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## STEERING SYSTEM FOR A MARINE VESSEL

### FIELD OF THE INVENTION

5 The present invention relates to a steering system for a waterjet propelled marine vessel.

### BACKGROUND TO THE INVENTION

10 A waterjet drive unit for a marine vessel comprises a steering deflector or nozzle (herein a deflector) through which water is expelled to propel the vessel, and which may be moved from one side to the other to change the angle of the waterjet to cause the vessel to steer to port or starboard when underway. A vessel propelled by two or more waterjet units, such as a catamaran with a waterjet unit in each hull, comprises a control system arranged to move the steering deflectors of both waterjet units. The steering deflectors are controlled by the  
15 helmsperson via a steering control device such as a helm wheel or a joystick which may be either pivoted from side to side or rotated to control the steering deflectors in different embodiments, or another form of steering control device.

20 It is an object of the present invention to provide an improved or at least alternative steering system for a marine vessel propelled by two or more waterjet units.

### SUMMARY OF THE INVENTION

25 In a first aspect, the present invention consists in of a steering system for a marine vessel comprising:

two or more waterjet units for propelling the vessel, each having a steering deflector;  
a manually moveable steering control device which is movable to steer the vessel to port or starboard; and

30 an associated control system arranged to operate the steering deflectors in accordance with movement of the steering control device to cause turning of the vessel and also to lower a reverse duct of an inside (to a turn) waterjet unit when a higher rate of turning of said vessel is commanded by the steering control device.

35 Preferably, the control system is arranged to cause the inside reverse duct to lower to an increasing extent when an increasing rate of turning is commanded by the steering control device.

Preferably, the control system is also arranged to alter the thrust generated by the inside and/or outside waterjet unit(s) when a higher rate of turning is commanded by the steering control device.

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Preferably, the control system is also arranged to increase the thrust generated by the inside waterjet unit when a higher rate of turning is commanded by the steering control device.

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Preferably, the control system is also arranged to increase the thrust generated by the outside waterjet unit when a higher rate of turn is commanded by the steering control device.

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Preferably, the control system is arranged to alter the thrust generated by the inside and/or outside waterjet unit(s) to a first extent when the steering control device is moved to command a first extent of turning and to a greater extent when the steering control device is moved to command a greater extent of turning.

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Preferably, the control system is arranged to cause the inside reverse duct to lower when the steering control device is moved to command a first extent of turn and to increase the thrust generated by the inside and/or outside waterjet unit(s) when the steering control device is moved to command a greater extent of turning.

Preferably, the control system is arranged to lower the reverse duct to different extent for different forward speeds of the vessel, for an equivalent rate of turn.

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Preferably, the steering control device is operable to steer the vessel at cruise speeds of the vessel wherein the steering control device is a helm wheel.

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Preferably, the steering control device is operable to steer the vessel at cruise speeds of the vessel and the vessel also comprises a separate manually movable control device operable to manoeuvre the vessel at slow speeds.

Preferably, the steering device is a helm wheel and the manoeuvre control device is movable in multiple axes.

In a second aspect, the present invention consists in a steering system for a marine vessel comprising:

two or more waterjet units each having a steering deflector, for propelling the vessel;  
a manually moveable steering control device which is movable to steer the vessel to  
5 port or starboard; and

an associated control system arranged to activate the steering deflectors of the waterjet units and alter the thrust generated by the inside and/or outside waterjet unit(s) in accordance with movement of the steering control device to cause turning of the vessel.

10 Preferably, the control system is arranged to operate the steering deflectors with movement of the steering control device to cause turning of the vessel and to also alter the thrust generated by the inside and/or outside waterjet unit(s) when a higher rate of turning of the vessel is commanded.

15 Alternatively, the control system is arranged to alter the thrust generated by the inside and/or outside waterjet unit(s) with movement of the steering control device to cause turning of the vessel and to also operate the steering deflectors when a higher rate of turning of the vessel is commanded.

20 Preferably, the control system is arranged to increase the thrust generated by the outside waterjet unit when a higher rate of turning is commanded by the steering control device.

Alternatively, the control system is arranged to decrease the thrust generated by the inside waterjet unit when a higher rate of turning is commanded by the steering control device.

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Alternatively, the control system is arranged to increase the thrust generated by the outside waterjet unit and decrease the thrust generated by the inside waterjet unit when a higher rate of turning is commanded by the steering control device.

30 Preferably, the control system is arranged to move the steering deflectors and alter the thrust generated by the inside and/or outside waterjet unit(s) to a first extent when the steering control device is moved to command a first extent of turning and to further move the steering deflectors and alter the thrust generated by the inside and/or outside waterjet unit(s) when the steering control device is moved to command a greater extent of the turning.

Alternatively, the control system is arranged to alter the thrust of the waterjet unit(s) to a first extent when the steering control device is moved to command a first extent of turn and to a greater extent when the steering control device is moved to command a greater extent of the  
5 turn.

Preferably, the control system is arranged to alter the thrust of the waterjet unit(s) to a different extent for different forward speeds of the vessel.

10 Preferably, the control system is also arranged to lower a reverse duct of an inside waterjet unit when a higher rate of turning is commanded by the steering control device.

Preferably, the steering control device is operable to steer the vessel at cruise speeds of the vessel.

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Preferably, the steering control device is a helm wheel.

Preferably, the steering control device is operable to steer the vessel at cruise speeds of the vessel and the vessel also comprises a separate manually movable control device operable to  
20 manoeuvre the vessel at slow speeds.

Preferably, the steering device is a helm wheel and the manoeuvre control device is movable in multiple axes.

25 In a third aspect, the present invention consists in a steering system for a marine vessel comprising:

two or more waterjet units each having a steering deflector, for propelling the vessel;  
a manually moveable steering control device which is movable to steer the vessel to  
port or starboard; and

30 an associated control system arranged to alter the thrust of the inside and/or outside waterjet units in accordance with movement of the steering control device to cause turning of the vessel.

Preferably, the control system is arranged to increase the thrust generated by the outside waterjet unit with movement of the steering control device to cause turning of the vessel.

5 Alternatively, the control system is arranged to decrease the thrust generated by the inside waterjet unit with movement of the steering control device to cause turning of the vessel.

Alternatively, the control system is arranged to increase the thrust generated by the outside waterjet unit and decrease the thrust generated by the inside waterjet unit with movement of the steering control device to cause turning of said vessel.

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Preferably, the control system is arranged to alter the thrust generated by the inside and/or outside waterjet unit(s) to a first extent when the steering control device is moved to command a first extent of turn and to further alter the thrust generated by the inside and/or outside waterjet unit(s) when the steering control device is moved to command a greater extent of the turning.

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Preferably, the control system is arranged to alter the thrust of the waterjet unit(s) to a different extent for different forward speeds of the vessel, for an equivalent rate of turn.

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Alternatively, the control system is also arranged to lower a reverse duct of the inside waterjet unit when the steering control device is moved to command a greater extent of the turn.

Preferably, the control system is also arranged operate the steering deflectors of the waterjet units when the steering control device is moved to command a greater extent of the turn.

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Preferably, the steering control device is operable to steer the vessel at cruise speeds of the vessel.

Preferably, the steering control device is a helm wheel.

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Preferably, the steering control device is operable to steer the vessel at cruise speeds of the vessel and the vessel also comprises a separate manually movable control device operable to manoeuvre the vessel at slow speeds.

Preferably, the steering device is a helm wheel and the manoeuvre control device is movable in multiple axes.

In a fourth aspect, the present invention consists in a steering system for a marine vessel  
5 comprising:

two or more waterjet units each having a steering deflector, for propelling the vessel;  
a manually moveable steering control device which is movable to steer the vessel to  
port or starboard; and

10 an associated control system arranged to operate the steering deflectors of the waterjet  
units in accordance with movement of the steering control device to cause turning of the  
vessel and also to alter the thrust of the inside and/or outside waterjet units in accordance with  
movement of the steering control device.

15 Preferably, the control system is arranged to decrease the thrust generated by the inside  
waterjet unit.

Alternatively, the control system is arranged to increase the thrust generated by the outside  
waterjet unit.

20 Alternatively, the control system is arranged to increase the thrust generated by the outside  
waterjet unit and decrease the thrust generated by the inside waterjet unit.

25 Preferably, the control system is arranged to alter the thrust of the waterjet unit(s) to a  
different extent for different forward speeds of the vessel, for an equivalent rate of turn.

Alternatively, the control system is arranged to alter the thrust of the waterjet unit(s) to an  
increasing extent when an increasing rate of turn is commanded.

30 Alternatively, the control system is also arranged to lower a reverse duct of the inside waterjet  
unit when the steering control device is moved to command a greater extent of the turn.

Preferably, the steering control device is operable to steer the vessel at cruise speeds of the  
vessel.

Preferably, the steering control device is a helm wheel.

Preferably, the steering control device is operable to steer the vessel at cruise speeds of the vessel and the vessel also comprises a separate manually movable control device operable to  
5 manoeuvre the vessel at slow speeds.

