data to the controller.

32. The craft of any preceding claim, wherein the remote computing device is at least one of a controller of another marine craft, a control tower server, a server carried by the vessel, and a handheld computing device.

33. A system comprising:

the marine craft of any one of claims 1 to 32; and

the remote computing device.

34. The system of claim 33, comprising a plurality of the marine craft, each of the marine craft in communication with and controlled by the remote computing device.

35. A computer implemented method of controlling a marine craft to perform an unmanned surface level operation, the method operable by a controller of the marine craft, the method comprising:

determining that a task is to be performed by the craft to assist a vessel including identifying a location of the vessel;

determining operation instructions for the craft, wherein the operating instructions comprise operation instructions for at least one propulsion drive of the marine craft and for at least one coupling mechanism of the marine craft;

activating the at least one propulsion drive to drive the marine craft towards the location of the vessel in accordance with the operation instructions;

coupling the at least one coupler to the vessel in accordance with the operation instructions;

performing the task; and

decoupling the at least one coupling mechanism from the vessel in accordance with the operation instructions.

36. The method of claim 35, wherein determining that a task is to be performed further comprises receiving a request to assist the vessel from at least one remote computing device over a wireless communications network, wherein request comprises location identifier for the vessel.

37. The method of claim 35, wherein determining that a task is to be performed further comprises detecting by a sensor device coupled to the controller the vessel within a predefined zone.

38. The method of any one of claims 35 to 37, wherein determining operation instructions comprises receiving data from at least one remote computing device over a wireless communications network, wherein the operation instructions are based on the data.

39. The method of any one of claims 35 to 37, wherein determining operation instructions comprises retrieving data from a memory of the controller.

40. The method of any one of claims 35 to 39, wherein activating the at least one propulsion drive comprises a processor of the controller executing program code associated with the operation instructions for the at least one propulsion drive to cause the controller to control a supply of power from a power source to the at least one propulsion drive.

41. The method of any one of claims 35 to 40, wherein coupling the at least one coupler to the vessel comprises a processor of the controller executing program code associated with the operation instructions for the at least one coupler to cause the controller to deploy the at least one coupler.

42. The method of any one of claims 35 to 41, wherein coupling the at least one coupler to the vessel comprises the controller executing program code associated with the operation instructions for the at least one coupler to cause the controller to activate the at least one coupler to couple to the vessel.

43. The method of any one of claims 35 to 42, wherein decoupling the at least one coupler from the vessel comprises the controller executing program code associated with the operation instructions for the at least one coupler to cause the controller to deactivate the at least one coupler to decouple the craft from the vessel.

44. The method of claim any one of claims 35 to 43, wherein the method further comprises receiving data from the remote computing device over a wireless communications network and updating the operation instructions based on the received data.

45. The method of any one of claims any one of claims 35 to 44, further comprising receiving from a sensor device provided on the marine craft sensor data comprising positioning information.

46. The method of claim 45, wherein positioning information is indicative of a position of the craft and/or the at least one coupler with respect to the vessel.

47. The method of claim 45 or 46, further comprising receiving from a sensor device provided on the marine craft sensor data comprising one or more of wave and water movements, tidal range and flow, current flow, wind data, temperature data and water depth.

48. The method of any one of claims 45 to 47, further comprising receiving from a sensor device provided on the marine craft sensor data comprising data on the topology of the sea bed.

49. The method of any one of claims 45 to 48, further comprising updating the operation instructions based on the sensor data.

50. The method of any one of claims 45 to 49, further comprising transmitting the sensor data to the remote computing device and receiving from the remote computing device via the communications network updated operation instructions based on the sensor data.

51. The method of any one of claims 35 to 50, further comprising cooperating with other marine craft of a group assigned to perform the task including receiving data from a controller of at least one other marine craft and updating the operation instructions based on the data.

52. The method of any one of claims 35 to 51, further comprising cooperating with other marine craft of a group assigned to perform the task including transmitting sensor data to a controller of at least one other marine craft.

53. A computer implemented method of controlling a marine craft to perform an unmanned surface level operation, the method operable by a computing device remote from the marine craft, the method comprising:

transmitting a request over a wireless communications network to a controller of at least one marine craft to perform a task, the request including an identification of a vessel

associated with the task;

determining operating instructions for the at least one marine craft;

transmitting operating instructions to the controller of the at least one marine craft to cause the marine craft to perform the task; and

monitoring operations of the at least one marine craft until the task is completed.

54. The method of claim 53 further comprising receiving a request for assistance from a server of the vessel over the wireless communications network.

55. The method of claim 53 or 54 wherein determining operating instructions comprises determining operating instructions for at least one of the at least one propulsion drive and the at least one coupler.

56. The method of any one of claims 53 to 55 further comprising assigning at least two marine craft to perform the task as a group.

57. The method of claim 56, wherein determining operating instructions comprises 5 determining a formation for the group of the marine craft and configuring operation instructions specific to each of the marine craft to achieve the formation when coupling to the vessel.

58. The method of any one of claims 53 to 57 wherein monitoring operations of the at 10 least one marine craft comprises receiving an indication from at least one of the controller of the at least one marine craft and a server of the vessel that the task has been completed.

59. The method of any one of claims 53 to 57, further comprising receiving data from the at least one of the controller of the at least one marine craft and a server of the vessel.

60. The method of claim 59, further comprising updating the operation instructions based on the received data and transmitting the updated operation instructions to at least one of the at least one marine craft.

61. The method of any one of claims 53 to 61, further comprising transmitting instructions to the controller of the at least one marine craft to cause the marine craft to depart from the vessel.

62. A computer program product comprising a computer readable medium encoded with computer executable instructions, which when executed in a computer system, is effective to cause the computer system to carry out the method of any one of claims 35 to 61.

63. The computer readable medium of claim 62, wherein the computer readable medium is a non-transitory computer readable medium.

