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(73) Proprietor: **Baldo Dielen Assessoria LTDA.**
Sao Fransisco do Sul, Santa Catarina (BR)

(72) Inventor: **BALDO ALOYSIUS MARIA, Dielen**
Sao Fransisco do Sul
Santa Catarina (BR)

(74) Representative: **EP&C**
P.O. Box 3241
2280 GE Rijswijk (NL)

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Description

[0001] The present invention relates to a vessel, especially a tug vessel, comprising a towing device and a hull, wherein the towing device comprises: a towline; a tow point where the vessel exerts a force, especially a horizontal force, onto the towline when applying a tensile force to an object by means of the towline, the tow point being provided on the vessel; and a first propulsion system and a second propulsion system.

[0002] Such a vessel is known from NL-1,023,447. Figure 2 of NL-1,023,447 shows a tug vessel with a towing device. The towing device (30) is arranged in the mid section of the vessel and consists of a circular guiding ring (31, 32), a towline (22) and a towing hook (33) where the towline applies force onto the vessel when applying a tensile force to a towed object by means of the towline. The towing hook (33) is mounted on the guiding ring (31, 32) and moveable along the guiding ring. As can be seen in figure 2d, the vessel has two propulsions systems in the form of conventional fixed screws. Both propulsion systems are arranged at the stern part of the vessel. According to NL-1,023,447 it is anticipated - see page 4 lines 31-34 - that these screw propulsions can be of the type having screw blades adjustable with respect to the fixed screw shaft so that they are continuously adjustable from forward to backward propulsion. Further NL-1,023,447 mentions - see page 8 line 10-11 - that also other propulsion systems like Voith Schneider propulsions can be used.

[0003] When it is required to exert maximum force on a towed object both propulsions of the vessel of NL-1,023,447 are required and are - both - directed in a direction essentially parallel to the length direction of the vessel so that the vessel has maximum stability against capsizing. In case both propulsions would be directed in a same direction essentially transverse to the vessel of NL-1,023,447, this automatically results in turning of the vessel around the towing point or centre of mass of the vessel so that this situation can not be maintained. When towing in transverse direction of the vessel, the propulsions of NL-1,023,447 will be directed in different directions so that one on the propulsions is actually pulling and the other is directed in opposite direction to prevent rotation of the vessel around the towing point/centre of mass of the vessel.

[0004] The present invention has as its object to improve the vessel according to the preamble of claim 1.

[0005] This object is according to the invention achieved by providing a vessel comprising a towing device and a hull, wherein the towing device comprises:

- a towline;
- a tow point - such as a fairlead, a bitt, or a tow hook - where the vessel exerts a force, especially a horizontal force, onto the towline when applying a tensile force to an object by means of the towline, the tow point being provided on the vessel;
- a first propulsion system and a second propulsion system;

characterized, in that the first propulsion system and second propulsion system each comprise an omni-directional propulsion device; and in that, viewed in longitudinal direction of the vessel,° the tow point is arranged in between the first omni-directional propulsion device and the second omni-directional propulsion device.

[0006] It is to be noted, that the vessel according to the invention can be used for tugging - in which case the vessel is, viewed in transport direction of the towed object, ahead of the object - as well as for assisting in manoeuvring an object - in which case the vessel might, viewed in transport direction of the towed object, behind the towed object. Further, the term 'omni-directional propulsion device' is in the field of vessel propulsion a well defined term. This term stands for a propulsion device which can be adjusted for providing thrust in any desired direction within a range of 360° around a central axis. Well known examples of such 'omni-directional propulsion device' are so called "Voith-Schneider" propulsion devices and so called "azimuthal" propulsion devices. The term tow point is well known from tug vessels. It is the point where the vessel, when attached to a towed object and during towing, exerts onto the towline effectively the horizontal force which is about equal to the horizontal component of the tensile force of the towline. It is noted that this does not mean that the towline (also called towing cable) extends horizontally. Although the towed/assisted object, which is in general a vessel (but in this application called an object), as well as the tug (in this application called a vessel) will obviously move in a horizontal plane, the towline is hardly ever horizontal, in particular when assisting vessels in port. Towline angles are then typically 20-45 degrees.

[0007] The configuration according to the invention has two omni-directional propulsion devices with in between the towing point and/or the centre of buoyancy of the vessel. This allows both omni-directional propulsion devices being used simultaneously for propulsion in the same direction irrespective of the position of the vessel with respect to the extension direction of the towline. Consequently the maximum available propulsion power can also be used when the towline extends transverse to the length direction of the vessel. The two omni-directional propulsion devices being provided at opposed sides of the towing point and/or centre of buoyancy of the vessel, prevents the length axis of the vessel from rotating with respect to the towline. This improves the manoeuvrability of the vessel and improves the ability of the vessel in assisting in manoeuvring an object as especially in this case the transverse orientation of the vessel

with respect to the towline is advantageous. When the vessel is transverse to the towline and the object pulls the vessel as the vessel is, viewed in transport direction of the towed object, behind the towed object, a transversely oriented vessel will experience a much larger resistance from the water than a vessel having its length direction in the same direction as the direction of extension of the towline.

[0008] According to a further embodiment of the invention, the first and second omni-directional propulsion device are provided in the vertical longitudinal sectional plane of the vessel. This means that the first and second omni-directional propulsion devices are each provided in or close to (which means within 10% of the width of the vessel) the vertical longitudinal sectional plane of the vessel. This arrangement allows for a slender hull with fine entrances at bow and stern. The slender hull will be more energy efficient, have better seakeeping characteristics and can reach higher speeds than a wider hull.

[0009] According to a further embodiment of the invention, the tow point is provided in the vertical longitudinal sectional plane of the vessel. This means that the tow point is provided in or close to (which means within 20% of the width of the vessel) the vertical longitudinal sectional plane of the vessel. This arrangement allows the towline and towing winch being stored in the centre of the vessel, which is advantageous with respect to the weight distribution of the vessel.

[0010] In order to improve the stability of the vessel and, as a result, to improve towage performance, the hull comprises, according to a further embodiment: a main hull; and a left and right side hull provided at the left respectively right longitudinal side of the main hull; wherein the side hulls are arranged for providing additional buoyancy counteracting capsizing and/or wherein the side hulls are arranged to increase stability, and as a result also maximum towing forces, without requiring (substantial) increase of water displacement. Such side hulls can be of basically two types. The first type of side hull is the so called sponson type. A sponson is a bulge formed onto the main hull. With the sponson type, there is no gap between the main hull and side hull through which water could flow. In case the side hulls are of the sponson type, the main hull and side hulls form so to say one integral hull. The second type of side hull is the so called outrigger type. An outrigger is sometimes also called an 'ama' (plural 'amas'). In case of two side hulls of the outrigger type, this results in a kind of trimaran. An outrigger is a floating body carried by one or more carriers, like beams or other structures, at a distance from the main hull so that, between the main hull and side hull a gap results through which water can flow. The advantage of applying a side hull of the outrigger type is that a high degree of stability can be obtained with a narrow main hull of low displacement (when compared with typical mono-hull type tugs of similar stability and towage performance). Furthermore, propulsion efficiency, indirect towage performance and course stability are increased. The advantages of a side hull of the sponson type (when compared woth normal 'monohull' tugs) are essentially the same as those of the outrigger type, although their effectiveness is less pronounced.