Preferably, the steering device is a helm wheel and the manoeuvre control device is movable in multiple axes.

10 In fifth aspect, the present invention consists in a steering system for a marine vessel comprising:

two or more waterjet units each having a steering deflector for propelling the vessel;  
a manually moveable steering control device which is movable to steer the vessel to  
port or starboard; and

15 an associated control system operable to alter the thrust of the waterjet units to lower a reverse duct of an inside (to a turn) waterjet unit in accordance with movement of the steering control device to cause turning of the vessel.

Preferably, the control system is arranged to alter the thrust generated by the inside and/or  
20 outside waterjet unit(s) with movement of the steering control device to cause turning of the vessel and to also lower a reverse duct of an inside waterjet unit when a higher rate of turning is commanded.

Alternatively, the control system is arranged to lower a reverse duct of an inside waterjet unit  
25 with movement of the steering control device to cause turning of the vessel and to also alter the thrust generated by the inside and/or outside waterjet unit(s) when a higher rate of turning is commanded.

Preferably, the control system is arranged to decrease the thrust generated by the inside  
30 waterjet unit.

Alternatively, the control system is arranged to increase the thrust generated by the outside waterjet unit.

Alternatively, the control system is arranged to increase the thrust generated by both the outside and inside waterjet units when the inside reverse duct is lowered when a higher rate of turning of said vessel is commanded by the steering control device.

- 5 Preferably, the control system is arranged to alter the thrust and/or lower a reverse duct to different extents for different forward speeds of the vessel.

Preferably, the control system is arranged to also operate the steering deflectors when a higher rate of turning of is commanded by the steering control device.

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Preferably, the steering control device is operable to steer the vessel at cruise speeds of the vessel.

Preferably, the steering control device is a helm wheel.

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Preferably, the steering control device is operable to steer the vessel at cruise speeds of the vessel and the vessel also comprises a separate manually movable control device operable to manoeuvre the vessel at slow speeds.

- 20 Preferably, the steering device is a helm wheel and the manoeuvre control device is movable in multiple axes.

In a sixth aspect, the present invention consists in a steering system for a marine vessel comprising:

- 25 two or more waterjet units each having a steering deflector for propelling the vessel;  
a manually moveable steering control device which is movable to steer the vessel to port or starboard; and

- an associated control system operable to activate the steering deflectors and lower the reverse duct of an inside (to a turn) waterjet unit in accordance with movement of the steering control device to cause turning of the vessel when turning of the vessel is commanded by the steering control device.
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Preferably, the control system is arranged lower the reverse duct of an inside waterjet unit with movement of the steering control device to cause turning of the vessel and to also activate the steering deflectors when a higher rate of turning is commanded.

5 Preferably, the control system is arranged to cause the inside reverse duct to lower to a first extent when the steering control device is moved to command a first extent of turn and lower to a greater extent when the steering control device is moved to command a greater extent of the turn.

10 Alternatively, the control system is arranged to cause the inside reverse duct to lower to an increasing extent when an increasing rate of turning is commanded by the steering control device.

15 Preferably, the control system is also arranged to increase the thrust generated by the inside and/or outside waterjet unit(s) when a higher rate of turning of said vessel is commanded by the steering control device.

20 Preferably, the control system is arranged to lower the reverse duct to different extents for different forward speeds of the vessel, for an equivalent rate of turn.

25 Preferably, the steering control device is operable to steer the vessel at cruise speeds of the vessel.

30 Preferably, the steering control device is a helm wheel.

35 Preferably, the steering control device is operable to steer the vessel at cruise speeds of the vessel and the vessel also comprises a separate manually movable control device operable to manoeuvre the vessel at slow speeds.

40 Preferably, the steering device is a helm wheel and the manoeuvre control device is movable in multiple axes.

In a seventh aspect, the present invention consists in a steering system for a marine vessel comprising:

two or more waterjet units each having a steering deflector for propelling the vessel;  
a manually moveable steering control device which is movable to steer the vessel to  
port or starboard; and

an associated control system operable to lower said reverse duct of an inside (to a turn)  
5 waterjet unit in accordance with movement of the steering control device to cause turning of  
the vessel and also arranged to alter the thrust of the waterjet units when a higher rate of  
turning of said vessel is commanded by the steering control device.

10 Preferably, the control system is arranged to cause the inside reverse duct to lower to a first  
extent when the steering control device is moved to command a first extent of turn and lower  
to a greater extent when the steering control device is moved to command a greater extent of  
the turn.

15 Alternatively, the control system is arranged to cause the inside reverse duct to lower to an  
increasing extent when an increasing rate of turning is commanded by the steering control  
device.

20 Preferably, the control system is also arranged to activate the steering deflectors of the  
waterjet units when said steering control device is moved to command a greater extent of  
turning.

Alternatively, the control system is arranged to lower the reverse duct to different extents for  
different forward speeds of the vessel, for an equivalent rate of turn.

25 Preferably, the steering device is operable to steer the vessel at cruise speeds of the vessel.

Preferably, the steering control device is a helm wheel.

30 Preferably, the steering device is operable to steer the vessel at cruise speeds of the vessel and  
the vessel also comprises a separate manually movable control device operable to manoeuvre  
the vessel at slow speeds.

Preferably, the steering device is a helm wheel and the manoeuvre control device is movable  
in multiple axes.

To those skilled in the art to which the invention relates, many changes in construction and widely differing embodiments and applications of the invention will suggest themselves without departing from the scope of the invention as defined in the appended claims. The disclosures and the descriptions herein are purely illustrative and are not intended to be in any sense limiting. The term 'comprising' as used in this specification and claims means 'consisting at least in part of', that is to say when interpreting statements in this specification and claims which include that term, the features, prefaced by that term in each statement, all need to be present but other features can also be present.

In this specification and the accompanying claims:

"vessel" is intended to include boats such as smaller pleasure runabouts and other boats, larger launches whether mono-hulls or multi-hulls, and larger ships. More generally, the control device of the invention may be suitable for any planing or displacement type vessels, regardless of their size, speed capabilities, and hull type.

"thrust" (unless the context indicates otherwise) refers to the thrust output of the propulsion unit(s) or engine(s) of the vessel before any deflection of the waterjet stream of by the steering deflector(s) and/or reverse duct(s); the thrust of one or both (or more) waterjet units is increased or decreased by an increase or decrease in the power output of the engine(s) driving that or those waterjet unit(s), by increasing or decreasing the throttle opening for those engine(s) in the case of an internal combustion engine for example.

"cruise speeds" is intended to mean vessel speeds over 5 knots, more preferably vessel speeds over 8 knots, and most preferably vessel speeds of 10 knots or above.

"slow speeds" is intended to mean vessel speeds of up to 5 knots

The invention consists in the foregoing and also envisages constructions of which the following gives examples only.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

Various forms of the invention will be described by way of example only and with reference to the drawings, in which:

**Figure 1** shows a schematic of one example form of the steering system;

5 **Figure 2** shows a turning manoeuvre using a steering system of one embodiment of the invention;

**Figure 3** shows a sharper turning manoeuvre using the steering system of Figure 2;

**Figure 4** shows a sharper turning manoeuvre using another embodiment of the invention;

**Figure 5** shows a sharper turning manoeuvre using a further embodiment of the invention;

10 **Figure 6** shows a turning manoeuvre using another embodiment of the invention;

**Figure 7** shows a sharper turning manoeuvre using the steering system of Figure 6;

**Figure 8** shows a turning manoeuvre using another embodiment of the invention;

**Figure 9** shows a sharper turning manoeuvre using the steering system of Figure 8;

15 **Figure 10** shows a sharper turning manoeuvre using another embodiment of the invention;  
and

**Figure 11** shows a sharper turning manoeuvre using another embodiment of the invention.

#### **DETAILED DESCRIPTION OF EMBODIMENTS**

20 The invention is now described with reference to marine vessels that are propelled with two waterjet units at the stern of the vessel ('twin waterjet vessel'). The systems and methods of the invention may also be used on waterjet vessels propelled by more than two waterjet units, such as three or four waterjet units for example. A marine vessel such as a catamaran for example, may have two waterjet units on each of the port and starboard sides respectively at  
25 the stern of the vessel. This type of vessel is referred to as a "quad waterjet vessel."

Referring to Figure 1, a schematic arrangement of one embodiment of the steering system of the invention is shown. The system includes a control system 100, which may be in the form

of a microprocessor, microcontroller, programmable logic controller (PLC) or the like. The control system 100 is programmed to receive and process data so as to appropriately steer the vessel, as will be described in detail later. The control system 100 may be a stand-alone or dedicated controller for steering or may be incorporated into existing vessel controllers. In one form, the control system 100 is a plug-in module that is connected to a network, such as a  
5 Controller Area Network (CAN), in the waterjet vessel.