64. A system configured to perform the method of any one of claims 35 to 61.

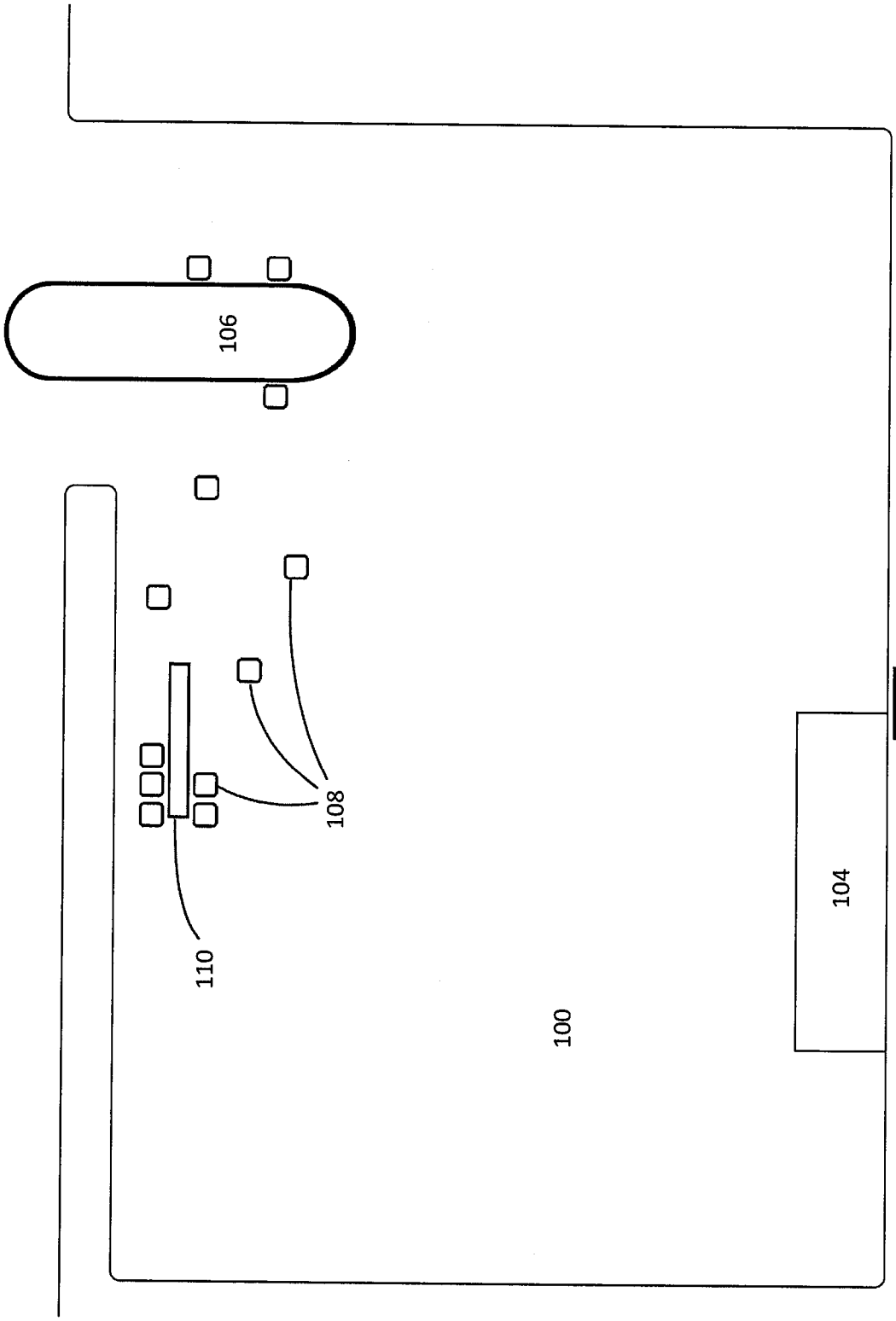

Figure 1

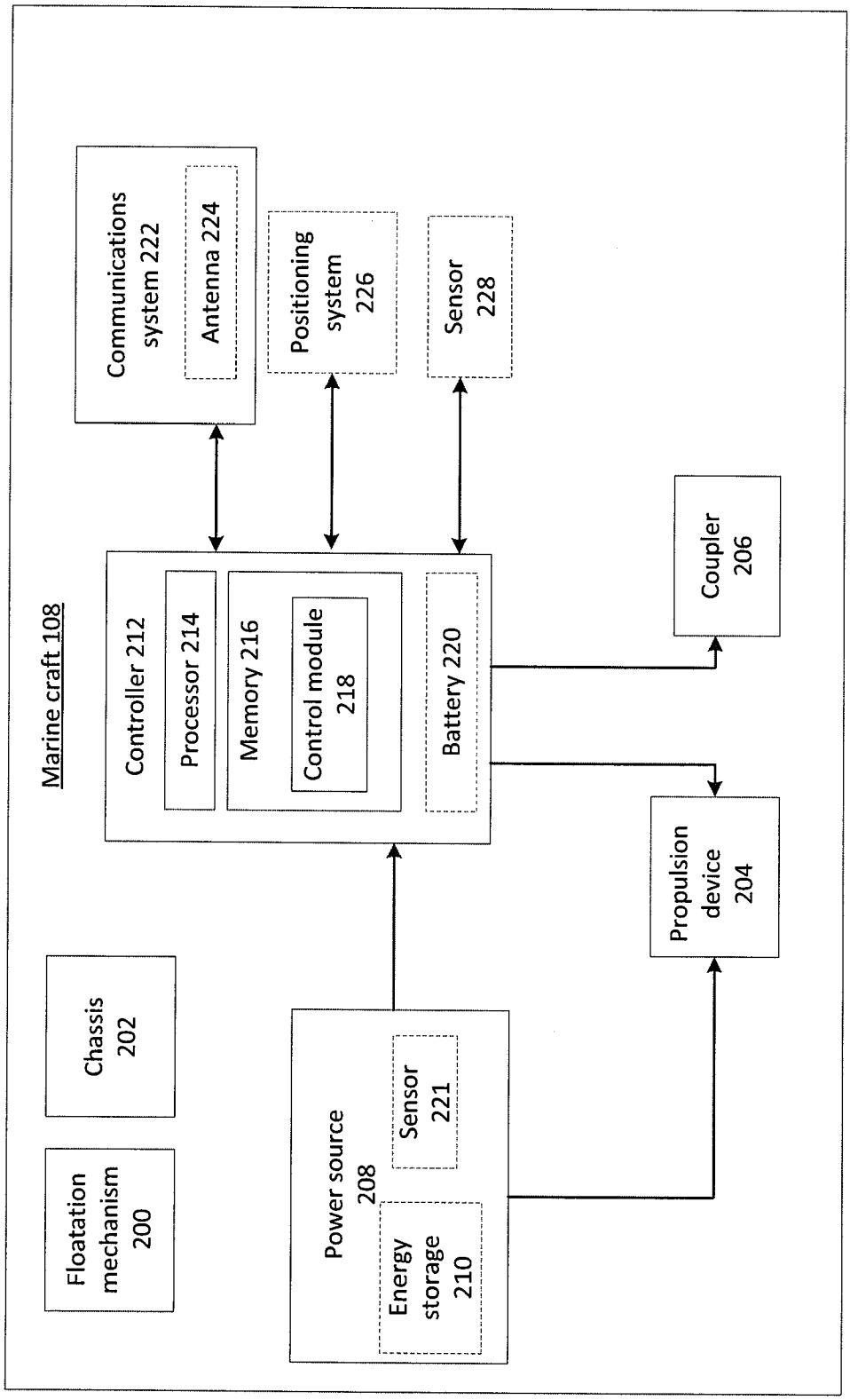
Marine craft 108
Communications system 222
Antenna 224
Positioning system 226
Sensor 228
Controller 212
Processor 214
Memory 216
Control module 218
Battery 220
Coupler 206
Propulsion device 204
Chassis 202
Floatation mechanism 200
Power source 208
Sensor 221
Energy storage 210

Figure 2

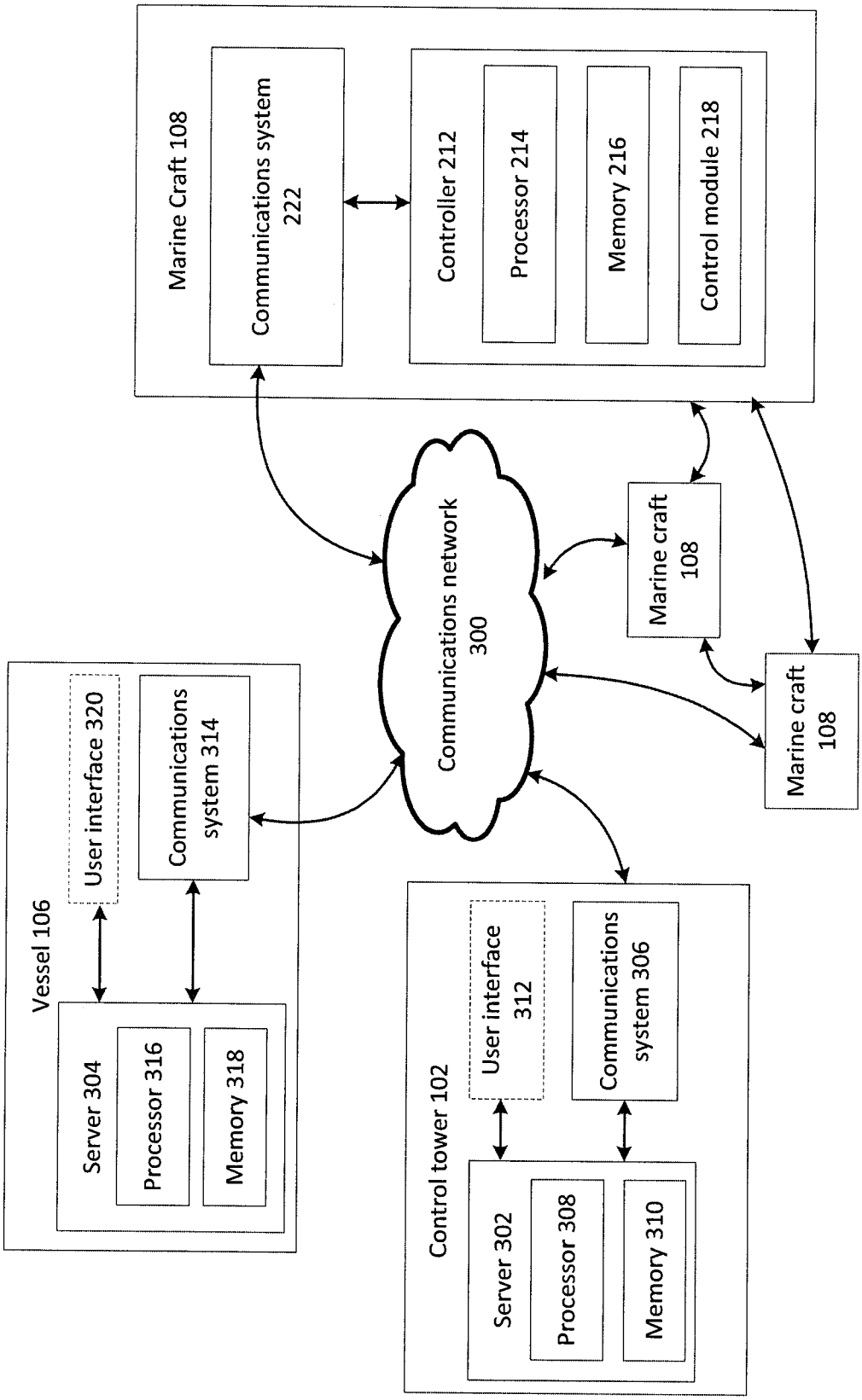
Marine Craft 108
Communications system 222
Controller 212
Processor 214
Memory 216
Control module 218
Communications network 300
Marine craft 108
Marine craft 108
Vessel 106
User interface 320
Communications system 314
Server 304
Processor 316
Memory 318
Control tower 102
User interface 312
Communications system 306
Server 302
Processor 308
Memory 310