[0011] For improved stability against capsizing, the draught of the main hull is, according to a further embodiment of the invention, larger than the draught of the side hulls. According to a further elaboration of this embodiment, the draught of the side hulls is larger than zero, such as 5 to 10 % of the draught if the main hull.

[0012] In order to ensure that the side hulls become effective at relative small heeling of the vessel, the draught of the main hull is, according to a further embodiment of the invention, at least 25%, especially at least 50%, larger than the draught of the side hulls.

[0013] In order to provide, on the one hand, low water resistance when the vessel runs at cruising speed without towing an object and to provide, on the other hand, good stability against capsizing when towing an object with a towline extending transversely to the vessel, the water displacement of the side hulls is according to a further embodiment, when the vessel is in horizontal condition, at most 20% of the total water displacement of the vessel, especially at most 15% of the total water displacement of the vessel, such as at most 12% or at most 10% of the total water displacement of the vessel. The term 'horizontal condition of the vessel' means the condition in which the heeling is zero degrees.

[0014] In order to increase lateral resistance and towline forces of the vessel in transverse direction under influence of a towing load and to improve course stability of the vessel, the hull, especially the main hull, is according to a further embodiment of the invention, provided with at least one keel. According to a further elaboration of this embodiment of the invention, the hull, especially the main hull, is provided with two keels which are mutually parallel. In order to avoid dry dock structures when the vessel is on shore, the two keels have, according to a further embodiment of the invention, a draught larger than or equal to the draught of the first and second omni-directional propulsion device and are arranged to support the vessel onto the keels when on shore. This arrangement allows placing the vessel directly on shore without damaging the omni-directional propulsion devices.

[0015] According to a further embodiment of the invention, the first and second propulsion system are arranged to provide the vessel a continuous bollard pull of at least 300 kN (≈ 30 t BP), preferably at least 450 kN (≈ 45 t BP), such as at least 650 kN (≈ 651 t BP).

[0016] According to a further embodiment of the invention, said continuous bollard pull is at most 1500 kN (≈ 150 t BP).

[0017] Unlike in ground vehicles, the statement of installed horsepower is not sufficient to understand how strong a tug vessel is. This because other factors, like transmission losses, propulsion type, efficiency of the propulsion system, have an influence as well. Therefore, in the field of tug vessels bollard pull values (BP) are used. In general these values are stated in tons. The bollard pull value represents the maximum pulling force that a vessel can exert on another vessel

or object. The bollard pull values as used in this application are so called continuous bollard pull values (sometimes also called steady or sustained bollard pull values). These are determined by practical trial in still water having a depth of at least 20 m. The vessel is connected by a cable to the fixed world, for example a bollard, and a load cell (dynamometer) provided in or on the cable measures the tensile force in the cable at maximum thrust of the vessel. The (continuous) bollard pull value is the tensile force which can be measured during a period of 5 to 10 minutes after the initial peak value has disappeared. Various test procedures to determine bollard pull are in existence. For reference, the procedures as described by the major Classification Societies can be utilized (Rules for Building and Classing Steel Vessels under 90 meters, American Bureau of Shipping, Part 5, Chapter 8, Appendix 2, Guidelines for Bollard Pull tests; or, Rules for Ships, Det Norske Veritas, Part 5, Chapter 7, Section 2, Appendix A, Bollard Pull testing Procedure or Bollard Pull Certification Procedures, Lloyd's Register of Shipping, Guidance Information).

[0018] According to a further embodiment of the invention, the first and second propulsion system are arranged for providing equal propulsion forces when operated at maximum power. Taking into account that according to the invention the first and second propulsion system can, under all towing conditions, be operated to provide propulsion in the same direction, this means that the towing vessel can exert maximum pushing and pulling forces in all directions (i.e. 360 degrees in horizontal plane). For example, when pushing sideways against an object, full bollard pull force is available. While the fender contact area sideways is large, the chances of damage to the object are reduced when pushing sideways. Also, when assisting objects 'under way' the propulsion forces can at all times be directed in the ideal direction, thereby maximizing towline forces and/or increasing fuel economy.

[0019] According to a further embodiment of the invention, the vessel comprises a further propulsion, which further propulsion has a maximum power of at most 30%, such as at most 20%, of the sum of the maximum power of the first propulsion system and second propulsion system. In mathematical form this means:

"Maximum power of further propulsion ≤ 0.3 x (maximum power of first propulsion system + maximum power of second propulsion system)".

[0020] For example, as envisaged by the inventor, the further propulsion can consist of a left and right propulsion unit, each having a maximum power of 170 kW, i.e. the further propulsion has a maximum power of 2x170 kW. The first and second propulsion system can each have a power of 2000 kW, i.e. the sum of their maximum powers is 4000 kW. In this example the maximum power of the further propulsion thus is 8,5% of the sum of the maximum power of the first and second propulsion system.

[0021] This further propulsion is primarily intended for cruising operation (such as transits, mobilizations) and standby without towing any object. This configuration allows the further propulsion being used during cruising whilst the first and second propulsion system, which are primarily intended for towing operation of the vessel, can be turned off. Realizing that the first and second propulsion system are primarily designed for towing operation and that their propulsion power is for cruising operation far oversized, it will be clear that the energy efficiency of the first and second propulsion system will be very low (inefficient) with respect to a further propulsion which is primarily designed for cruising operation. This configuration thus allows very efficient usage of fuels. According to a further elaboration of this embodiment, the further propulsion is arranged for driving a generator and/or for driving one or more towing winches directly or indirectly via for example a generator generating electric power for operating said winch and optionally providing electric power for other systems as well.

[0022] According to a further embodiment of the invention, the further propulsion comprises 2 propulsion elements, which are both provided at the same distance from the stern of the vessel and at opposing sides of the vertical longitudinal sectional plane of the vessel. This allows arrangement of the further propulsion system without hindering the first and second propulsion systems in their operation, allows for easy manoeuvring of the vessel and ensures good water flow to the propulsion elements.

[0023] Vessel according to one of the preceding clauses, wherein the vessel is provided with a so called articulated barge coupling system. So called articulated barge couplings are known from the prior art, also in relation to vessels. Such couplings are intended for coupling a vessel to a barge which is to be manipulated by the vessel.