As shown in Figure 1, the control system 100 controls two waterjet units 102. The two waterjet units 102 are typically placed port and starboard at the stern of the vessel. Where  
10 more than two waterjet units are provided as referred to previously, the control system 100 may be adapted to steer at least one port waterjet unit and one starboard waterjet unit. Alternatively, the control system 100 may be adapted to steer two port waterjet units and one starboard waterjet unit if the vessel is turning to starboard for example. Whilst only two operational steering system configurations are detailed for vessels having more than two  
15 waterjet units, persons skilled in the art will appreciate that these are examples only and as such should not be considered to be in any way limiting.

Each waterjet unit 102 includes a pumping unit 104 driven by an engine 106 through a driveshaft 108. Each waterjet unit also includes a steering deflector 110 and a reverse duct  
20 112, of known form. In the form illustrated, each reverse duct 112 is of a type that features split passages to improve reverse thrust. The split-passage reverse duct 112 also affects the direction of the reverse thrust to port and starboard and thus the steering of the vessel, when the duct is lowered into the jet stream. The steering deflectors 110 pivot about generally vertical axes 114 while the reverse ducts 112 pivot about generally horizontal axes 116,  
25 independently of the steering deflectors. Activators for the engine throttle, steering deflector and reverse duct of each unit are controlled by control signals from the actuation modules 118 and 120 through control input ports 122, 124 and 126 respectively. The actuation modules 118 and 120 are in turn controlled by the control system 100.

30 The control system 100 receives inputs from a manually moveable steering control device 128, such as a helm wheel, or other steering control device for steering the vessel at speeds which include cruise speeds, such as a cruise-steering joystick. In at least some cases the vessel may also incorporate a separate control device operable to manoeuvre the vessel at slow speeds, such as a (second) multi-axis joystick for example, or other multi-axis

manoeuvre control device. The steering control device 128 is used by a helmsperson to manually steer the vessel at least at cruise speeds.

In the preferred embodiment, the control system 100 is activated as a result of the  
5 helmsperson moving the steering control device 128. This results in the control system 100  
generating all control signals to the activators to cause pivoting of the steering deflectors 110  
and/or altering the position of the reverse ducts 112 and/or changing the thrust output  
generated by the vessel's engines, to improve the steering command(s). Alternatively, there  
10 may also be one or more supplementary control devices, such as throttle levers to control the  
thrust of the waterjet units, that also can provide inputs to the control system 100. Where  
suitable or desired, the one or more supplementary control devices may form part of the  
steering control device 128 as mentioned above.

Figure 2 shows the operation of the manually moveable steering control device 128 and the  
15 control system 100 to turn a vessel 200 to port, as shown by arrow 202, in one embodiment of  
the invention. To make the turn, the helmsperson manually moves the steering control device  
128 to port. In the form shown, the steering control device 128 is a helm wheel that has been  
turned or rotationally displaced from a neutral position, represented by the phantom arrow  
128a, to port by a first range of motion or extent,  $\varphi_1$ , represented by arrow 128b. The  
20 rotational displacement of the helm wheel results in input signals, which represent the turning  
demanded by the helmsperson, being sent to the control system of the present invention. The  
control system then accordingly moves the steering deflectors 204 to port. The jet streams  
produced by the waterjet units are redirected as a result, which in turn produces force vectors  
206. The combined effect of the force vectors 206 on the port and starboard of the vessel  
25 stern is a turning moment to port. This then results in the vessel 200 making the turn  
demanded by the helmsperson.

Figure 3 shows the vessel 200 making a sharper turn 302 to port. The helmsperson moves the  
helm wheel 128 further to port. In this case, the helm wheel 128 has been turned or  
30 rotationally displaced from the neutral position, represented by the phantom arrow 128a, to  
port by a second range of motion or extent,  $\varphi_2$ , represented by arrow 128c. As compared to  
the turning manoeuvre demanded in Figure 2, the turning manoeuvre demanded in Figure 3 is  
much sharper, as reflected by the greater rotational displacement of  $\varphi_2$  of the helm wheel 128  
as compared to  $\varphi_1$ .

As in Figure 2, the rotational displacement of the helm wheel results in input signals, which represent the turning demanded by the helmsperson, being sent to the control system. As shown in Figure 3, the control system recognises a demand for a sharper turn when the rotational displacement of the helm wheel, or a corresponding movement of other steering control devices, is greater than a first range of motion or extent, and not only moves the steering deflectors 206 to port, but also lowers the reverse duct 304 of an inside (to the turn) waterjet unit. That is, the reverse duct of the side to which the vessel should be turned is lowered

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The effect of also lowering the reverse duct 304 on the inside (to the turn) waterjet unit is that the jet stream produced by the inside waterjet unit is be partially or fully redirected, producing a force vector 306 in the astern direction. The amount of jet stream redirected, and thus the magnitude of the force vector 306, is dependent on the extent to which the reverse duct is lowered. Force vector 306 in combination with the force vectors 206 produced by the redirection of the jet stream by the steering deflectors 204 results in a greater turning moment being generated. This then causes the vessel 200 to make the sharp turn demanded by the helmsperson.

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The steering system is thus arranged such that the increasing movement of the steering control device to port or starboard, such as increasing the rotational displacement of a helm wheel or of a single axis joystick, from a neutral position, increases the rate of turn of the vessel. When the steering control device 128 is moved to port or starboard over a first range of movement, the steering deflectors 110 of the waterjet units 102 move to cause a turning movement of the vessel 200 to port or starboard. This is shown in Figure 2. When the steering control device 128 is moved to a second range of movement, beyond the first range of movement to port or starboard, the control system 100 causes the inside reverse duct to be lowered so that the reverse duct impinges into the water flow from the inside waterjet and increases the turning moment on the vessel 200, sharpening the turn of the vessel 200. This is shown in Figure 3.

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In one form, the control system 100 may be arranged to cause the inside reverse duct to: (i) lower to a first extent as the steering control device 128 is moved to a first extent to commence the turn; (ii) lower to a greater extent as the steering control device 128 is moved

to a greater extent to sharpen the turn; and (iii) raise as the steering control device 128 is returned to a central position to complete the turn.

In another form, the control system 100 may be arranged to cause the inside reverse duct to lower only once a turn has commenced and the steering control device 128 is moved beyond a first extent, so that there is no lowering of the reverse duct as the steering control device 128 is turned to the first extent to commence the turn. Once the steering control device 128 is moved beyond the first extent, the reverse duct lowers in accordance with the movement of the steering control device 128 to increase the rate of turn to meet the turn rate commanded by the steering control device 128. The reverse duct then raises as the steering control device 128 is returned to a centre point to complete the turn.

The control system 100 may be programmed with either of the above forms, or alternatively with both of the above forms together with an input for a helmsperson to indicate which of the two forms should be applied.

The extent and rate at which the reverse duct is lowered is preferably proportional to the forward speed of the vessel 200. In other words, the inside reverse duct may lower to a lesser extent at a higher forward speed of the vessel than at a lower forward speed to make an equivalent turn. The reverse duct may lower so as to impinge partially into the jet stream from the inside waterjet unit, or to a greater extent into the jet stream from the inside waterjet unit so that there is no net forward thrust from the inside waterjet unit during a part or all of the turn. Alternatively, the reverse duct may lower fully so that a reverse thrust is provided by the inside waterjet unit to maximally increase the rate of turn of the vessel 200, particularly at slower speeds, at least during part of a turn. This benefits multi-hulled vessels such as catamarans, which have a poor turning capability at planing speed.

In another embodiment, the steering system of the invention is arranged to generate a higher turning moment by operating the throttles of the waterjet units differentially such that an inside (to the turn) waterjet unit generates less thrust when compared to the outside (to the turn) waterjet unit. This embodiment is described in detail below with reference to Figure 4. Figure 4 shows that the helmsperson has displaced the helm wheel 128 to port. The control system recognises the displacement of the helm wheel 128 as a demand for a sharp turn. As before, the control system moves the steering deflectors to port. To generate a greater turning

moment, the control system also operates the throttles of the waterjet units such that the thrust generated by the inside (to the turn) waterjet unit is lower than the thrust generated by the outside (to the turn) waterjet unit. In Figure 4, the thrust of the outside (to the turn) waterjet unit is increased, resulting in a force vector 406. Compared to the force vector of the outside (to the turn) waterjet unit in Figure 3, the force vector 406 has a higher magnitude, represented by the longer arrow of force vector 406.

As alternatives to increasing the thrust of the outside (to the turn) waterjet unit, the control system may reduce the thrust of the inside (to the turn) waterjet unit and maintain the thrust of the outside (to the turn) waterjet unit, or reduce the thrust of the inside (to the turn) waterjet unit and increase the thrust of the outside (to the turn) waterjet unit.

It is possible in a further embodiment to combine the above to generate a higher turning moment to make an even sharper turn. This is described below with reference to Figure 5. The figure shows, with arrow 502, the turn that is to be made by the vessel 200. Relative to the arrows 302 and 402, it is clear that the arrow 502 represents a much sharper turn. The helmsperson has rotationally displaced the helm wheel from the neutral position 128a by a third range of motion or extent  $\phi_3$  to a position 128d. In this embodiment, the control system interprets this motion of the helm wheel as a demand for a very sharp turn and causes a combination of using a reverse duct and manipulating the engine thrust to produce differential thrust to effect the sharp turn.