Figure 3

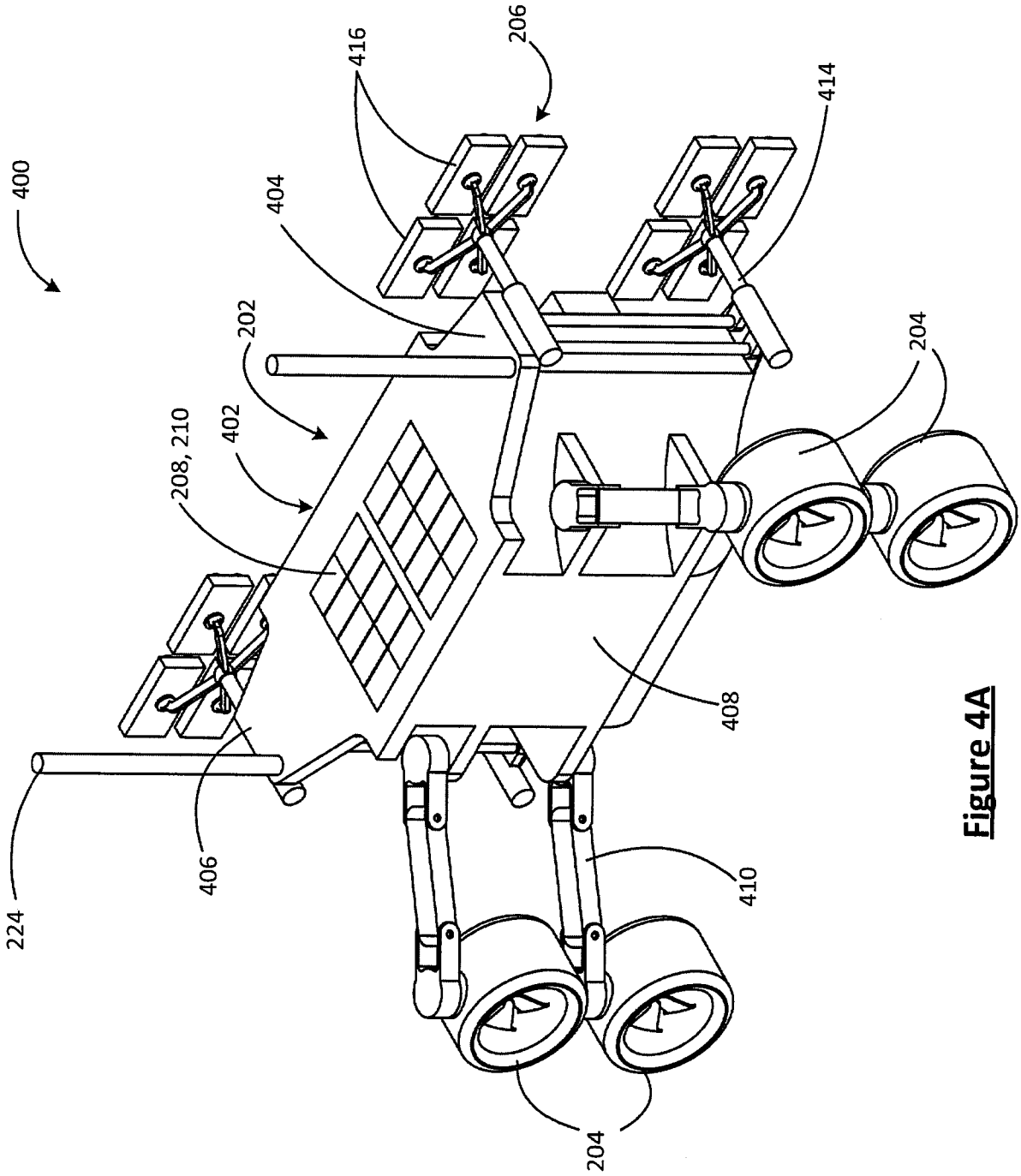

Figure 4A

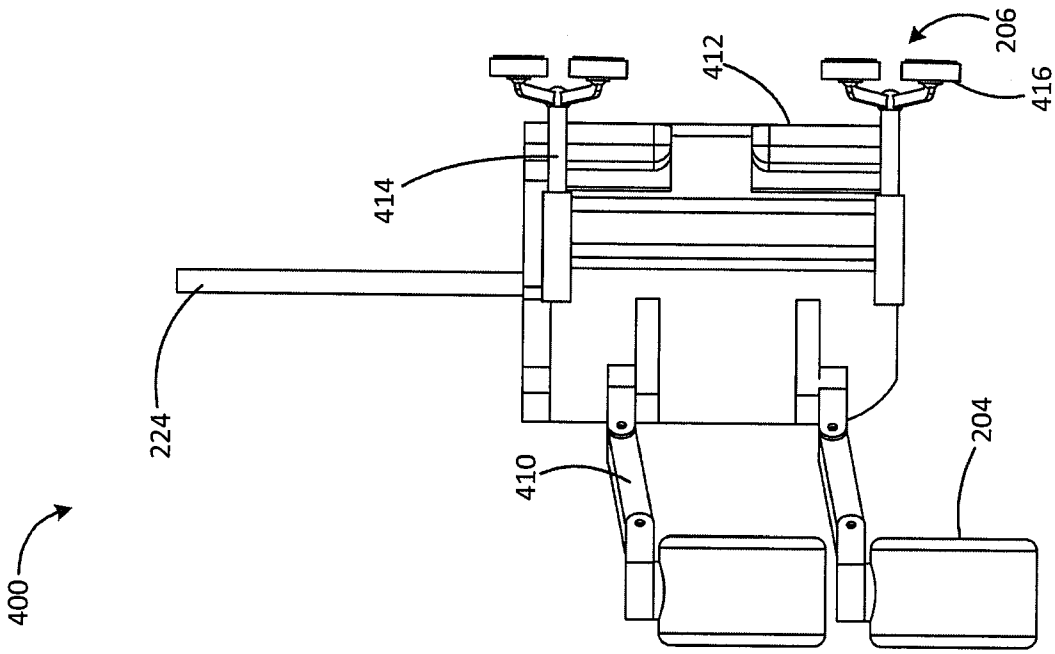

Figure 4C

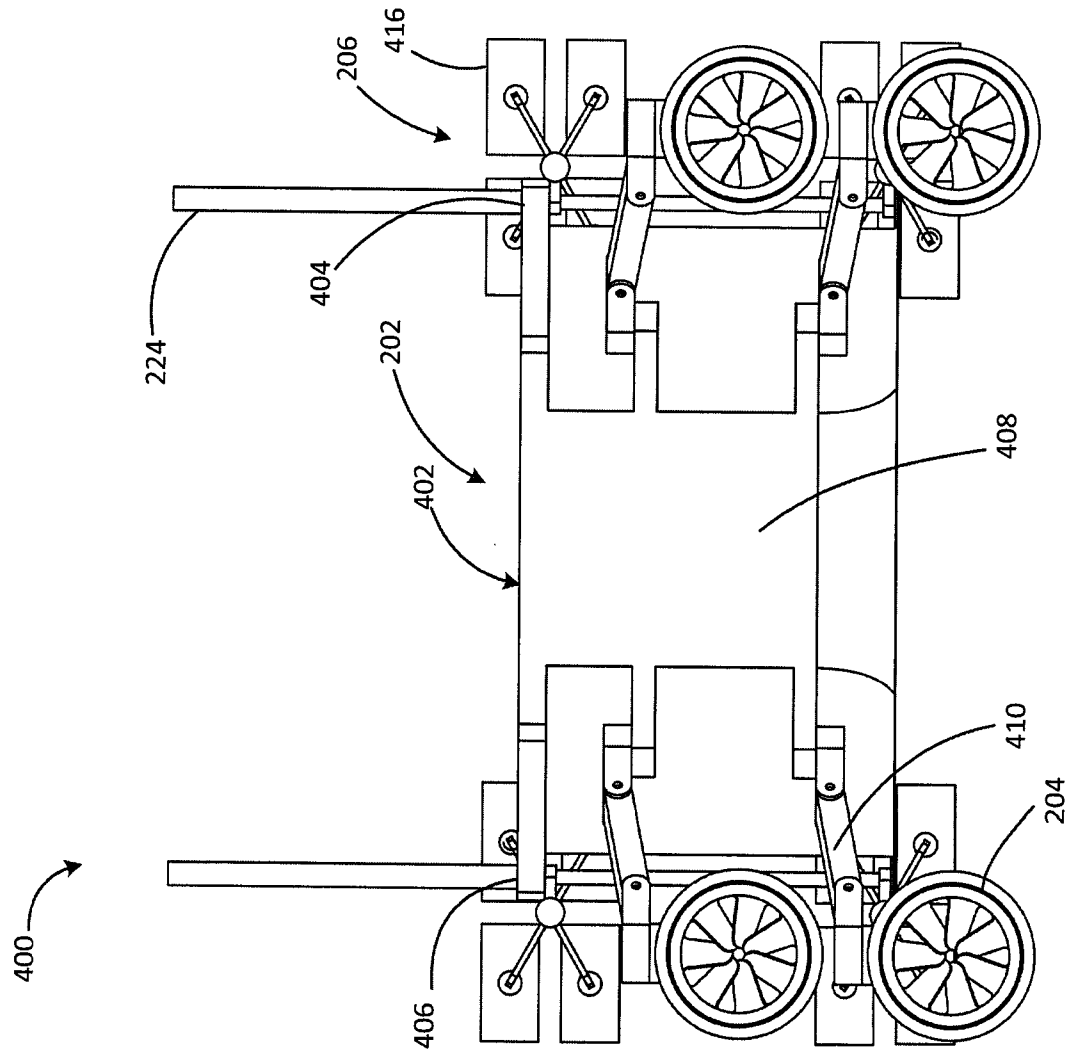

Figure 4B

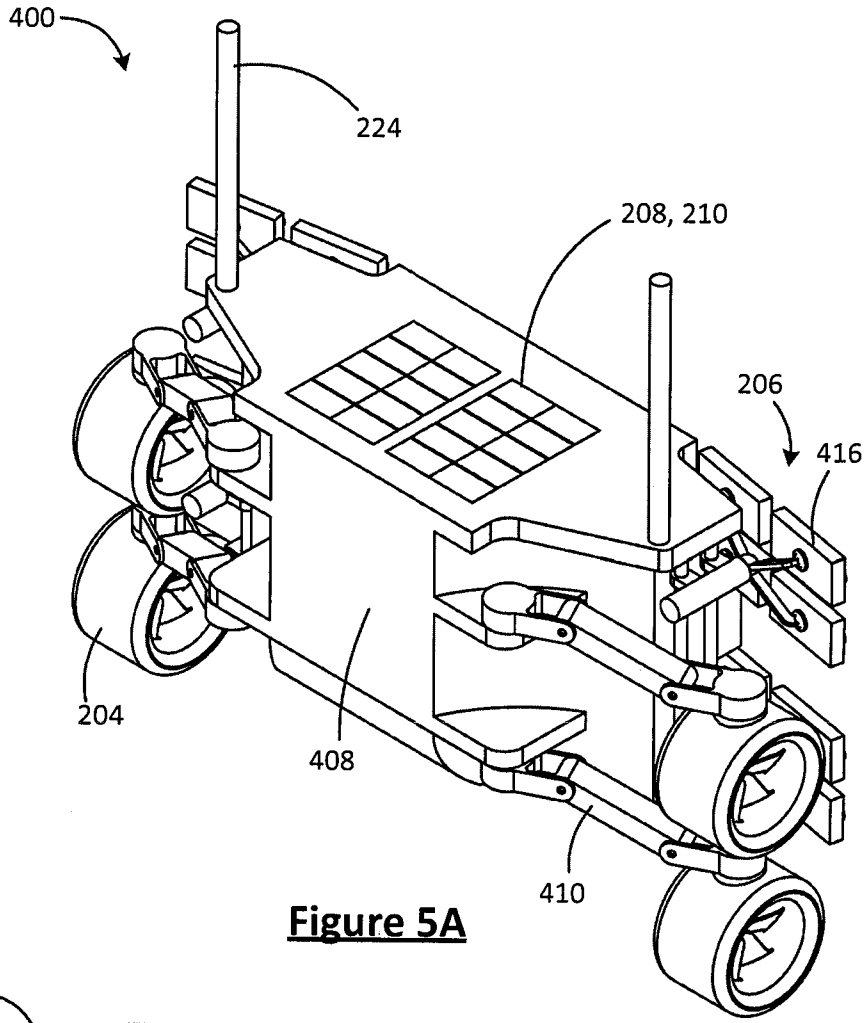

Figure 5A

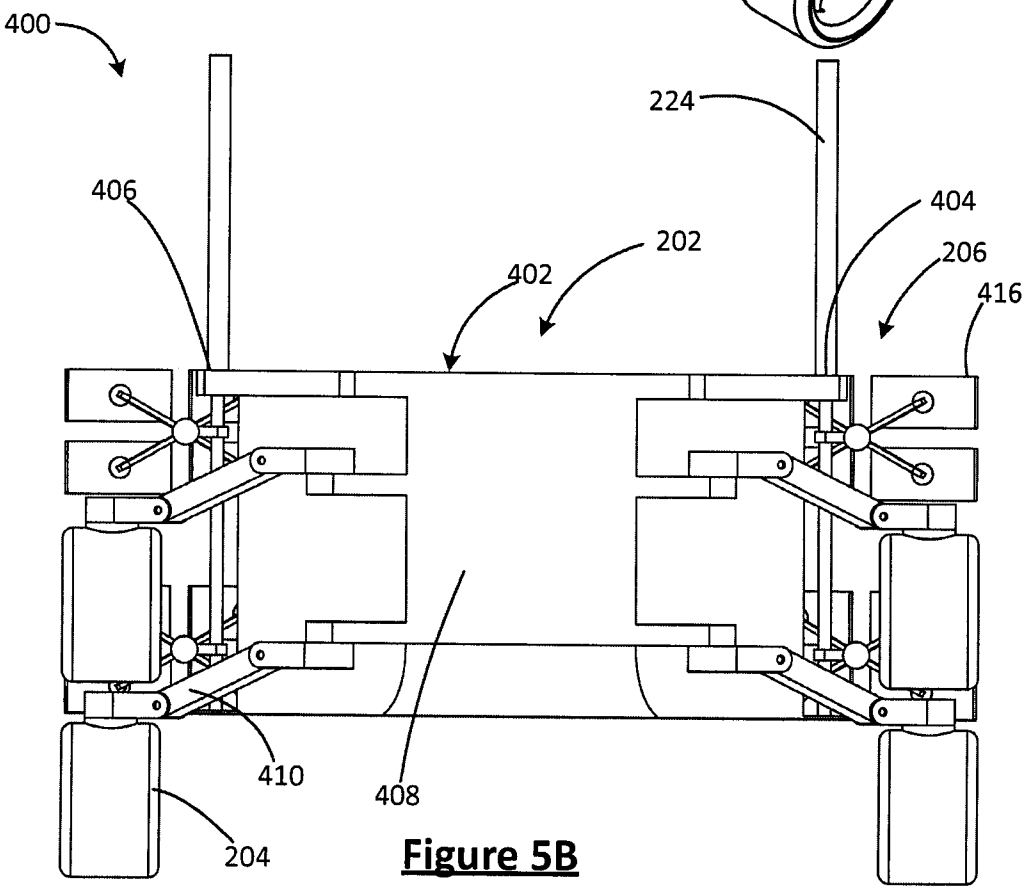

Figure 5B