[0024] According to a further embodiment of the invention, the towline extends from the tow point to the object to which the towline is attached. According to a further aspect of the invention, the invention also relates to an assembly of a vessel according to the invention and an object, the towline extends from the tow point to the object to which the towline is attached.

[0025] According to a further embodiment of the invention, the tow point is, measured from the stern of the vessel, provided at a distance of 20% to 50 % of the length of the vessel, preferably at a distance of 30% to 50% of the length of the vessel, more preferably at a distance of about 40% to 45% of the length of the vessel. This means that the tow point is arranged close to the rotating point of the under water body of the vessel. This allows easy positioning of the vessel with respect to the towline.

[0026] According to the invention, the tow point can be formed by a bitt or a tow hook, which both actually attach the towline to the vessel at the location of the tow point.

[0027] According to a further embodiment of the invention, the towing device further comprises a fairlead for guiding the towline, wherein the fairlead forms the tow point. This allows the towline to be attached to the vessel in another more practical location.

[0028] According to another further embodiment of the invention, the towing device further comprises: a towing winch mounted on the vessel for winding and unwinding the towline; and a fairlead for guiding the towline towards the towing winch. Here the fairlead provides guidance for the towline in order to ensure it is properly received on the winch. The winch allows the length of the tow part of the towline to be adjusted depending from circumstances.

[0029] According to a further embodiment of the invention, the towing winch is provided at the vertical longitudinal sectional plane of the vessel. This provides a symmetric weight distribution over the vessel.

[0030] According to a further embodiment of the invention, the towing winch is, measured from the stern of the vessel, provided at a distance of 20% to 60 % of the length of the vessel, preferably provided at a distance of 30% to 60 % of the length of the vessel, more preferably at a distance of about 40% to 50% of the length of the vessel. This provides a symmetric weight distribution over the vessel.

[0031] According to a further embodiment of the invention, the vessel is a tug vessel.

[0032] According to a further embodiment of the invention, the towing device further comprises a, guiding arc mounted on the vessel, wherein, viewed in vertical direction, the guiding arc is provided above the deck and wherein the guiding arc extends along the deck, which guiding arc is arranged for guiding the towline along the deck while swinging the vessel with respect to the towline while applying a tensile force to an object. This guiding arc allows the towline to swivel with respect to the vessel. Although this guiding arc can be in accordance with known prior art like disclosed in NL-1,023,447, it is according to this invention preferred to arrange this guiding arc in accordance with the non-published earlier NL-application NL-2003746, titled 'vessel' and filed on November 3, 2009 in the name of 'Baldo Dielen Assessoria LTDA', Brasil. All teaching of the guiding arc in NL-2003746 is hereby incorporated by reference.

[0033] Below, the invention will be further explained with reference to the drawings. These drawings are all of schematic nature. In these drawings:

Figure 1 shows a first embodiment of the invention in a perspective view;
Figure 2 shows a second embodiment of the invention in a perspective view from above;
Figure 3 shows the second embodiment of figure 2 in a perspective view from below;
Figure 4 shows the second embodiment of figures 2 and 3 in a bottom view;
Figure 5 shows a third embodiment of the invention in a bottom view;
Figure 6 shows a fourth embodiment of the invention in a bottom view;
Figure 7 shows a fifth embodiment of the invention in a perspective view from below;
Figure 8 shows the fifth embodiment of figure 7 in a perspective view from above, when used for pushing or pulling a barge;
Figure 9 shows a side view of figure 8;
Figure 10 shows a schematic diagram of the effective pulling force of various types of vessels;
Figure 11 shows schematically the forces during indirect towing of a prior art vessel (Fig. 11A) and of a vessel according to the invention (Fig. 11 B); and
Figure 12 shows schematically a prior art vessel (Fig. 12A) and a vessel according to the invention (Fig. 12B) during assisting a vessel object in a channel.

[0034] In the description below, different embodiments of the vessel are indicated by different reference numbers, but same or similar parts of these embodiments are indicated with the same reference number or sign.

[0035] Figure 1 shows a first embodiment 10 of the vessel according to the invention. The vessel 10 comprises a main hull 61 (without side hulls as are present in the other embodiments). The main hull 61 has a length direction L and a transverse direction T (see figure 2) extending horizontally, transverse to the longitudinal direction. On the deck 84 there is indicated an imaginary longitudinally deck centre line 81 extending in longitudinal direction and defining the longitudinally centre of the deck. The so called 'vertical longitudinal sectional plane' of the vessel is defined by the longitudinally deck centre line 81 and a vertical through the longitudinally deck centre line 81.

[0036] The vessel 10 further comprises two omni-directional propulsion devices 71 and 72, which in all shown embodiments 10, 20, 30, 40, 50 are a so called azimuthal propulsion device. It is however noted that in all embodiments of the invention, the omni-directional propulsion device can also be of a different type, like a Voith-Schneider propulsion device. A characteristic of a omni-directional propulsion device is that the direction of the thrusting force generated by the omni-directional propulsion device can be adjusted to be directed in any desired direction essentially perpendicular to the vertical axis 85 as indicated in figure 1, i.e. the propulsion direction can be rotated (as indicated with arrow R in figure 4) around a vertical axis 85. In case of a azimuthal propulsion device, the thrusting propeller (which rotates around

a horizontal axis for thrusting action) is actually rotated around the vertical axis 85. As will be realized, it is for the invention not required that the vertical axis 85 extends exactly vertical.

[0037] The vessel according to the invention further has a so called towing point 65 defining the position where the towline 64 acts in horizontal direction on the vessel. According to the invention, this towing point 65 is positioned, viewed in longitudinal direction of the vessel 10, in between the first omni-directional propulsion device 71 (further called ODPD) and the second ODPD 72. As follows from figure 1, it is not required that the towing point 65 is arranged at the same vertical height as the ODPDs 71 and 72. In general the towing point 65 will, viewed in vertical direction, be arranged higher than the ODPDs 71, 72. Although it is preferred that both the ODPDs 71, 72 as well as the towing point are arranged in the vertical longitudinal sectional plane (as shown in all figures), it is not required that these are all arranged in the vertical longitudinal sectional plane, neither is it required that these are arranged in one plane parallel to the vertical longitudinal sectional plane. It is for example very well conceivable that the towing point as arranged at a side of the main hull, whilst the ODPDs 71 and 72 are arranged in or around the vertical longitudinal sectional plane.