As with the embodiment described in Figure 3, the control system lowers the reverse duct of the inside (to the turn) waterjet unit. Unlike the partial lowering of the reverse duct in Figure 3, indicated with broken lines, the reverse duct in this embodiment is completely lowered. Also, the control system increases the thrust generated by the inside (to the turn) waterjet unit. The combination of these operations results in a higher magnitude force being generated astern, shown as force vector 506, as compared to the force vector 306 of Figure 3.

In Figure 5, the thrust generated by the outside (to the turn) waterjet unit remains the same during the turning manoeuvre. If an even higher turning moment is desired, which may be commanded by a further range of motion of the helm wheel, the control system may increase the thrust of the outside (to the turn) waterjet unit.

For each of the embodiments described above the steering deflectors of the waterjet units are moved to cause a turning movement to port or to starboard due to the movement of the steering control device from a neutral position to port or starboard.

5 In further alternative embodiments, the steering system can be arranged such that when the steering control device 128 is moved to port or starboard over a first range of movement shown as arrow 602 in Figure 6, the position of the inside (to a turn) reverse duct 604 is lowered partially or fully to cause a turning movement of the vessel to port or starboard. Figure 6 shows the inside reverse duct 604 in the partially lowered position 604. When the  
10 steering control device 128 is moved to a second range of movement, beyond the first range of movement to port or starboard shown as arrow 702 in Figure 7, the control system 100 causes the steering deflectors 706 of the water jet units to move to increase the turning moment on the vessel 200 thereby sharpening the turn to port or starboard. This will result in a force vector 708 as shown in Figure 7.

15 The control system 100 may be arranged to cause the inside reverse duct 704 to: (i) lower to a first extent as the steering control device 128 is moved to a first extent to commence the turn; (ii) lower to a greater extent as the steering control device 128 is moved to a greater extent to sharpen the turn; and (iii) raise as the steering control device 128 is returned to a central  
20 position to complete the turn. The inside reverse duct 704 may alternatively be arranged such that the control system 100 may be arranged to cause the inside reverse duct 704 to: (i) lower to a first extent as the steering control device 128 is moved to a first extent to commence the turn and remain in that position as the steering control device 128 is moved to a greater extent; and (ii) raise as the steering control device 128 is returned to a central  
25 position to complete the turn. As a further alternative, the control system 100 may be arranged to cause the inside reverse duct 704 to be gradually lowered as the steering control device 128 is moved from a first extent through to a greater extent to effect a sharper turn of the vessel 200. The inside reverse duct 704 will be raised as the steering control device 128 is returned to a  
30 central position to complete the turn.

In other embodiments the steering system of the invention is arranged to generate a turning moment by operating the engine throttles such that an outside (to a turn) waterjet unit generates more or increased ahead thrust compared to the inside(to the turn) waterjet unit.

When a greater steering control device 128 is moved from a first extent to a greater extent to effect a sharper turn of the vessel 200, the control system 100 operates the engine throttles of the outside and/or inside waterjet units a second time to effect a sharper turn of the vessel.

5 There are a number of configurations for controlling the ahead and astern thrust output from the outside and/or inside waterjet units. Typical configurations are detailed in Table 1 below.

Another embodiment is shown with reference to Figure 8 that shows the vessel 200 that is to make a turn to port shown as arrow 802. The helmsperson has displaced the helm wheel or steering control device 128 to port. The control system 100 recognises the displacement of the steering control device 128 as a demand for a turn. The control system 100 lowers the  
10 the inside (to the turn) reverse duct 804 either partially or fully (shown partially lowered in Figure 8) and at the same time alters the thrust by operating the engine throttles to control the thrust output from the inside and/or outside waterjet units. To generate a greater turning moment and produce a force vector 806. The engine throttles of the inside and/or outside waterjet  
15 units can again be altered to effect the sharper turn shown as arrow 902 in Figure 9.

Alternatively, to generate a greater turning moment, the control system 100 moves the steering deflectors 904 and at the same time operates the engine throttles such that the ahead thrust generated by the outside (to the turn) waterjet unit is greater than the astern thrust generated by the inside(to the turn) waterjet unit. This will result in a force vector 906 as  
20 shown in Figure 9.

As alternatives to increasing the ahead thrust of the outside (to the turn) waterjet unit, the control system 100 may also increase the astern thrust to the inside (to the turn) waterjet unit, or maintain the ahead thrust to the outside waterjet unit and increase the thrust to the inside  
25 waterjet unit.

In other embodiments the steering system can be arranged such that when the steering control device 128 is moved to port or starboard over a first range of movement, the position of the inside (to a turn) reverse duct 1004 is lowered partially or fully to cause a turning movement  
30 of the vessel 200 to port or starboard. This is already shown in Figure 6. When the steering control device 128 is moved to a second range of movement, beyond the first range of movement to port or starboard, the control system 100 causes the engine throttles to operate to alter the thrust output of the waterjet units to increase the turning moment on the vessel 200

thereby sharpening the turn to port or starboard shown as arrow 1002 in Figure 10. This will result in a force vector 1006.

The control and operation of the inside reverse duct 1004 has already been discussed above with reference to Figure 6 and is applicable to this embodiment of the invention. Similarly, the control of the engine throttles to effect an increased turning moment has also been outlined above and is applicable to this embodiment of the invention.

In other embodiments and with the inside reverse duct 1104 either partially or fully lowered (shown as fully lowered in Figure 11), the steering system of the invention is arranged to generate a higher turning moment by moving the steering deflectors 1108 of the waterjet units when the steering control device 128 is moved to a second range of movement shown as arrow 1102 in Figure 11. As such, the higher turning moment is generated by operating the engine throttles to alter the thrust output from the waterjet units in tandem with the movement of the steering deflectors 1108. This will generate a large force vector 1106 as shown in Figure 11.

The control system 100 may be arranged to operate the marine vessel propulsion systems either in isolation or in combination with each other to cause a turning movement of the vessel 200 in response to movement of the steering control device 128. Whilst a number of the embodiments have been described in detail above, the table below includes further possible embodiments that can be implemented by the vessel control system 100.

First extent of turn	Second extent of turn	To generate a higher rate of turn	Reverse duct depth configurations	Throttle control	
				Inside (to the turn) waterjet unit	Outside (to the turn) waterjet unit
Steering deflectors moved	Inside (to the turn) reverse duct lowered	Throttle control	a. Partially lower	Reverse duct	not operable
			b. Fully lower	Maintain	Increase
				Decrease	Maintain

			c. Gradually lower during turn	Decrease <b>Reverse duct</b> Maintain Increase Increase Increase	Increase <b>operable</b> Increase Maintain Decrease Increase
Steering deflectors moved	Throttle control	Inside (to the turn) reverse duct lowered	a. Partially lower b. Fully lower c. Gradually lower during turn	<b>Reverse duct</b> Maintain Decrease Decrease <b>Reverse duct</b> Maintain Increase Increase Increase	<b>not operable</b> Increase Maintain Increase <b>operable</b> Increase Maintain Decrease Increase
Throttle control				Maintain Decrease Decrease	Increase Maintain Increase
Throttle control	Steering deflectors moved	Inside (to the turn) reverse duct lowered	a. Partially lower b. Fully lower c. Gradually lower during turn	<b>Reverse duct</b> Maintain Decrease Decrease <b>Reverse duct</b> Maintain Increase Increase	<b>not operable</b> Increase Maintain Increase <b>operable</b> Increase Maintain Decrease

				Increase	Increase
Throttle control	Inside (to the turn) reverse duct lowered	Steering deflectors moved	a. Partially lower b. Fully lower c. Gradually lower during turn	Reverse duct	not operable
				Maintain	Increase
				Decrease	Maintain
				Decrease	Increase
				Reverse duct	operable
				Maintain	Increase
				Increase	Maintain
				Increase	Decrease
Inside (to the turn) reverse duct lowered	Steering deflectors moved	Throttle control	a. Partially lower b. Fully lower c. Gradually lower during entire turn movement	Maintain	Increase
				Increase	Maintain
				Increase	Decrease
				Increase	Increase
Inside (to the turn) reverse duct lowered	Throttle control	Steering deflectors moved	a. Partially lower b. Fully lower c. Gradually lower during entire turn movement	Maintain	Increase
				Increase	Maintain
				Increase	Decrease
				Increase	Increase

Whilst the above table outlines a number of steering system operational embodiments during the first and the subsequent extent of a turn, this should not be considered in any way limiting. As an example, a combination of two propulsion systems can be activated to undertake a first extent of a turn and a third propulsion system activated when a higher rate (second extent) of

turn is demanded. Alternatively, the three propulsion systems can be activated to undertake an entire turn (first and second extent). In this case, the positioning of the reverse ducts and/or thrust provided by the engine throttles may be varied during the turn for example, to provide the higher rate of turning.