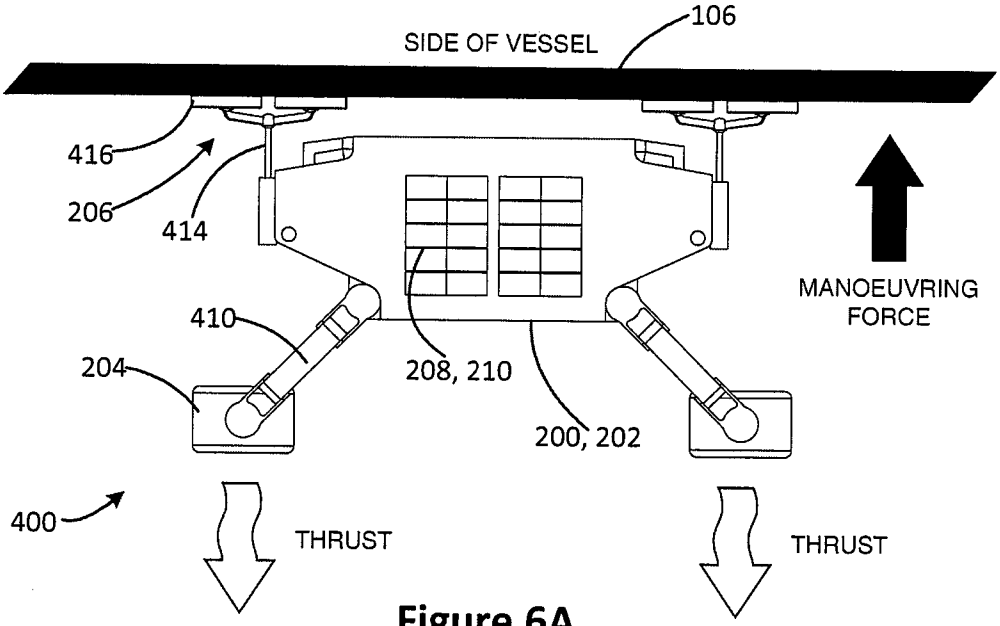

Figure 6A

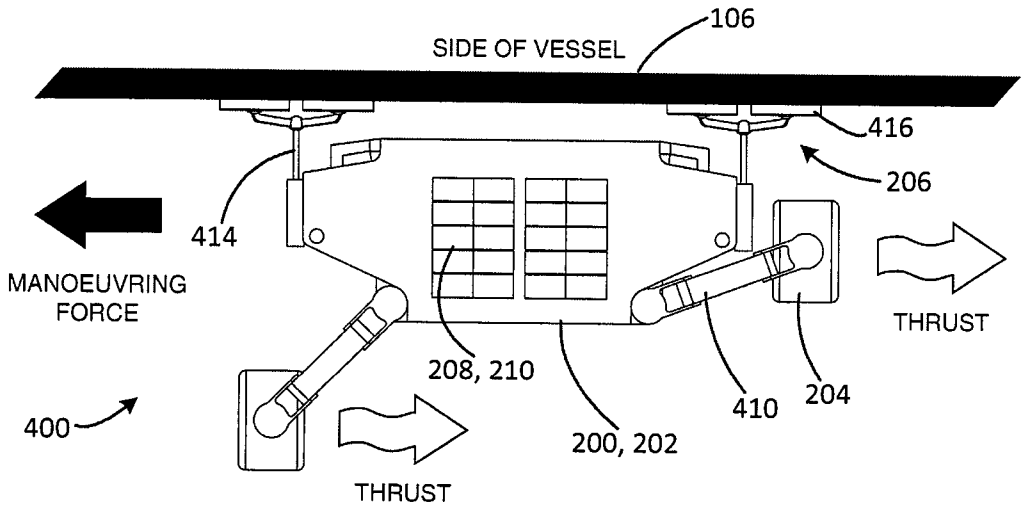

Figure 6B

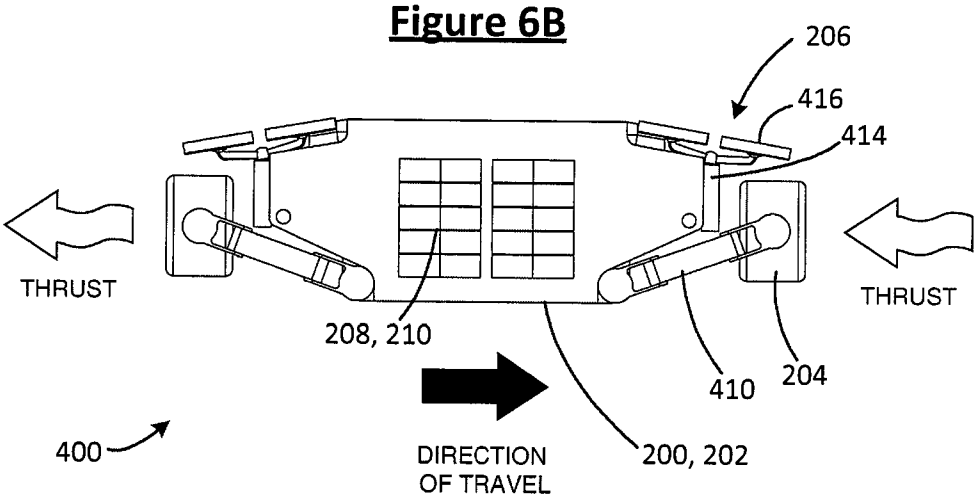

Figure 6C

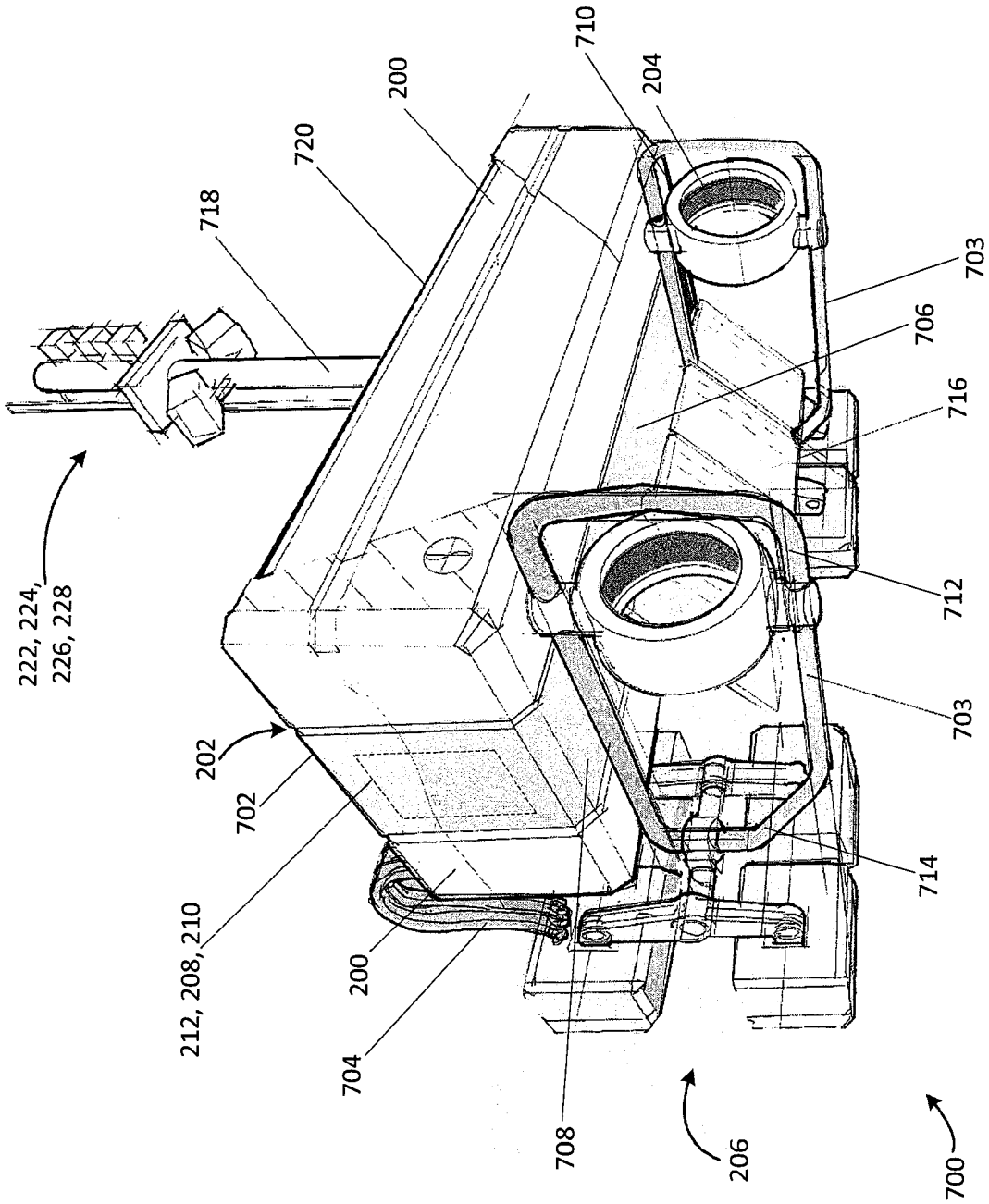
710
204
200
720
718
703
706
716
222, 224,
226, 228
712
703
202
702
714
212, 208, 210
200
704
708
206
700