[0038] Figures 2-4 show a second embodiment 20 of the vessel according to the invention. The main differences between the vessel 20 and 10 are the following:

- on deck 84 of the main hull 61 there is provided a guiding arc 69 for guiding the towline 64 so that it can rotate around the tow point 65. For details and advantages of this guiding arc 69, reference is made to the earlier mentioned NL-2003746 of applicant, which is fully incorporated into this application by reference. As will be understood, this guiding arc 69 can also be applied with the embodiment 10 of figure 1. Further, it is to be noted that it is also conceivable to leave this guiding arc away from the embodiment 20 as well as from the embodiments 30, 40, 50 (to be discussed below);
- The vessel 20 provided with two side hulls 62 in the form of so called outriggers 62. These outriggers 62 are carried by transverse carriers 75 (see figure 4) so that there is a gap 86 between the main hull 61 and side hulls 62. When in water, water can pass through this gap 86. Above water level, the gap might be closed, for example by the carrier.
- The vessel 20 is provided with two keels 66 on the main hull 61. As will be clear also embodiment 10 could be provided with two keel (or one keel arranged centrally, like in embodiment 30 and 40, to e discussed below). Further it will be clear that also more keels as well as one keel or no keel are conceivable with the embodiment 20 (as well as with the other embodiments 30, 40, 50 to be discussed below).
- The vessel 20 is provided with a further propulsion 73 consisting of two propulsion elements 74, each provided on one side of the vessel. These serve for thrusting the vessel during transit (i.e. when no load is towed). As will e clear also embodiment 10 can e provided with such an additional propulsion. Further it will be clear that the additional propulsion 73, 74 can also be left away from the embodiment 20 as well as the other embodiments 30, 40 and 50 (discussed below).

[0039] In figure 2, reference number 82 indicates the water line of the main hull 61 and reference number 83 indicates the water line of the side hull 62. It can be seen that the draught D1 of the main hull is larger than the draught D2 of the side hull 62. In this embodiment the draught D1 is about 150% of the draught D2, i.e. 1.5 times larger. Further it can be seen that the draught D4 of the keels 66 is larger than the draught D3 of the ODPDs 71, 72, so that when on shore the vessel 20 can stand on the keels 66 without damaging the ODPDs 71, 72.

[0040] Figure 5 shows a third embodiment 30 of the vessel according to the invention. The main differences between the vessel 30 and vessel 20 is that vessel 30 has only one central keel 66 whilst vessel 20 has two keels 66 spaced apart. As will e clear, the vessel 30 can in addition be provided with two keels 66 spaced apart, like shown in figures 2-4. Further all remarks made in relation to vessel 10 concerning leaving away parts of the vessel, apply to the third embodiment 30 as well.

[0041] Figure 6 shows a fourth embodiment 40 of the vessel according to the invention. The main differences between the vessel 40 and vessel 30 is that vessel 40 has side hulls in the form of so called sponsons 63, whilst vessel 30 has side hulls in the form of so called outriggers 62. Each sponson 63 is formed onto and against a side of main hull 61 so that there no gap between the sponson 63 and main hull 61. As will be clear, the remarks concerning leaving away of the vessel 20 or vessel 30 (as well as concerning adding parts to said vessels 20, 30) apply to vessel 40 as well.

[0042] Figure 7 shows a fifth embodiment 50 of the vessel according to the invention. The main differences between the vessel 50 and vessel 40 is that vessel 50 has two keels whilst vessel 40 has one keel. As will be clear, the remarks concerning leaving away parts of the vessel 20 or vessel 30 or vessel 40 (as well as concerning adding parts to said vessels 20, 30, 49) apply to vessel 50 as well.

[0043] Figures 8 and 9 show an assembly of, one the one hand, a vessel 50 provided with a so called articulated barge coupling system and, on the other hand, a barge 70. As will be clear the vessel 50 can be replaced by any other vessel 10, 20, 30 or 40.

[0044] Figures 10-12 give an impression of the advantages of the vessel according to the invention over prior art tug vessels.

[0045] Figure 10 shows a schematic diagram of the effective pulling force of various types of vessels. Reference number 90 indicates schematically the positioning of the vessel; graph 91 a indicates the effective pulling force of a Voith-Schneider tug having two Voith-Schneider devices arranged in the stern part of the vessel (like the configuration of the vessel 100 shown in figures 11A and 12A); graph 91 b indicates the effective pulling force of an ASD tug (ASD=Azimuthal Stern Drive) as indicated with 100 in figures 11A and 12A; graph 91c indicates the effective pulling force of a so called tractor tug; and graph 92 indicates the effective pulling force of a vessel according to the invention.

[0046] In the diagram of figure 10, it is assumed that all vessels have the same installed power of 100 ppu (=propulsion power unit). Taking into account Voith-Schneider devices have a lower efficiency, the graph 91 a for a Voith-Schneider tug shows considerable lower values (a maximum of 75 ppu against a maximum of about 100 ppu for the others). Assuming the vessel is, in figure 10, oriented with its back (stern) facing to the left, its front facing to the right, its left side (port side) facing upwards and its right side (starboard side) facing downwards, the towline is rotated over 360° around the vertical through the tow point and the bollard pull force is determined for each rotation angle. As one can see from graph 92, the bollard pull force of a vessel according to the invention is about 100 in all directions (circular graph 92). However, the bollard pull force for the prior art vessels decreases very considerable when the towline is rotated from a direction parallel to the length direction of the vessel towards a direction perpendicular to the length direction of the vessel, see the about perpendicular/oval graphs 91a, 91b and 91c. The advantages of the vessel according to the invention over the prior art vessels, are evident and speak for them selves.

[0047] Figure 11 shows schematically the forces during indirect towing of a prior art vessel (Fig. 11A) and of a vessel according to the invention (Fig. 11 B). Indirect towing means that, viewed in the direction X in which the towed vessel object 60 moves, the towing vessel 100 (an ASD tug according to the prior art) or 50 (according to the invention) is behind the towed vessel object 60 in order to keep the towed vessel object 60 in its course by exerting pulling forces on the stern of the towed vessel object 60. The prior art towing vessel 100 and invented towing vessel 50 are compared under similar circumstances. The angle β between the length direction of the towing vessel 50, 100 and the direction of movement X of the towed vessel object 60 is in both cases the same. Further the angle y between the towline and the line perpendicular to the length direction of the towed vessel object 60 is in both cases the same. Also the maximum bollard pull force of the towing vessels 50, 100 is the same (for the ASD tug 100 this maximum bollard pull force is in the length direction of the ASD tug 100), i.e. both towing vessels 50, 100 have comparable power. As follows clearly from comparison of figures 11A and 11B, the invented towing vessel can exert a considerable larger towing force F_T on the towline than the prior art ASD tug. This appears to be due to the fact that the thrusting forces P1 and P2 of the MDPDs 71 and 72 of the invented towing vessel are directed essentially transverse to the direction X of movement of the towed vessel object 60, whilst the thrusting forces P1 and P2 of the MDPDs 171 and 172 of the ASD tug 100 are directed essentially in the direction X of movement of the towed vessel object 60. The advantages of the vessel according to the invention over the prior art vessels, are evident and speak for them selves.