5

It is preferable that the forward momentum or speed of the vessel 200 does not change as the vessel 200 undertakes a turning manoeuvre (unless the helmsperson separately commands this by also operating the foreard or reverse thrust control device). If the reverse ducts 112 are lowered for example, under the control of the control system 100, a drag will be generated that will cause a small decrease in the vessel's forward speed. The control system 100 of the invention may automatically compensate for potential speed variations by increasing the thrust output by the vessel's waterjet units. This will cause the forward vessel speed to be maintained throughout the turning manoeuvre. The control system 100 can alternatively be overridden by the helmsperson by manually altering the engine throttle control(s).

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The foregoing describes the invention including preferred forms thereof. Alterations and modifications as will be obvious to those skilled in the art are intended to be incorporated within the scope hereof. For instance, where the vessel 200 is reversing and a sharp turn is required, the reverse duct should be raised rather than lowered. The features described above for lowering the reverse ducts for sharpening a turn during a forward motion are similarly applicable in relation to raising the inside (to a turn) reverse duct for sharpening a turn during a reverse motion.

20

Three ranges of motion,  $\phi_1$ ,  $\phi_2$  and  $\phi_3$ , have been described for the steering control device. The three ranges of motion may be, for instance, a first range of motion that results in normal steering using just the steering deflectors, a second range of motion that results in steering using the steering deflector as well as the reverse duct either partially or fully lowered that results in increased turning capability compared to the first range, and a third range of motion that results in steering using the steering deflector as well as the reverse duct either partially or fully lowered and in addition by adjusting the throttle(s) and thus the revolutions-per-minute (RPM) of the appropriate waterjet unit(s) and hence increasing the turning capability compared to the second range.

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Persons skilled in the art will appreciate that the results defined for the ranges of motion above are only examples and are non-limiting. Skilled persons will also appreciate that more than three ranges of motion may be defined, where desired or where necessary.

**WHAT WE CLAIM IS:**

1. A steering system for a marine vessel comprising:  
5 two or more waterjet units for propelling the vessel, each having a steering deflector;  
a manually moveable steering control device which is movable to steer the vessel to  
port or starboard; and  
an associated control system arranged to operate the steering deflectors in accordance  
with movement of the steering control device to cause turning of the vessel and also to lower  
10 a reverse duct of an inside (to a turn) waterjet unit when a higher rate of turning of said vessel  
is commanded by the steering control device.
2. A steering control system according to claim 1 wherein the control system is arranged  
to cause the inside reverse duct to lower to an increasing extent when an increasing rate of  
15 turning is commanded by the steering control device.
3. A steering system according to claim 1 or claim 2 wherein the control system is also  
arranged to alter the thrust generated by the inside and/or outside waterjet unit(s) when a  
higher rate of turning is commanded by the steering control device.  
20
4. A steering system according to any one of claims 1 to 3 wherein the control system is  
also arranged to increase the thrust generated by the inside waterjet unit when a higher rate of  
turning is commanded by the steering control device.
- 25 5. A steering system according to any one of claims 1 to 4 wherein the control system is  
also arranged to increase the thrust generated by the outside waterjet unit when a higher rate  
of turn is commanded by the steering control device.
6. A steering system according to any one of claims 3 to 5 wherein the control system is  
30 arranged to alter the thrust generated by the inside and/or outside waterjet unit(s) to a first  
extent when the steering control device is moved to command a first extent of turning and to a  
greater extent when the steering control device is moved to command a greater extent of  
turning.

7. A steering system according to any one of claims 1 to 6 wherein the control system is arranged to cause the inside reverse duct to lower when the steering control device is moved to command a first extent of turn and to increase the thrust generated by the inside and/or outside waterjet unit(s) when the steering control device is moved to command a greater extent of turning.
8. A steering system according to any one of claims 1 to 7 wherein the control system is arranged to lower the reverse duct to different extent for different forward speeds of the vessel, for an equivalent rate of turn.
9. A steering system according to any one of claims 1 to 8 wherein the steering control device is operable to steer the vessel at cruise speeds of the vessel.
10. A steering system according to claim 9 wherein the steering control device is a helm wheel.
11. A steering system according to any one of claims 1 to 8 wherein the steering control device is operable to steer the vessel at cruise speeds of the vessel and the vessel also comprises a separate manually movable control device operable to manoeuvre the vessel at slow speeds.
12. A steering system according to claim 11 wherein the steering device is a helm wheel and the manoeuvre control device is movable in multiple axes.
13. A steering system for a marine vessel comprising:  
two or more waterjet units each having a steering deflector, for propelling the vessel;  
a manually moveable steering control device which is movable to steer the vessel to port or starboard; and  
an associated control system arranged to activate the steering deflectors of the waterjet units and alter the thrust generated by the inside and/or outside waterjet unit(s) in accordance with movement of the steering control device to cause turning of the vessel.
14. A steering system according to claim 13 wherein the control system is arranged to operate the steering deflectors with movement of the steering control device to cause turning

of the vessel and to also alter the thrust generated by the inside and/or outside waterjet unit(s) when a higher rate of turning of the vessel is commanded.

15. A steering system according to claim 13 wherein the control system is arranged to alter the thrust generated by the inside and/or outside waterjet unit(s) with movement of the steering control device to cause turning of the vessel and to also operate the steering deflectors when a higher rate of turning of the vessel is commanded.

16. A steering system according to any one of claims 13 to 15 wherein the control system is arranged to increase the thrust generated by the outside waterjet unit when a higher rate of turning is commanded by the steering control device.

17. A steering system according to any one of claims 13 to 15 wherein the control system is arranged to decrease the thrust generated by the inside waterjet unit when a higher rate of turning is commanded by the steering control device.

18. A steering system according to any one of claims 13 to 15 wherein the control system is arranged to increase the thrust generated by the outside waterjet unit and decrease the thrust generated by the inside waterjet unit when a higher rate of turning is commanded by the steering control device.

19. A steering system according to any one of claims 13 to 18 wherein the control system is arranged to move the steering deflectors and alter the thrust generated by the inside and/or outside waterjet unit(s) to a first extent when the steering control device is moved to command a first extent of turning and to further move the steering deflectors and alter the thrust generated by the inside and/or outside waterjet unit(s) when the steering control device is moved to command a greater extent of the turning.

20. A steering system according to claim 13 to 18 wherein the control system is arranged to alter the thrust of the waterjet unit(s) to a first extent when the steering control device is moved to command a first extent of turn and to a greater extent when the steering control device is moved to command a greater extent of the turn.

21. A steering control system according to any one of claims 13 to 20 wherein the control system is arranged to alter the thrust of the waterjet unit(s) to a different extent for different forward speeds of the vessel.
- 5 22. A steering system according to any one of claims 13 to 21 wherein the control system is also arranged to lower a reverse duct of an inside waterjet unit when a higher rate of turning is commanded by the steering control device.
- 10 23. A steering system according to any one of claims 16 to 22 wherein the steering control device is operable to steer the vessel at cruise speeds of the vessel.
24. A steering system according to claim 23 wherein the steering control device is a helm wheel.
- 15 25. A steering system according to any one of claims 16 to 22 wherein the steering control device is operable to steer the vessel at cruise speeds of the vessel and the vessel also comprises a separate manually movable control device operable to manoeuvre the vessel at slow speeds.
- 20 26. A steering system according to claim 25 wherein the steering device is a helm wheel and the manoeuvre control device is movable in multiple axes.
- 25 27. A steering system for a marine vessel comprising:  
two or more waterjet units each having a steering deflector, for propelling the vessel;  
a manually moveable steering control device which is movable to steer the vessel to port or starboard; and  
an associated control system arranged to alter the thrust of the inside and/or outside waterjet units in accordance with movement of the steering control device to cause turning of  
30 the vessel.
28. A steering system according to claim 27 wherein the control system is arranged to increase the thrust generated by the outside waterjet unit with movement of the steering control device to cause turning of the vessel.

29. A steering system according to claim 27 wherein the control system is arranged to decrease the thrust generated by the inside waterjet unit with movement of the steering control device to cause turning of the vessel.

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30. A steering system according to claim 27 wherein the control system is arranged to increase the thrust generated by the outside waterjet unit and decrease the thrust generated by the inside waterjet unit with movement of the steering control device to cause turning of said vessel.

10

31. A steering system according to any one of claims 27 to 30 wherein the control system is arranged to alter the thrust generated by the inside and/or outside waterjet unit(s) to a first extent when the steering control device is moved to command a first extent of turn and to further alter the thrust generated by the inside and/or outside waterjet unit(s) when the steering control device is moved to command a greater extent of the turning.

15

32. A steering system according to any one of claims 27 to 31 wherein the control system is arranged to alter the thrust of the waterjet unit(s) to a different extent for different forward speeds of the vessel, for an equivalent rate of turn.

20

33. A steering system according to any one of claims 27 to 31 wherein the control system is also arranged to lower a reverse duct of the inside waterjet unit when the steering control device is moved to command a greater extent of the turn.

25

34. A steering system according to any one of claims 27 to 33 wherein the control system is also arranged operate the steering deflectors of the waterjet units when the steering control device is moved to command a greater extent of the turn.