Figure 7

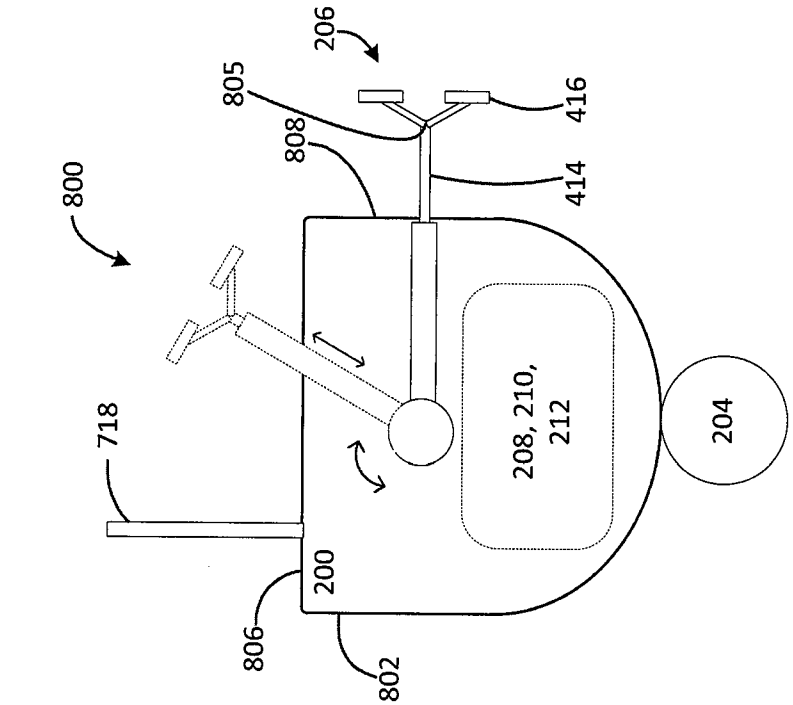

Figure 8B

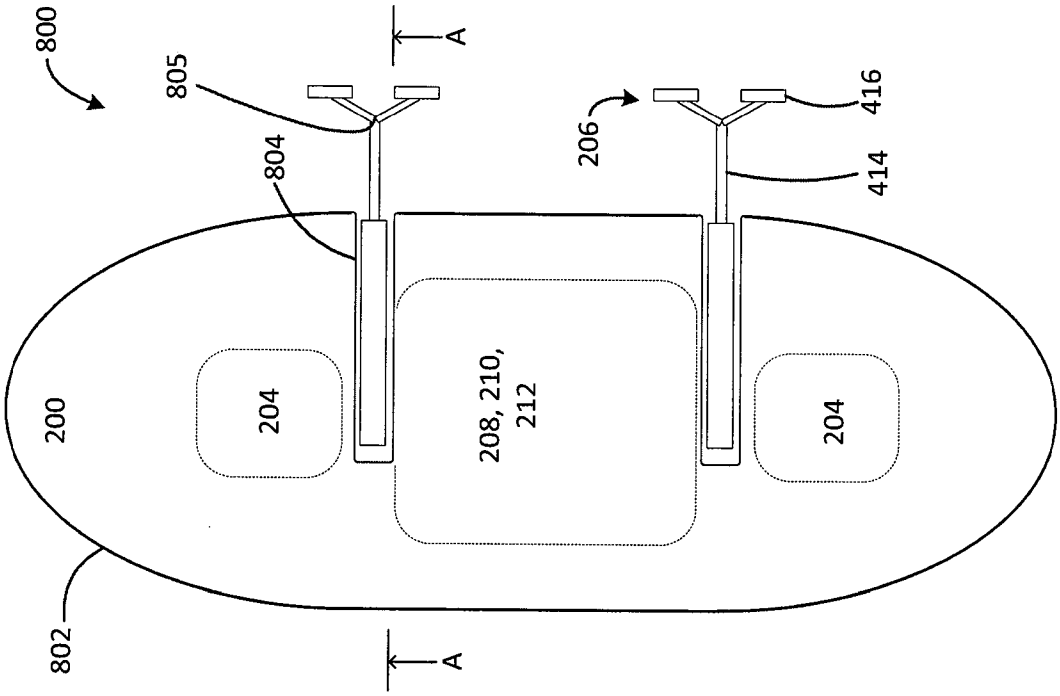

Figure 8A

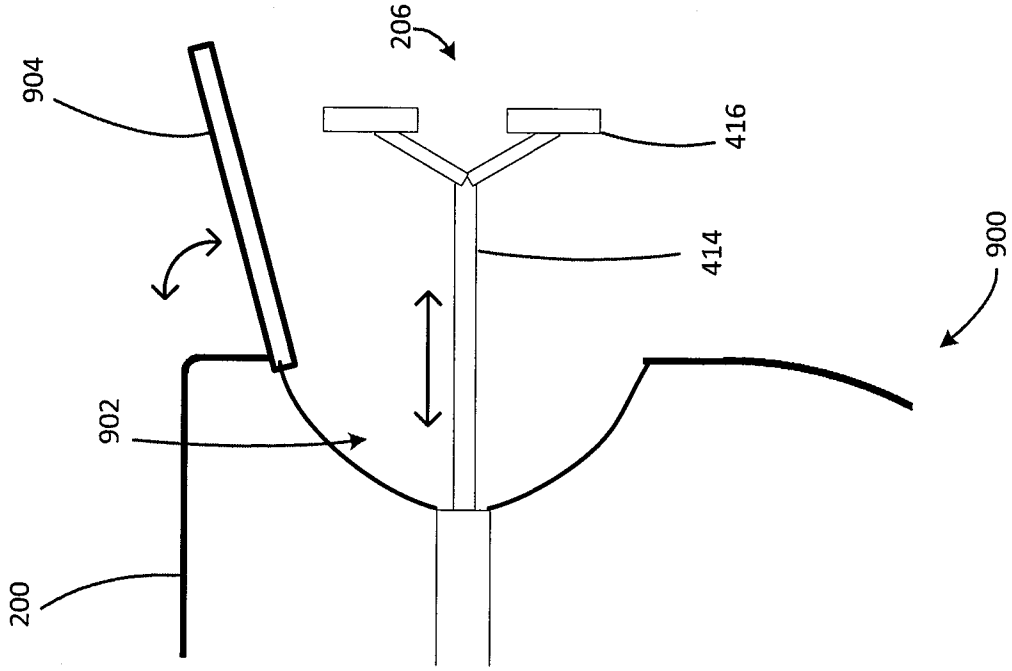

Figure 9B

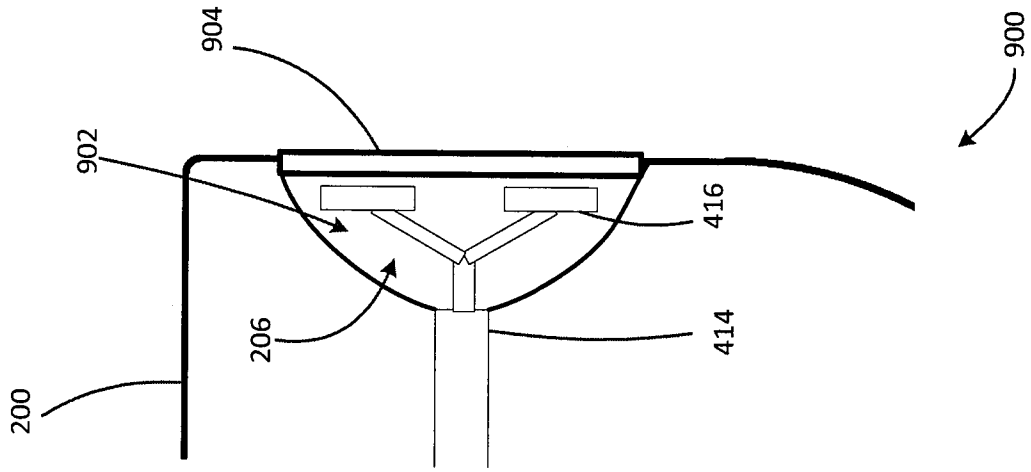

Figure 9A

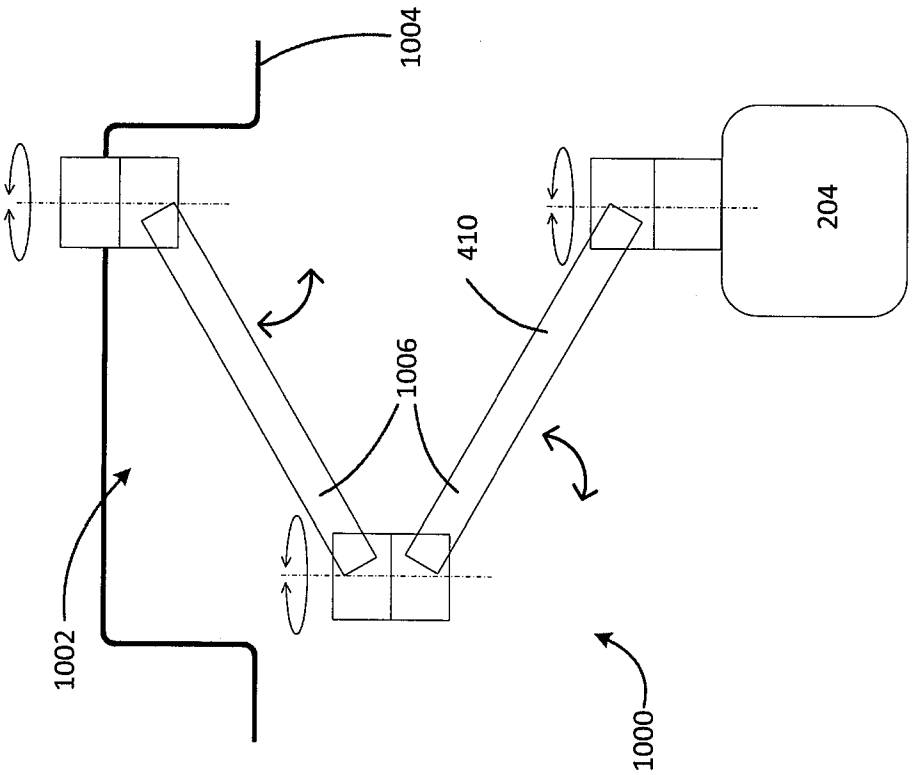

Figure 10B

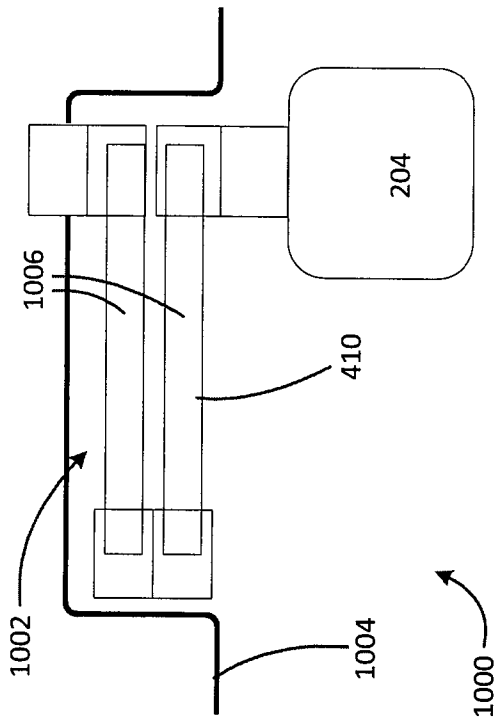

Figure 10A

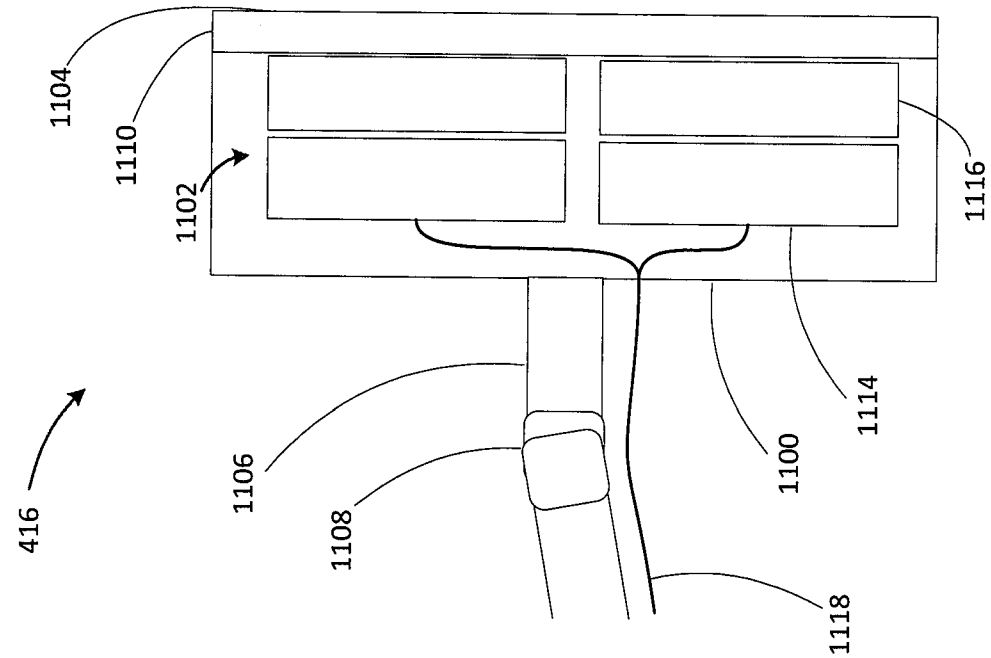

Figure 11B