[0048] Figure 12 shows schematically a prior art vessel (Fig. 12A) and a vessel according to the invention (Fig. 12B) during assisting a vessel object in a channel. As follows clearly from comparison of figures 12A and 12B, the invented towing vessel 50 requires in case of towing action in transverse directions much less space than a prior art ASD tug 100. This means that the invented towing vessel 50 can assist a towed vessel object through much smaller channels (the bank of which is indicated with 101) than a prior art ASD tug vessel 100. Evidently this is also advantageous in crowded waters.

[0049] Although a vessel 50 is shown in figures 11B and 12B, it will be clear that this vessel 50 can be replaced by any other embodiment of a vessel according to the invention, like a vessel 10, 20, 30 or 40.

[0050] The invention can be further described by the next following clauses:

1] Vessel (10, 20, 30, 40, 50) comprising a towing device and a hull (61, 62, 63), wherein the towing device comprises:

- a towline (64);
- a tow point (65) - such as a fairlead, a bitt, or a tow hook - where the vessel (10, 20, 30, 40, 50) exerts a force, especially a horizontal force, onto the towline (64) when applying a tensile force to an object (60) by means of the towline (64), the tow point (65) being provided on the vessel;
- a first propulsion system (71) and a second propulsion system (72);

characterized, in that the first propulsion system and second propulsion system each comprise an omni-directional propulsion device (71, 72); and in that, viewed in longitudinal direction of the vessel, the tow point (65) is arranged between the first omni-directional propulsion device (71) and the second omni-directional propulsion device (72).

2] Vessel (10, 20, 30, 40, 50) according to clause 1, wherein the first and second omni-directional propulsion device (71, 72) are provided in the vertical longitudinal sectional plane of the vessel.

3] Vessel (10, 20, 30, 40, 50) according to one of the preceding clauses, wherein the tow point (65) is provided in the vertical longitudinal sectional plane of the vessel.

4] Vessel (10, 20, 30, 40, 50) according to one of the preceding clauses, wherein each omni-directional propulsion device (71, 72) comprises one chosen from the group: a Voith-Schneider propulsion device or an azimuthal propulsion device.

5] Vessel (20, 30, 40, 50) according to one of the preceding clauses, wherein the hull comprises:

- a main hull (61); and
- a left and right side hull (62, 63) provided at the left respectively right longitudinal side of the main hull (61).

6] Vessel (20, 30, 40, 50) according to clause 5, wherein the draught (D1) of the main hull (61) is larger than the draught (D2) of the side hulls (62, 63).

7] Vessel (20, 30, 40, 50) according to clause 6, wherein the draught (D1) of the main hull (61) is at least 25%, especially at least 50%, larger than the draught (D2) of the side hulls (62, 63).

8] Vessel (20, 30, 40, 50) according to one of clauses 5-7, wherein, in horizontal condition of the vessel, the water displacement of the side hulls (62, 63) is at most 20% of the total water displacement of the vessel (20, 30, 40, 50), especially at most 15% of the total water displacement of the vessel, such as at most 12% or at most 10% of the total water displacement of the vessel.

9] Vessel (40, 50) according to one of clauses 5-8, wherein each side hull comprises a sponson (63) formed onto the main hull (61).

10] Vessel (20, 30) according to one of clauses 5-8, wherein each side hull comprises an outrigger (62) attached to the main hull (61) by one or more transverse carriers (75).

11] Vessel (20, 30, 40, 50) according to one of the preceding clauses, wherein the hull, especially the main hull (61), is provided with at least one keel (66).

12] Vessel (20, 50) according to clause 11, wherein the hull, especially the main hull (61), is provided with two keels (66) which are mutually parallel.

13] Vessel (20, 50) according to clause 12, wherein the keels (66) have a draught (D4) larger than or equal to the draught (D3) of the first and second omni-directional propulsion device (71, 72) and are arranged to support the vessel (20, 50) onto the keels (66) when on shore.

14] Vessel (10, 20, 30, 40, 50) according to one of the preceding clauses, wherein the first and second propulsion system (71, 72) are arranged to provide the vessel a continuous bollard pull of at least 300 kN (= 30 t BP), preferably at least 450 kN (≈ 45 t BP), such as at least 650 kN (≈ 65 t BP).

15] Vessel (10, 20, 30, 40, 50) according to clause 14, wherein said continuous bollard pull is at most 1500 kN (≈ 150 t BP).

16] Vessel (10, 20, 30, 40, 50) according to one of the preceding clauses, wherein the first and second propulsion system are arranged for providing essentially equal propulsion forces when operated at maximum power.

17] Vessel (10, 20, 30, 40, 50) according to one of the preceding clauses, wherein the vessel comprises a further propulsion (73), which further propulsion (73) has a maximum power of at most 30%, such as at most 20%, of the sum of the maximum power of the first propulsion system (71) and second propulsion system (72).

18] Vessel (10, 20, 30, 40, 50) according to clause 17, wherein the further propulsion (73) is arranged for driving one or more towing winches and/or a generator generating electric power.

19] Vessel (10, 20, 30, 40, 50) according to clause 17 or 18, wherein the further propulsion (73) comprises 2 propulsion elements (74), which are both provided at the same distance from the stern (67) of the vessel and at opposing sides of the vertical longitudinal sectional plane of the vessel.

20] Vessel (50) according to one of the preceding clauses, wherein the vessel is provided with an articulated barge coupling system (68).

21] Vessel (10, 20, 30, 40, 50) according to one of the preceding clauses, wherein the towline (64) extends from the tow point (65) to the object (60) to which the towline (64) is attached.

22] Vessel (10, 20, 30, 40, 50) according to one of the preceding clauses, wherein, measured from the stern of the vessel, the tow point (65) is provided at a distance of 20% to 50 % of the length of the vessel, preferably at a distance of 30% to 50 % of the length of the vessel, more preferably at a distance of about 40% to 45% of the length of the vessel.

23] Vessel (10, 20, 30, 40, 50) according to one of the preceding clauses, wherein the towing device further comprises a fairlead for guiding the towline, and wherein the fairlead forms the tow point (65).

24] Vessel (10, 20, 30, 40, 50) according to one of the preceding clauses, wherein the towing device further comprises:

- a towing winch mounted on the vessel for winding and unwinding the towline; and
- a fairlead for guiding the towline towards the towing winch.

25] Vessel (10, 20, 30, 40, 50) according to clause 24, wherein the towing winch is provided at the vertical longitudinal sectional plane of the vessel.

26] Vessel (10, 20, 30, 40, 50) according to one of clauses 24 - 25, wherein, measured from the stern (67) of the vessel, the towing winch is provided at a distance of 20% to 60 % of the length of the vessel, preferably provided at a distance of 30% to 60 % of the length of the vessel, more preferably at a distance of about 40% to 50% of the length of the vessel.

27] Vessel (10, 20, 30, 40, 50) according to one of the preceding clauses, wherein the vessel is a tug vessel.