30

35. A steering system according to any one of claims 27 to 34 wherein the steering control device is operable to steer the vessel at cruise speeds of the vessel.

36. A steering system according to claim 35 wherein the steering control device is a helm wheel.

37. A steering system according to any one of claims 27 to 34 wherein the steering control device is operable to steer the vessel at cruise speeds of the vessel and the vessel also comprises a separate manually movable control device operable to manoeuvre the vessel at  
5 slow speeds.

38. A steering system according to claim 37 wherein the steering device is a helm wheel and the manoeuvre control device is movable in multiple axes.

10

39. A steering system for a marine vessel comprising:  
two or more waterjet units each having a steering deflector, for propelling the vessel;  
a manually moveable steering control device which is movable to steer the vessel to  
port or starboard; and

15

an associated control system arranged to operate the steering deflectors of the waterjet units in accordance with movement of the steering control device to cause turning of the vessel and also to alter the thrust of the inside and/or outside waterjet units in accordance with movement of the steering control device.

20

40. A system according to claim 39 wherein the control system is arranged to decrease the thrust generated by the inside waterjet unit.

41. A system according to claim 39 wherein the control system is arranged to increase the thrust generated by the outside waterjet unit.

25

42. A system according to claim 39 wherein the control system is arranged to increase the thrust generated by the outside waterjet unit and decrease the thrust generated by the inside waterjet unit.

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43. A steering system according to any one of claims 39 to 42 wherein the control system is arranged to alter the thrust of the waterjet unit(s) to a different extent for different forward speeds of the vessel, for an equivalent rate of turn.

44. A steering control system according to any one of claims 39 to 42 wherein the control system is arranged to alter the thrust of the waterjet unit(s) to an increasing extent when an increasing rate of turn is commanded.
- 5 45. A system according to any one of claims 39 to 42 wherein the control system is also arranged to lower a reverse duct of the inside waterjet unit when the steering control device is moved to command a greater extent of the turn.
- 10 46. A steering system according to any one of claims 39 to 45 wherein the steering control device is operable to steer the vessel at cruise speeds of the vessel.
47. A steering system according to claim 46 wherein the steering control device is a helm wheel.
- 15 48. A steering system according to any one of claims 39 to 45 wherein the steering control device is operable to steer the vessel at cruise speeds of the vessel and the vessel also comprises a separate manually movable control device operable to manoeuvre the vessel at slow speeds.
- 20 49. A steering system according to claim 48 wherein the steering device is a helm wheel and the manoeuvre control device is movable in multiple axes.
50. A steering system for a marine vessel comprising:  
two or more waterjet units each having a steering deflector for propelling the vessel;  
25 a manually moveable steering control device which is movable to steer the vessel to port or starboard; and  
an associated control system operable to alter the thrust of the waterjet units to lower a reverse duct of an inside (to a turn) waterjet unit in accordance with movement of the steering control device to cause turning of the vessel.
- 30 51. A steering system according to claim 50 wherein the control system is arranged to alter the thrust generated by the inside and/or outside waterjet unit(s) with movement of the steering control device to cause turning of the vessel and to also lower a reverse duct of an inside waterjet unit when a higher rate of turning is commanded.

52. A steering system according to claim 50 wherein the control system is arranged to lower a reverse duct of an inside waterjet unit with movement of the steering control device to cause turning of the vessel and to also alter the thrust generated by the inside and/or outside waterjet unit(s) when a higher rate of turning is commanded.

53. A steering system according to any one of claims 50 to 52 wherein the control system is arranged to decrease the thrust generated by the inside waterjet unit.

10 54. A steering system according to any one of claims 50 to 52 wherein the control system is arranged to increase the thrust generated by the outside waterjet unit.

15 55. A steering system according to any one of claims 50 to 52 wherein the control system is arranged to increase the thrust generated by both the outside and inside waterjet units when the inside reverse duct is lowered when a higher rate of turning of said vessel is commanded by the steering control device.

20 56. A steering system according to any one of claims 50 to 55 wherein the control system is arranged to alter the thrust and/or lower a reverse duct to different extents for different forward speeds of the vessel.

25 57. A steering system according to any one of claims 50 to 56 wherein the control system is arranged to also operate the steering deflectors when a higher rate of turning of is commanded by the steering control device.

58. A steering system according to any one of claims 50 to 57 wherein the steering control device is operable to steer the vessel at cruise speeds of the vessel.

30 59. A steering system according to claim 58 wherein the steering control device is a helm wheel.

60. A steering system according to any one of claims 50 to 57 wherein the steering control device is operable to steer the vessel at cruise speeds of the vessel and the vessel also

comprises a separate manually movable control device operable to manoeuvre the vessel at slow speeds.

- 5 61. A steering system according to claim 60 wherein the steering device is a helm wheel and the manoeuvre control device is movable in multiple axes.
62. A steering system for a marine vessel comprising:  
two or more waterjet units each having a steering deflector for propelling the vessel;  
a manually moveable steering control device which is movable to steer the vessel to  
10 port or starboard; and  
an associated control system operable to activate the steering deflectors and lower the reverse duct of an inside (to a turn) waterjet unit in accordance with movement of the steering control device to cause turning of the vessel when turning of the vessel is commanded by the steering control device.
- 15 63. A steering system according to claim 62 wherein the control system is arranged lower the reverse duct of an inside waterjet unit with movement of the steering control device to cause turning of the vessel and to also activate the steering deflectors when a higher rate of turning is commanded.
- 20 64. A steering system according to claim 62 or claim 63 wherein the control system is arranged to cause the inside reverse duct to lower to a first extent when the steering control device is moved to command a first extent of turn and lower to a greater extent when the steering control device is moved to command a greater extent of the turn.
- 25 65. A steering control system according to claim 62 or 63 wherein the control system is arranged to cause the inside reverse duct to lower to an increasing extent when an increasing rate of turning is commanded by the steering control device.
- 30 66. A steering system according to any one of claims 62 to 65 wherein the control system is also arranged to increase the thrust generated by the inside and/or outside waterjet unit(s) when a higher rate of turning of said vessel is commanded by the steering control device.

67. A steering system according to any one of claims 62 to 66 wherein the control system is arranged to lower the reverse duct to different extents for different forward speeds of the vessel, for an equivalent rate of turn.

5 68. A steering system according to any one of claims 62 to 67 wherein the steering control device is operable to steer the vessel at cruise speeds of the vessel.

69. A steering system according to claim 68 wherein the steering control device is a helm wheel.

10

70. A steering system according to any one of claims 62 to 66 wherein the steering control device is operable to steer the vessel at cruise speeds of the vessel and the vessel also comprises a separate manually movable control device operable to manoeuvre the vessel at slow speeds.

15

71. A steering system according to claim 70 wherein the steering device is a helm wheel and the manoeuvre control device is movable in multiple axes.

72. A steering system for a marine vessel comprising:

20

two or more waterjet units each having a steering deflector for propelling the vessel;  
a manually moveable steering control device which is movable to steer the vessel to port or starboard; and

25

an associated control system operable to lower said reverse duct of an inside (to a turn) waterjet unit in accordance with movement of the steering control device to cause turning of the vessel and also arranged to alter the thrust of the waterjet units when a higher rate of turning of said vessel is commanded by the steering control device.

30

73. A steering system according to claim 72 wherein the control system is arranged to cause the inside reverse duct to lower to a first extent when the steering control device is moved to command a first extent of turn and lower to a greater extent when the steering control device is moved to command a greater extent of the turn.

74. A steering control system according to claim 72 wherein the control system is arranged to cause the inside reverse duct to lower to an increasing extent when an increasing rate of turning is commanded by the steering control device.

5 75. A steering system according to any one of claims 72 to 74 wherein the control system is also arranged to activate the steering deflectors of the waterjet units when said steering control device is moved to command a greater extent of turning.

10 76. A steering system according to any one of claims 72 to 74 wherein the control system is arranged to lower the reverse duct to different extents for different forward speeds of the vessel, for an equivalent rate of turn.

15 77. A steering system according to any one of claims 72 to 76 wherein the steering device is operable to steer the vessel at cruise speeds of the vessel.

78. A steering system according to claim 77 wherein the steering control device is a helm wheel.

20 79. A steering system according to any one of claims 72 to 76 wherein the steering device is operable to steer the vessel at cruise speeds of the vessel and the vessel also comprises a separate manually movable control device operable to manoeuvre the vessel at slow speeds.

25 80. A steering system according to claim 79 wherein the steering device is a helm wheel and the manoeuvre control device is movable in multiple axes.