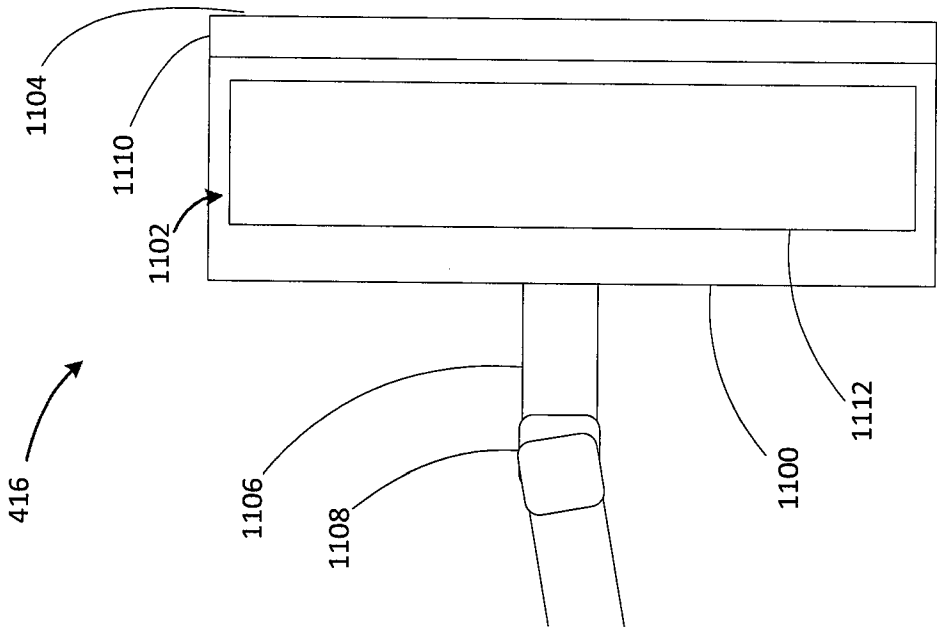

Figure 11A

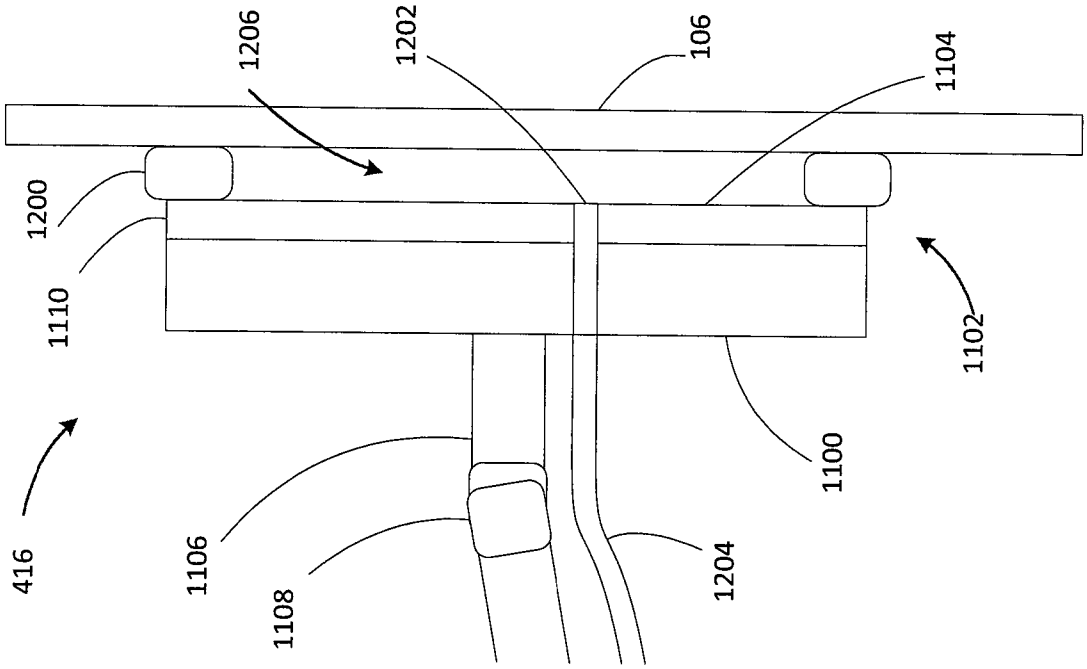

Figure 12B

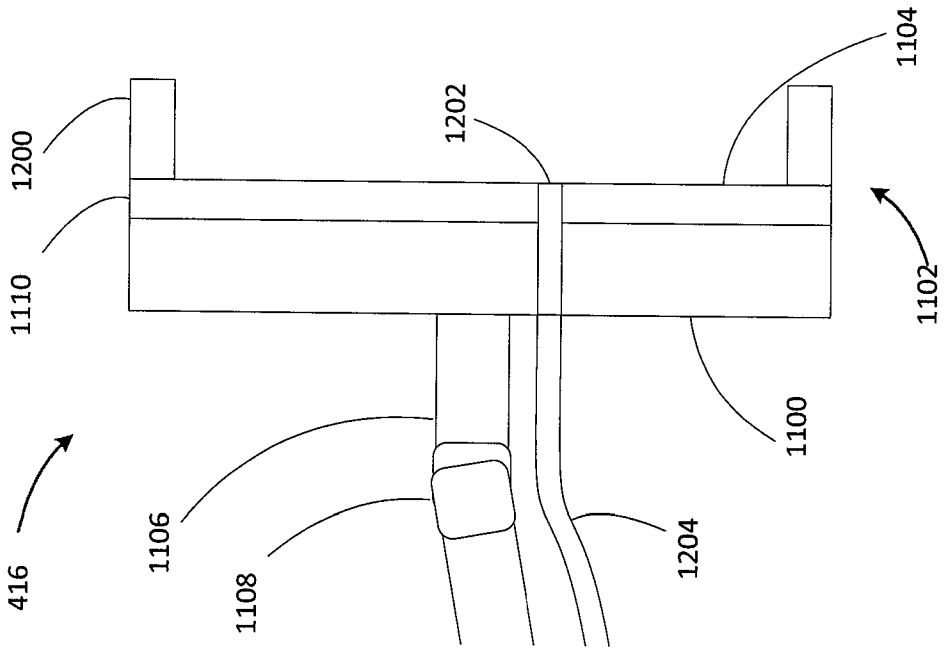

Figure 12A

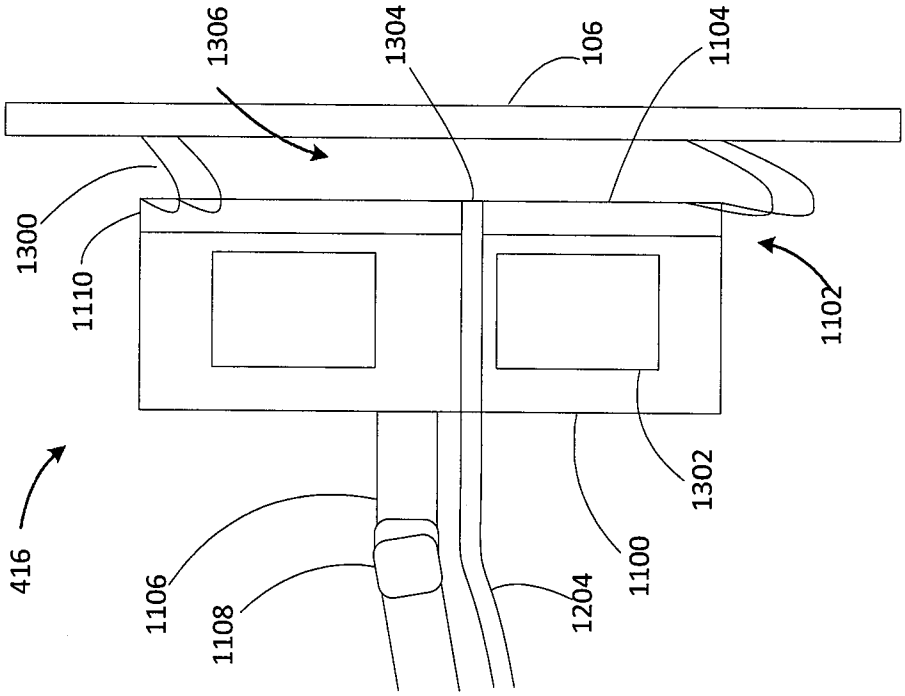

Figure 13B

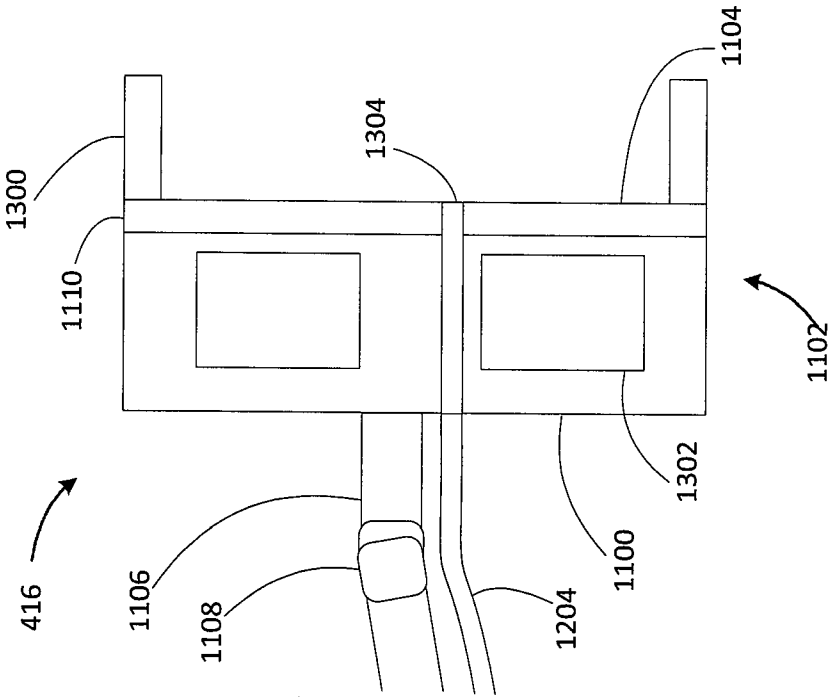

Figure 13A

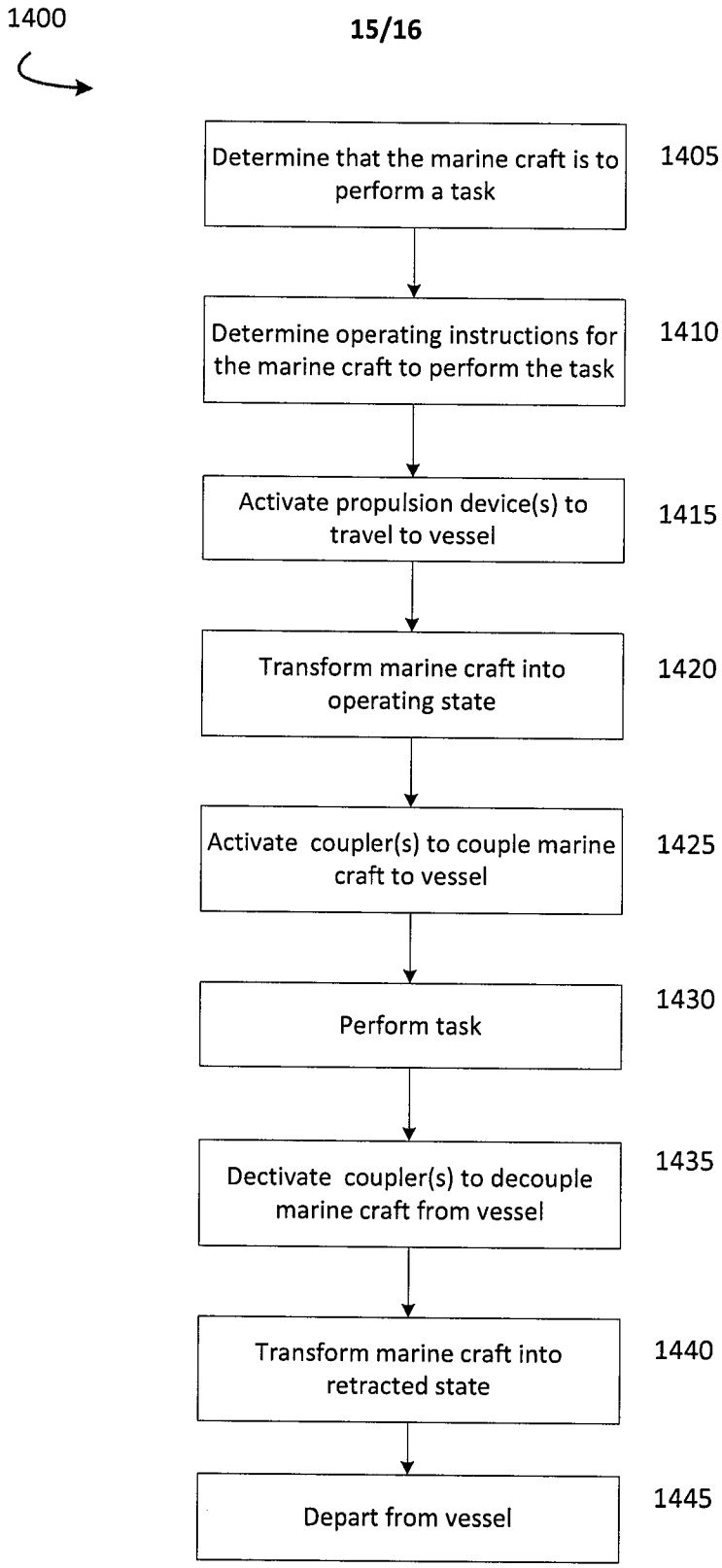
1400
Determine that the marine craft is to perform a task
1405
Determine operating instructions for the marine craft to perform the task
1410
Activate propulsion device(s) to travel to vessel
1415
Transform marine craft into operating state
1420
Activate coupler(s) to couple marine craft to vessel
1425
Perform task
1430
Dectivate coupler(s) to decouple marine craft from vessel
1435
Transform marine craft into retracted state
1440
Depart from vessel
1445