28] Vessel (10, 20, 30, 40, 50) according to one of the preceding clauses, wherein the towing device further comprises a, guiding arc (69) mounted on the vessel, wherein, viewed in vertical direction, the guiding arc (69) is provided above the deck (84) and wherein the guiding arc (69) extends along the deck (84), which guiding arc (69) is arranged for guiding the towline (64) along the deck (84) when swinging the vessel with respect to the towline while applying a tensile force to an object.

[0051] It is to be noted that within the scope of the claims, many variants of the invention are conceivable. For example: the first propulsion system can according to the invention also comprise two (or more) of said first omni-directional propulsion devices, which in case of two of said first omni-directional propulsion devices could according to the invention be arranged symmetrically with respect to the vertical longitudinal sectional plane of the vessel; and/or the second propulsion system can according to the invention also comprise two (or more) of said second omni-directional propulsion devices, which in case of two of said second omni-directional propulsion devices could according to the invention be arranged symmetrically with respect to the vertical longitudinal sectional plane of the vessel.

List of used reference numbers/signs

[0052]

10	vessel
20	vessel
30	vessel
40	vessel
50	vessel
60	object
61	main hull
62	side hull of outrigger type/outrigger
63	side hull of sponson type/sponson
64	towline
65	tow point
66	keel
67	stern
68	articulated barge coupling system
69	guiding arc
70	barge
71	first propulsion system/first omni-directional propulsion device (the aft unit)
72	second propulsion system/ second omni-directional propulsion device (the forward unit)
73	further propulsion
74	propulsion element
75	transverse carrier
81	longitudinal deck centre line
82	water line of main hull
83	water line of side hull
84	deck
85	vertical rotation axis of omni-directional propulsion device
86	gap
90	schematic representation of a tug vessel
91a-c	effective pulling force of prior art vessels
92	effective pulling force of vessel according to the invention
100	prior art vessel
171	(first) propulsion system of prior art vessel
172	(second) propulsion system of prior art vessel

D1 draught of main hull

D2 draught of side hull
D3 draught of first/second propulsion device
D4 draught of keel
L longitudinal direction of vessel
P1 thrust direction of first propulsion device
P2 thrust direction of second propulsion device
R rotation of omni-directional propulsion device
T transverse direction of vessel
X direction of movement of towed object

Claims

1. Vessel (10, 20, 30, 40, 50) comprising a towing device and a hull (61, 62, 63), wherein the towing device comprises:

- a towline (64);
- a tow point (65) - such as a fairlead, a bitt, or a tow hook - where the vessel (10, 20, 30, 40, 50) exerts a force, especially a horizontal force, onto the towline (64) when applying a tensile force to an object (60) by means of the towline (64), the tow point (65) being provided on the vessel;
- a first propulsion system (71) and a second propulsion system (72);

characterized, in that the first propulsion system and second propulsion system each comprise an omni-directional propulsion device (71, 72); and **in that**, viewed in longitudinal direction of the vessel, the tow point (65) is arranged between the first omni-directional propulsion device (71) and the second omni-directional propulsion device (72).

2. Vessel (10, 20, 30, 40, 50) according to claim 1, wherein the first and second omni-directional propulsion device (71, 72) are provided in the vertical longitudinal sectional plane of the vessel.

3. Vessel (10, 20, 30, 40, 50) according to one of the preceding claims, wherein the tow point (65) is provided in the vertical longitudinal sectional plane of the vessel.

4. Vessel (10, 20, 30, 40, 50) according to one of the preceding claims, wherein each omni-directional propulsion device (71, 72) comprises one chosen from the group: a Voith-Schneider propulsion device or an azimuthal propulsion device.

5. Vessel (20, 30, 40, 50) according to one of the preceding claims, wherein the hull, especially the main hull (61), is provided with at least one keel (66).

6. Vessel (20, 50) according to claim 5, wherein the hull, especially the main hull (61), is provided with two keels (66) which are mutually parallel.

7. Vessel (10, 20, 30, 40, 50) according to one of the preceding claims, wherein the first and second propulsion system (71, 72) are arranged to provide the vessel a continuous bollard pull of at least 300 kN (≈ 30 t BP), preferably at least 450 kN (≈ 45 t BP), such as at least 650 kN (≈ 65 t BP).

8. Vessel (10, 20, 30, 40, 50) according to one of the preceding claims, wherein the first and second propulsion system are arranged for providing essentially equal propulsion forces when operated at maximum power.

9. Vessel (50) according to one of the preceding claims, wherein the vessel is provided with an articulated barge coupling system (68).

10. Vessel (10, 20, 30, 40, 50) according to one of the preceding claims, wherein the towline (64) extends from the tow point (65) to the object (60) to which the towline (64) is attached.

11. Vessel (10, 20, 30, 40, 50) according to one of the preceding claims, wherein, measured from the stern of the vessel, the tow point (65) is provided at a distance of 20% to 50 % of the length of the vessel, preferably at a distance of 30% to 50 % of the length of the vessel, more preferably at a distance of about 40% to 45% of the length of the vessel.

12. Vessel (10, 20, 30, 40, 50) according to one of the preceding claims, wherein the towing device further comprises:

- a towing winch mounted on the vessel for winding and unwinding the towline; and
- a fairlead for guiding the towline towards the towing winch.

13. Vessel (10, 20, 30, 40, 50) according to claim 12, wherein the towing winch is provided at the vertical longitudinal sectional plane of the vessel.

14. Vessel (10, 20, 30, 40, 50) according to one of claims 12 - 13, wherein, measured from the stern (67) of the vessel, the towing winch is provided at a distance of 20% to 60 % of the length of the vessel, preferably provided at a distance of 30% to 60 % of the length of the vessel, more preferably at a distance of about 40% to 50% of the length of the vessel.

15. Vessel (10, 20, 30, 40, 50) according to one of the preceding claims, wherein the vessel is a tug vessel.

Patentansprüche

1. Wasserfahrzeug (10, 20, 30, 40, 50), das eine Schleppvorrichtung und einen Rumpf (61, 62, 63) umfasst, wobei die Schleppvorrichtung umfasst:

- eine Schleppleine (64);
- einen Zugpunkt (65) - wie beispielsweise eine Leinenführung (fairlead), einen Poller oder einen Schlepphaken - an dem das Wasserfahrzeug (10, 20, 30, 40, 50) eine Kraft, insbesondere eine horizontale Kraft, auf die Schleppleine (64) ausübt, wenn über die Schleppleine (64) eine Zugkraft auf ein Objekt (60) wirkt, wobei sich der Zugpunkt (65) an dem Wasserfahrzeug befindet;
- ein erstes Antriebssystem (71) und ein zweites Antriebssystem (72);

dadurch gekennzeichnet, dass das erste Antriebssystem und das zweite Antriebssystem jeweils eine omnidirektionale Antriebsvorrichtung (71, 72) umfassen, und dass, in Längsrichtung des Wasserfahrzeugs gesehen, der Zugpunkt (65) zwischen der ersten omnidirektionalen Antriebsvorrichtung (71) und der zweiten omnidirektionalen Antriebsvorrichtung (72) angeordnet ist.