1/4

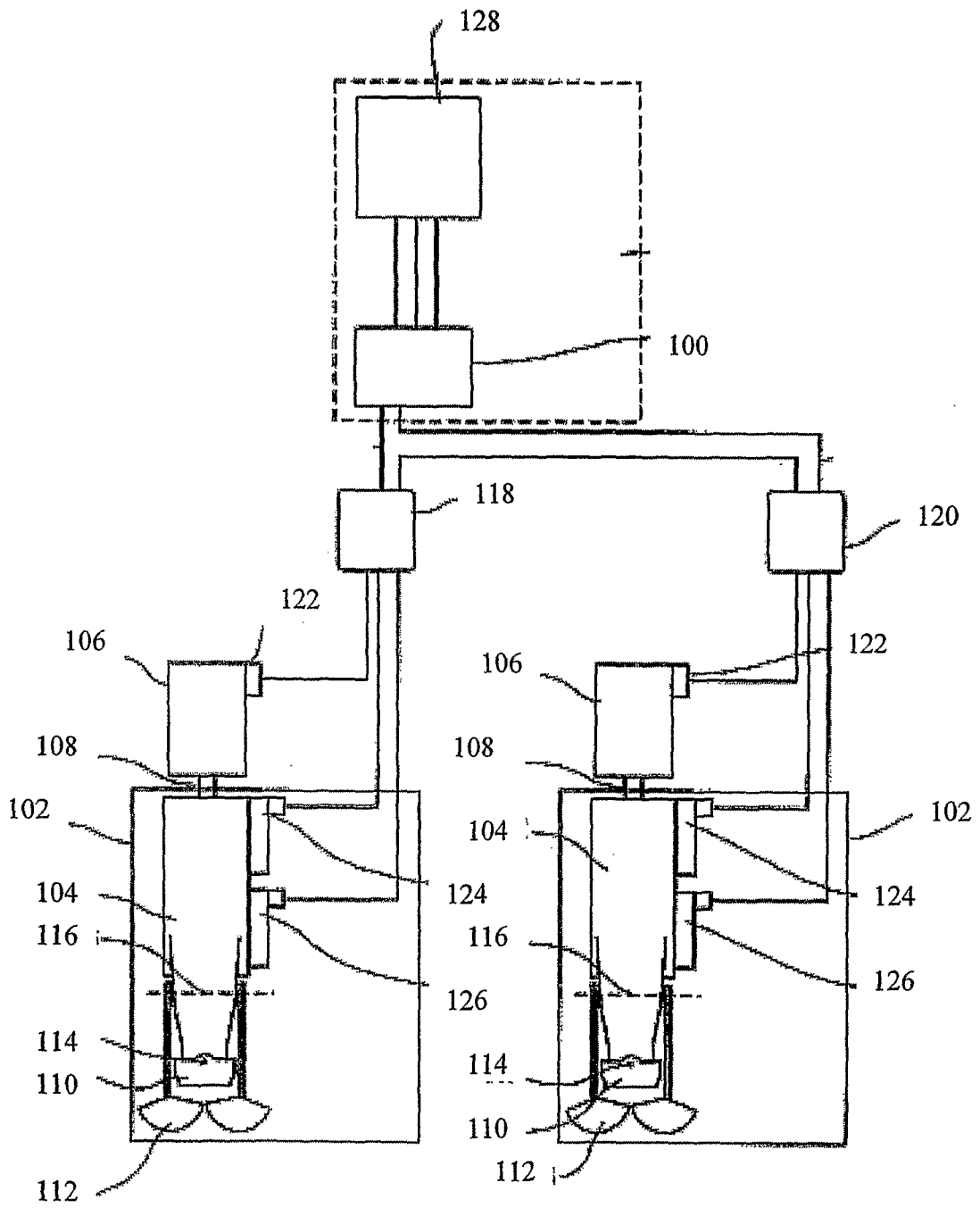


FIGURE 1

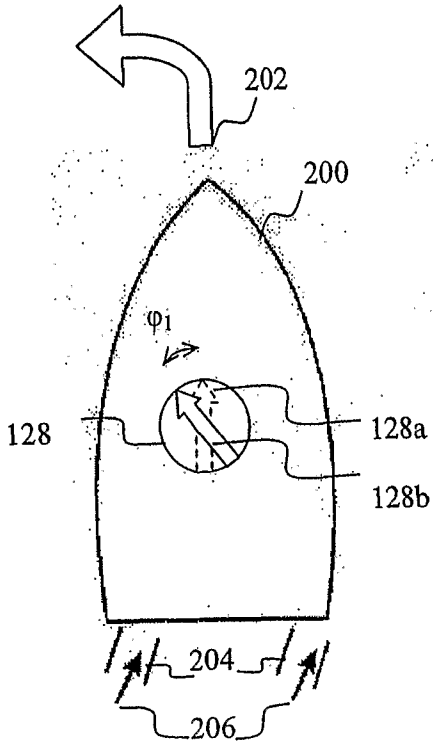


FIGURE 2

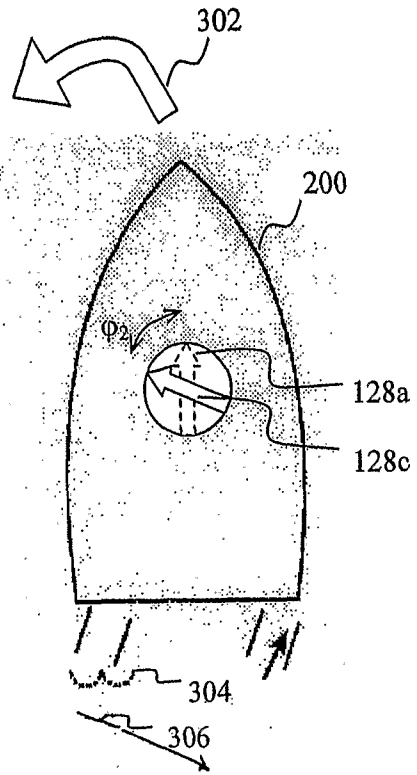


FIGURE 3

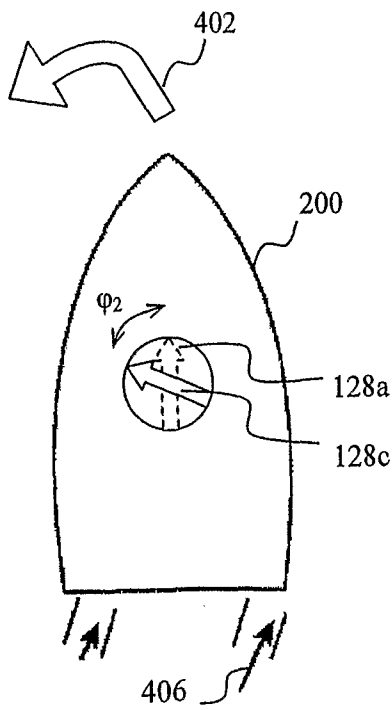


FIGURE 4

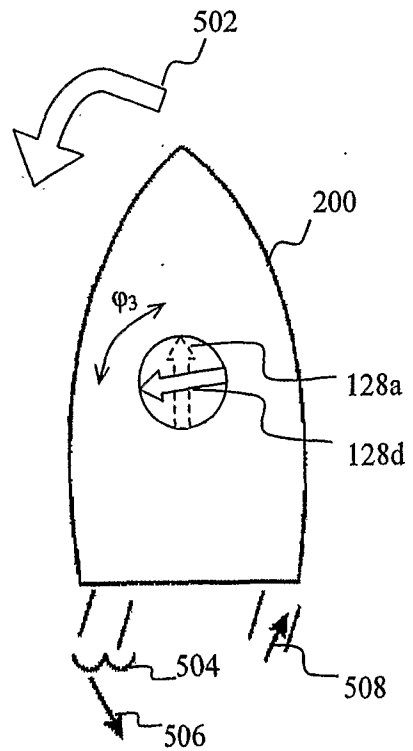


FIGURE 5

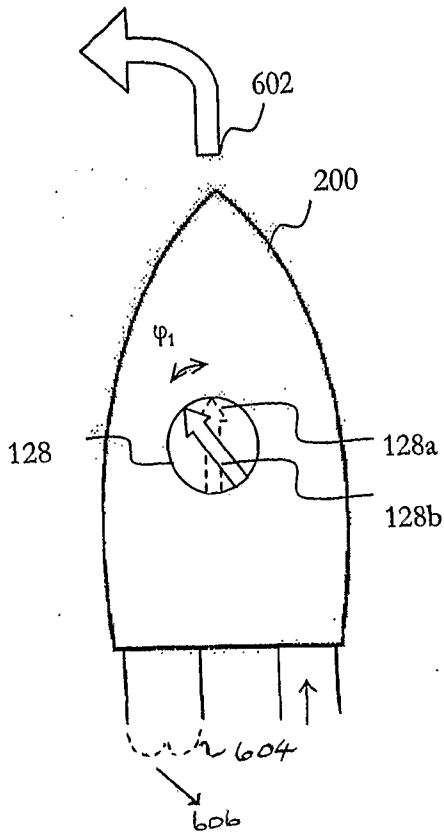


FIGURE 6

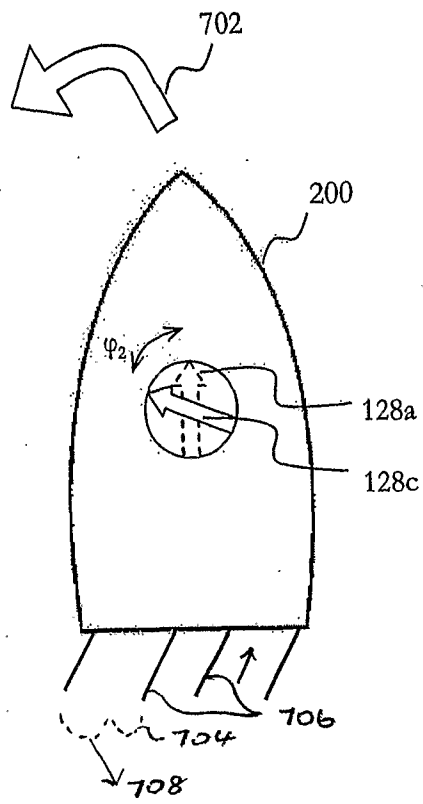


FIGURE 7

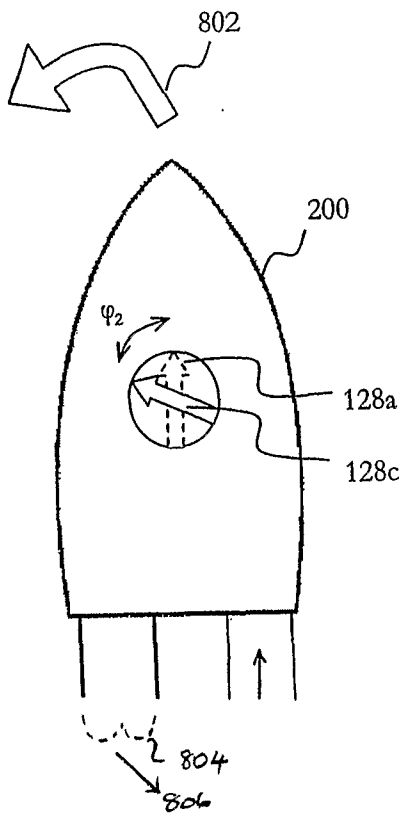


FIGURE 8

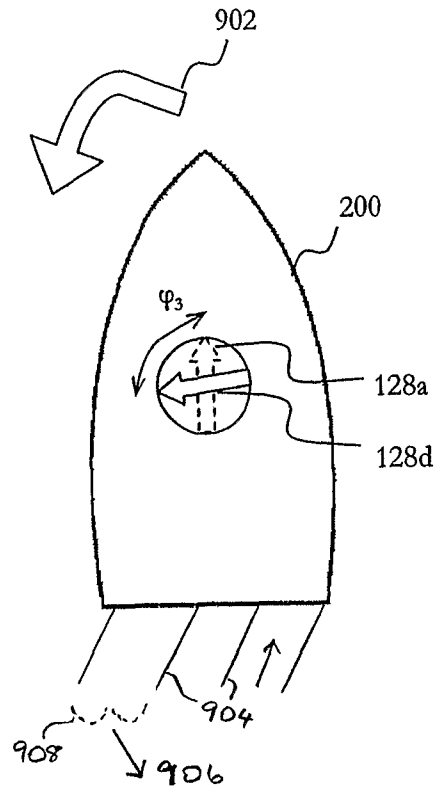


FIGURE 9

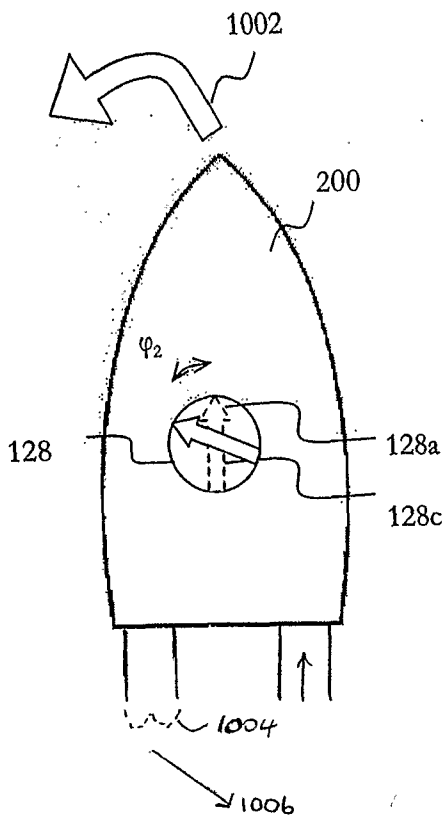


FIGURE 10

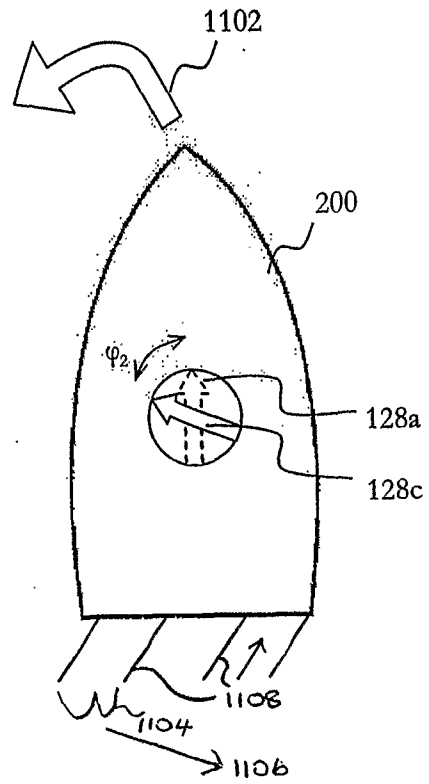


FIGURE 11

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/NZ2007/000103

A. CLASSIFICATION OF SUBJECT MATTER		
Int. Cl.		
<b>B63H 25/46</b> (2006.01) <b>B63H 11/107</b> (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) DWPI IPC B63H 11/, B63H 25/ and keywords: steering, deflector, reverse and thrust		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
E, X	WO 2007/055606 A1 (CWF HAMILTON & CO LTD) 18 May 2007 Page 18, example 1; claims 13, 15, 16, 18, 23, 33	1-61
E, X	WO 2007/055605 A1 (CWF HAMILTON & CO LTD) 18 May 2007 Page 14, example 1; claims 14, 16, 17, 19, 23, 26, 33, 42-44, 46	1-61
P, X	WO 2006/062416 A1 (CWF HAMILTON & CO LTD) 15 June 2006 Page 17, example 1; claims 7, 8, 18, 25	1-61
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C		<input checked="" type="checkbox"/> 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	"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	
"E" earlier application or patent but published on or after the international filing date	"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	
"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)	"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	
"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family	
"P" document published prior to the international filing date but later than the priority date claimed		
Date of the actual completion of the international search 10 August 2007	Date of mailing of the international search report 16 AUG 2007	