Figure 14

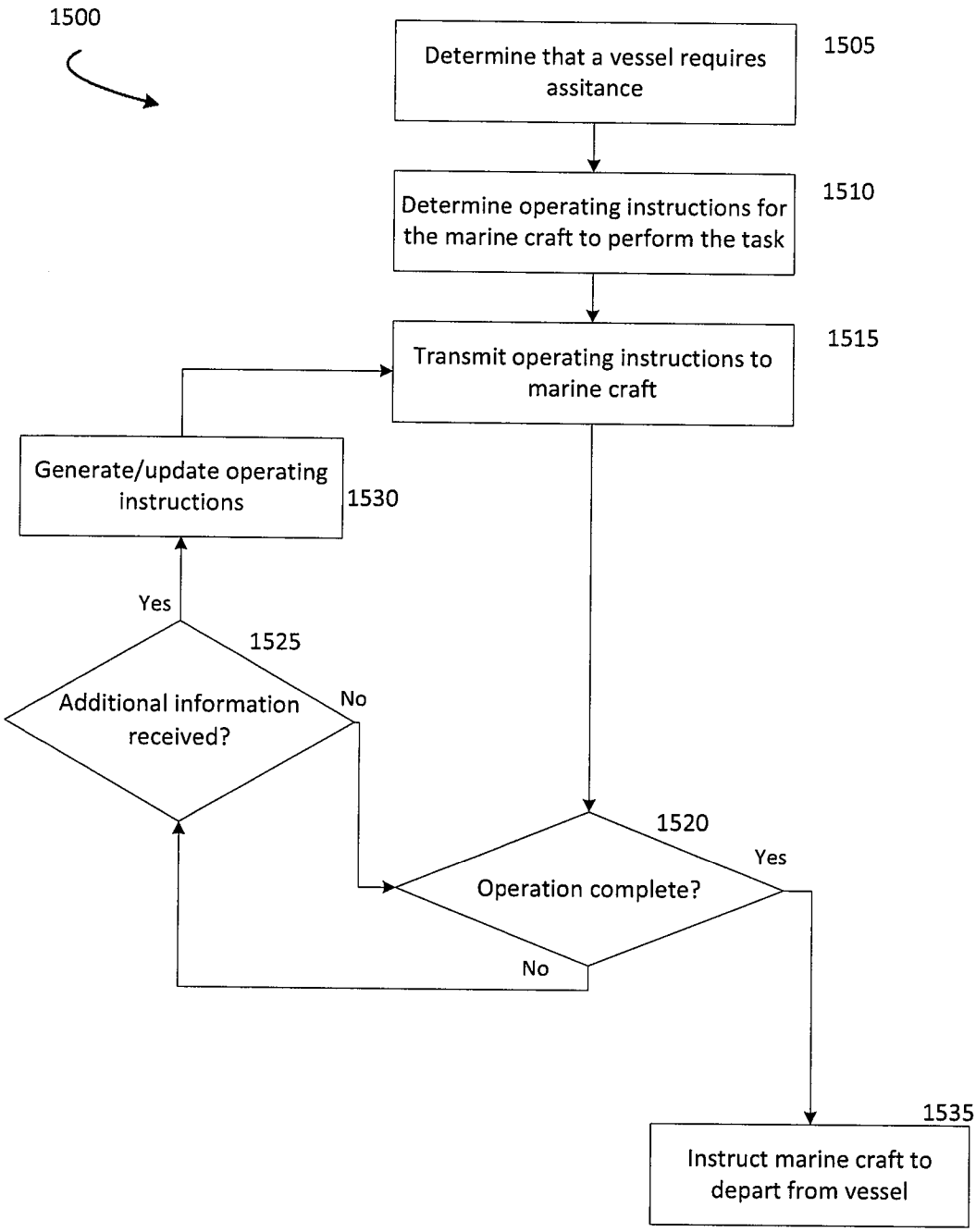
1500
Determine that a vessel requires assitance
1505
Determine operating instructions for the marine craft to perform the task
1510
Transmit operating instructions to marine craft
1515
Generate/update operating instructions
1530
Yes
1525
Additional information received?
No
1520
Operation complete?
Yes
No
1535
Instruct marine craft to depart from vessel

Figure 15

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2015/050457

A. CLASSIFICATION OF SUBJECT MATTER

B63B 35/66 (2006.01) B63B 21/56 (2006.01) B63H 25/02 (2006.01) G05D 1/02 (2006.01)

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

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

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

EPODOC/WPIAP/TXTE: IPC/CPC B63B21/02/low, 21/56/low, 35/66, 35/665, 2021/006, 2035/006/low; B63H2025/028; G05D1/02/low, 1/0206, 1/0875, 1/0011/low and/or Keywords (unmanned, non-manned, autonomous, remote, robot, slave, radio-control, wireless, tug, push, pull, manoeuver, manipulate, dock, berth, marine, ship, boat, craft, vessel, USV, ASC, rig, platform, rare earth, monitor, check, observe, record, operate, undertake, task, execute, perform, action, couple, tow, rescue, recover, identify, designate, target) & like terms.

ESPACENET: CPC B63B 21/02, 21/56/low, 35/665, 2035/006/low; B63H2025/28 and Keywords (unmanned, autonomous, remote, rare earth) & like terms; Applicant/Inventor name searches. IP^{2}SG Patent Database: Applicant name search. AUSPAT: Applicant and Inventor name searches.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
2 November 2015	02 November 2015
Name and mailing address of the ISA/AU	**Authorised officer**
AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA Email address: pct@ipaustralia.gov.au	Mark Smith AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No. 0262832573

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2015/050457

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:

because they relate to subject matter not required to be searched by this Authority, namely:

the subject matter listed in Rule 39 on which, under Article 17(2)(a)(i), an international search is not required to be carried out, including

2. ☐ Claims Nos.:

because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos:

because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a)

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See Supplemental Box for Details

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☒ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		International application No. **PCT/AU2015/050457**
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 6269763 B1 (WOODLAND) 07 August 2001 Whole document Cols 12-13; Figs 3, 14 & 26-27	1-6, 8, 9, 11-32, 35-64 7, 10
X	JP H06255574 A (MITSUBISHI HEAVY INDUSTRIES LTD et al.) 13 September 1994, [ESPACENET English translation] Abstract; Pars [06]-[12]; Figs 1-6	1-2, 11, 16, 21-24, 27, 31-49, 50-52, 62, 63
X	US 6354235 B1 (DAVIES) 12 March 2002 Abstract; Col. 4 line 51 - col. 11 line 27; Figs 7-10	1-3, 11, 23-24, 27-34
Y	US 2009/0123233 A1 (HERZOGENRATH) 14 May 2009 Abstract; Pars [22]-[23], [32]-[33]; Fig. 1	7
Y	JP H07223582 A (MITSUBISHI HEAVY INDUSTRIES LTD) 22 August 1995, [ESPACENET English translation] Abstract	10
Y	US 2007/0203623 A1 (SAUNDERS et al.) 30 August 2007 Whole document, esp. Pars [195]-[242]; Figs 1, 14, 19	53, 58-64
Y	US 2012/0265380 A1 (KUWATA et al.) 18 October 2012 Abstract; Pars [79] - [92], [170]-[175]	53, 58-64
A	US 6056237 A (WOODLAND) 02 May 2000, [Explicitly incorporated into D1 by reference, see col. 16 line 65.] Whole document, esp. col. 15 et seq.	2, 21-22, 32-34, 36, 38, 44, 62-64
A	WO 2004/103830 A2 (AEPCO, INC.) 02 December 2004 Abstract; Fig. 10	1
A	WO 2006/004584 A2 (MARQUARDT) 12 January 2006 Abstract; Par. [34]	35, 53
A	KR 20110059206 A (KIM et al.) 02 June 2011, [ESPACENET English translation] Abstract	51-52, 56

INTERNATIONAL SEARCH REPORT	International application No. PCT/AU2015/050457

Supplemental Box

Continuation of: **Box III**

This International Application does not comply with the requirements of unity of invention because it does not relate to one invention or to a group of inventions so linked as to form a single general inventive concept.

This Authority has found that there are different inventions based on the following features that separate the claims into distinct groups:

- I. Claims 1-32, 33-34, 35-52 and 62-64 (when appended to claims 35-52) are directed to a marine craft, a system including the craft, a method of controlling the marine craft to perform an unmanned surface level operation, and a computer readable medium encoded with computer executable instructions for the controller to carry out the method. The features/steps of a controller for a propulsion drive and a coupler wherein the controller is operative to control the propulsion drive and couple and decouple the marine craft from a vessel are specific to this first group of claims.
-
- II. Claims 53-61, 62-63 (when appended to claims 53-61) and 64 are directed to a method of controlling a marine craft to perform an unmanned surface level operation under control of a remote computing device, a computer readable medium encoded with computer executable instructions for the remote computer to carry out the method and a system including the remote computing device. The steps of the remote computing device transmitting an (unspecified) task performance request and operating instructions to a controller of a marine craft over a wireless communications network and monitoring operations of the marine craft until task completion is specific to this second group of claims.

PCT Rule 13.2, first sentence, states that unity of invention is only fulfilled when there is a technical relationship among the claimed inventions involving one or more of the same or corresponding special technical features. PCT Rule 13.2, second sentence, defines a special technical feature as a feature which makes a contribution over the prior art.

When there is no special technical feature common to all the claimed inventions there is no unity of invention.

In the above groups of claims, the identified features may have the potential to make a contribution over the prior art but are not common to all the claimed inventions and therefore cannot provide the required technical relationship. The only feature common to all of the claimed inventions and which provides a technical relationship among them is the remotely coordinated, autonomous operation of an unmanned marine craft involving a remote computing device and a wireless communications link between the computing device and on-board controller.

However this feature does not make a contribution over the prior art because it is disclosed in:
D1: US 6269763 B1 (WOODLAND) 7 August 2001

Therefore in the light of this document this common feature cannot be a special technical feature. Therefore there is no special technical feature common to all the claimed inventions and the requirements for unity of invention are consequently not satisfied *a posteriori*.

It was considered that search and examination for the second invention will require more than negligible additional search and examination effort over that for the first invention alone, and therefore an additional search fee was warranted.

INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/AU2015/050457**

This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document/s Cited in Search Report		**Patent Family Member/s**	
Publication Number	**Publication Date**	**Publication Number**	**Publication Date**
US 6269763 B1	07 August 2001	US 6269763 B1	07 Aug 2001
JP H06255574 A	13 September 1994	JP H06255574 A	13 Sep 1994
US 6354235 B1	12 March 2002	US 6354235 B1	12 Mar 2002
		CA 2357477 A1	19 Mar 2003
US 2009/0123233 A1	14 May 2009	US 2009123233 A1	14 May 2009
JP H07223582 A	22 August 1995	JP H07223582 A	22 Aug 1995
US 2007/0203623 A1	30 August 2007	US 2007203623 A1	30 Aug 2007
		US 2011004367 A1	06 Jan 2011
US 2012/0265380 A1	18 October 2012	US 2012265380 A1	18 Oct 2012
		US 8849483 B2	30 Sep 2014
US 6056237 A	02 May 2000	US 6056237 A	02 May 2000
WO 2004/103830 A2	02 December 2004	WO 2004103830 A2	02 Dec 2004
		CN 1809493 A	26 Jul 2006
		EP 1633636 A2	15 Mar 2006
		EP 1633636 B1	11 Dec 2013
		JP 2007516124 A	21 Jun 2007
		JP 4773967 B2	14 Sep 2011
		KR 20060014405 A	15 Feb 2006
		KR 101130939 B1	29 Mar 2012
		US 2004237870 A1	02 Dec 2004
		US 7096811 B2	29 Aug 2006
WO 2006/004584 A2	12 January 2006	WO 2006004584 A2	12 Jan 2006
KR 20110059206 A	02 June 2011	KR 20110059206 A	02 Jun 2011

End of Annex

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.