2. Wasserfahrzeug (10, 20, 30, 40, 50) nach Anspruch 1, wobei sich die erste und die zweite omnidirektionale Antriebsvorrichtung (71, 72) in der vertikalen Längsschnittebene des Wasserfahrzeugs befinden.

3. Wasserfahrzeug (10, 20, 30, 40, 50) nach einem der vorangehenden Ansprüche, wobei sich der Zugpunkt (65) in der vertikalen Längsschnittebene des Wasserfahrzeugs befindet.

4. Wasserfahrzeug (10, 20, 30, 40, 50) nach einem der vorangehenden Ansprüche, wobei jede omnidirektionale Antriebsvorrichtung (71, 72) eine Antriebsvorrichtung umfasst, die aus der Gruppe aus Voith-Schneider-Antriebsvorrichtung und Azimuth-Antriebsvorrichtung ausgewählt wird.

5. Wasserfahrzeug (10, 20, 30, 40, 50) nach einem der vorangehenden Ansprüche, wobei der Rumpf, insbesondere der Hauptrumpf (61), mit wenigstens einem Kiel (66) versehen ist.

6. Wasserfahrzeug (10, 20, 30, 40, 50) nach Anspruch 5, wobei der Rumpf, insbesondere der Hauptrumpf (61), mit zwei Kielen (66) versehen ist, die parallel zueinander sind.

7. Wasserfahrzeug (10, 20, 30, 40, 50) nach einem der vorangehenden Ansprüche, wobei das erste und das zweite Antriebssystem (71, 72) so eingerichtet sind, dass sie dem Wasserfahrzeug einen kontinuierlichen Pfahlzug von wenigstens 300 kN (≈ 30 t BP), vorzugsweise wenigstens 450 kN (= 45 t BP), so beispielsweise wenigstens 650 kN (= 65 t BP) verleihen.

8. Wasserfahrzeug (10, 20, 30, 40, 50) nach einem der vorangehenden Ansprüche, wobei das erste und das zweite Antriebssystem so eingerichtet sind, dass sie im Wesentlichen gleiche Antriebskräfte erzeugen, wenn sie mit maximaler Leistung betrieben werden.

9. Wasserfahrzeug (50) nach einem der vorangehenden Ansprüche, wobei das Wasserfahrzeug mit einem Schleppkahn-Gelenkkupplungssystem (articulated barge coupling system) (68) versehen ist.

10. Wasserfahrzeug (10, 20, 30, 40, 50) nach einem der vorangehenden Ansprüche, wobei sich die Schleppleine (64) von dem Zugpunkt (65) zu dem Objekt (60) erstreckt, an dem die Schleppleine (64) angebracht ist.

11. Wasserfahrzeug (10, 20, 30, 40, 50) nach einem der vorangehenden Ansprüche, wobei sich der Zugpunkt (65), vom Heck des Wasserfahrzeugs aus gemessen, in einem Abstand von 20 % bis 50 % der Länge des Wasserfahrzeugs, vorzugsweise in einem Abstand von 30 % bis 50 % der Länge des Wasserfahrzeugs, noch besser in einem Abstand von ungefähr 40 % bis 45 % der Länge des Wasserfahrzeugs, befindet.

12. Wasserfahrzeug (10, 20, 30, 40, 50) nach einem der vorangehenden Ansprüche, wobei die Schleppvorrichtung des Weiteren umfasst:

- eine Schleppwinde, die an dem Wasserfahrzeug zum Aufwickeln und Abwickeln der Schleppleine installiert ist; und
- eine Leinenführung zum Führen der Schleppleine auf die Schleppwinde zu.

13. Wasserfahrzeug (10, 20, 30, 40, 50) nach Anspruch 12, wobei sich die Schleppwinde in der vertikalen Längsschnittebene des Wasserfahrzeugs befindet.

14. Wasserfahrzeug (10, 20, 30, 40, 50) nach einem der Ansprüche 12 - 13, wobei sich die Schleppwinde, vom Heck (67) des Wasserfahrzeugs aus gemessen, in einem Abstand von 20 % bis 60 % der Länge des Wasserfahrzeugs, vorzugsweise in einem Abstand von 30 % bis 60 % der Länge des Wasserfahrzeugs, noch besser in einem Abstand von ungefähr 40 % bis 50 % der Länge des Wasserfahrzeugs, befindet.

15. Wasserfahrzeug (10, 20, 30, 40, 50) nach einem der vorangehenden Ansprüche, wobei das Wasserfahrzeug ein Schlepp-Wasserfahrzeug ist.

Revendications

1. Navire (10, 20, 30, 40, 50) comprenant un dispositif de remorquage et une coque (61, 62, 63), dans lequel le dispositif de remorquage comprend :

- un câble de remorquage (64) ;
- un point de remorquage (65) - tel qu'un guide-câble, une bitte, un crochet de remorquage - où le navire (10, 20, 30, 40, 50) exerce une force, en particulier une force horizontale, sur le câble de remorquage (64) lors de l'application d'une force de tension à un objet (60) au moyen du câble de remorquage (64), le point de remorquage (65) étant prévu sur le navire ;
- un premier système de propulsion (71) et un deuxième système de propulsion (72) ;

caractérisé en ce que le premier système de propulsion et le deuxième système de propulsion comprennent chacun un dispositif de propulsion omnidirectionnelle (71, 72) ; et **en ce que**, vu dans la direction longitudinale du navire, le point de remorquage (65) est agencé entre le premier dispositif de propulsion omnidirectionnelle (71) et le deuxième dispositif de propulsion omnidirectionnelle (72).

2. Navire (10, 20, 30, 40, 50) selon la revendication 1, dans lequel les premier et deuxième dispositifs de propulsion omnidirectionnelle (71, 72) sont prévus dans le plan de coupe longitudinal vertical du navire.

3. Navire (10, 20, 30, 40, 50) selon l'une quelconque des revendications précédentes, dans lequel le point de remorquage (65) est prévu dans le plan de coupe longitudinal vertical du navire.

4. Navire (10, 20, 30, 40, 50) selon l'une quelconque des revendications précédentes, dans lequel chaque dispositif de propulsion omnidirectionnelle (71, 72) comprend un élément choisi dans le groupe comprenant : un dispositif de propulsion Voith-Schneider ou un dispositif de propulsion azimutale.

5. Navire (20, 30, 40, 50) selon l'une quelconque des revendications précédentes, dans lequel la coque, en particulier

la coque principale (61), est pourvue d'au moins une quille (66).