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustalia.gov.au Facsimile No. (02) 6285 3929	Authorized officer <b>S.J. DESCHANEL</b> AUSTRALIAN PATENT OFFICE (ISO 9001 Quality Certified Service) Telephone No : (02) 6283 2368	

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/NZ2007/000103

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2005/0159052 A1 (BORRETT) 21 June 2005 Whole document	1-61
X	EP 0778196 A1 (KAWASAKI JUKOGYO KABUSHIKI KAISHA) 11 June 1997 Abstract; page2, lines 1-7, 30-38; page 5, lines 36-40	13-32, 34-49
X	US 6800003 B2 (HILL et al) 5 October 2004 Abstract; column 6, line 62-column 7, line 52; column 8, lines 57-59	13-32, 34-49
X	US 6336833 B1 (RHEAULT et al) 8 January 2002 Abstract	27-32, 35-38
X	US 5494464 A (KOBAYASHI) 27 February 1996 Abstract; column 1. lines 20-25	50-61
A	US 2004/0147179 A1 (MIZUNO et al) 29 July 2004	
A	US 6960105 B2 (URAKI et al) 1 November 2005	
A	JP 9-328096 A (KAWASAKI HEAVY IND LTD) 22 December 1997 See esp@cenet English Abstract	

**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:
  
2.  Claims Nos.: **62-80**  
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:  
Independent claims 62 and 72 are not clear because there is no antecedent to "the reverse duct".
  
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:

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

Information on patent family members

International application No.

PCT/NZ2007/000103

This Annex lists the known "A" publication level 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 Cited in Search Report		Patent Family Member			
WO	2007055606				
WO	2007055605				
WO	2006062416	AU	2005312429		
US	2005159052	AU	13144/01	EP	1232091
		US	2003019414	US	6865996
				NZ	513559
				WO	0134463
EP	0778196	JP	9156596		
US	6800003	US	2004038601		
US	6336833	CA	2207938	CA	2306193
		US	6428371	US	2002014193
		US	2002127926	US	6405669
				US	2002042233
US	5494464	JP	4353097	JP	7187083
				US	5607332
US	2004147179	JP	2004155407	US	7118431
				US	2007032142
US	6960105	CA	2403592	CN	1418796
		JP	2003090234	US	2003082965
				JP	2003089387
Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.					
END OF ANNEX					