6. Navire (20, 50) selon la revendication 5, dans lequel la coque, en particulier la coque principale (61), est pourvue de deux quilles (66) qui sont mutuellement parallèles.

7. Navire (10, 20, 30, 40, 50) selon l'une quelconque des revendications précédentes, dans lequel les premier et deuxième systèmes de propulsion (71, 72) sont agencés pour fournir au navire une capacité de traction continue d'au moins 300 kN (≈ 30 t BP), de préférence d'au moins 450 kN (≈ 45 t BP), par exemple d'au moins 650 kN (≈ 65 t BP).

8. Navire (10, 20, 30, 40, 50) selon l'une quelconque des revendications précédentes, dans lequel les premier et deuxième systèmes de propulsion sont agencés pour fournir des forces de propulsion essentiellement égales lors d'un fonctionnement à puissance maximum.

9. Navire (50) selon l'une quelconque des revendications précédentes, dans lequel le navire est pourvu d'un système d'accouplement de barge articulé (68).

10. Navire (10, 20, 30, 40, 50) selon l'une quelconque des revendications précédentes, dans lequel le câble de remorquage (64) s'étend du point de remorquage (65) jusqu'à l'objet (60) auquel le câble de remorquage (64) est attaché.

11. Navire (10, 20, 30, 40, 50) selon l'une quelconque des revendications précédentes, dans lequel, mesuré à partir de la poupe du navire, le point de remorquage (65) est prévu à une distance de 20 % à 50 % de la longueur du navire, de préférence à une distance de 30 % à 50 % de la longueur du navire, plus préférablement à une distance d'environ 40 % à 45 % de la longueur du navire.

12. Navire (10, 20, 30, 40, 50) selon l'une quelconque des revendications précédentes, dans lequel le dispositif de remorquage comprend en outre :

- un treuil de remorquage monté sur le navire pour enrouler et dérouler le câble de remorquage ; et
- un guide-câble pour guider le câble de remorquage vers le treuil de remorquage.

13. Navire (10, 20, 30, 40, 50) selon la revendication 12, dans lequel le treuil de remorquage est prévu dans le plan de coupe longitudinal vertical du navire.

14. Navire (10, 20, 30, 40, 50) selon l'une des revendications 12 et 13, dans lequel, mesuré à partir de la poupe (67) du navire, le treuil de remorquage est prévu à une distance de 20 % à 60 % de la longueur du navire, de préférence prévu à une distance de 30 % à 60 % de la longueur du navire, plus préférablement à une distance d'environ 40 % à 50 % de la longueur du navire.

15. Navire (10, 20, 30, 40, 50) selon l'une quelconque des revendications précédentes, dans lequel le navire est un remorqueur.

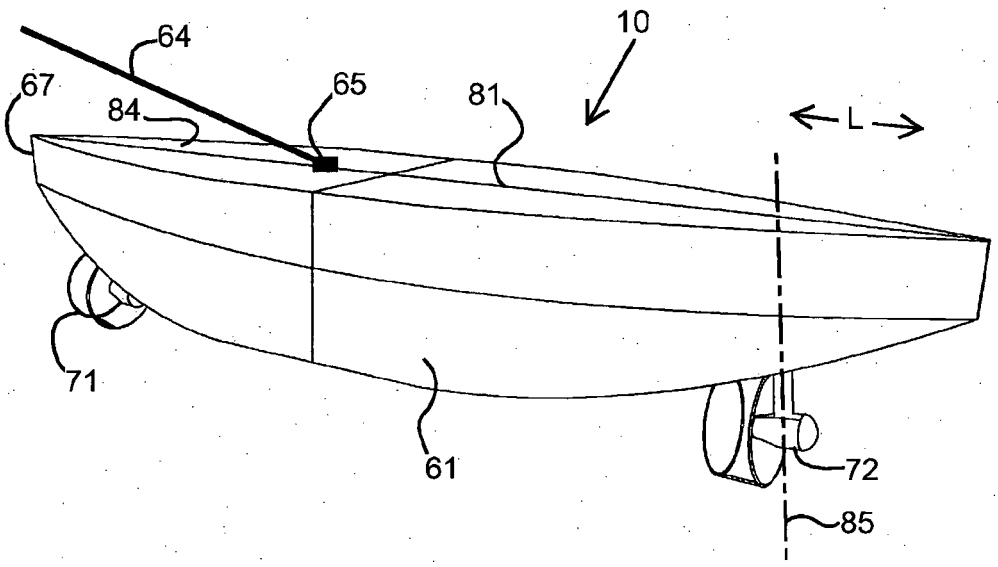

64
10
67
84
65
81
L
71
61
72
85

Fig. 1

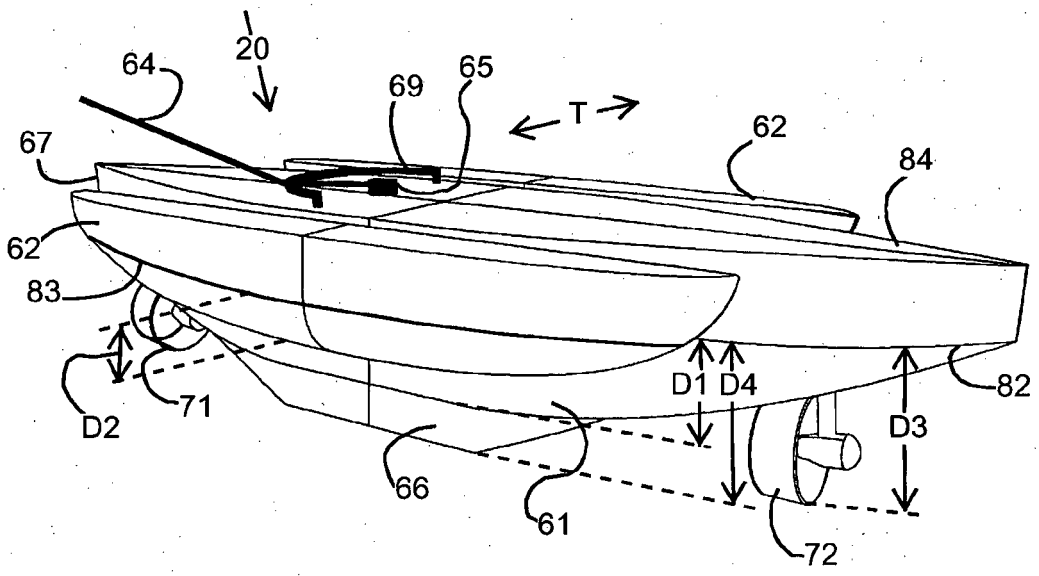

20
64
69
65
T
67
62
84
62
83
D1
D4
82
D2
71
D3
66
61
72

Fig. 2

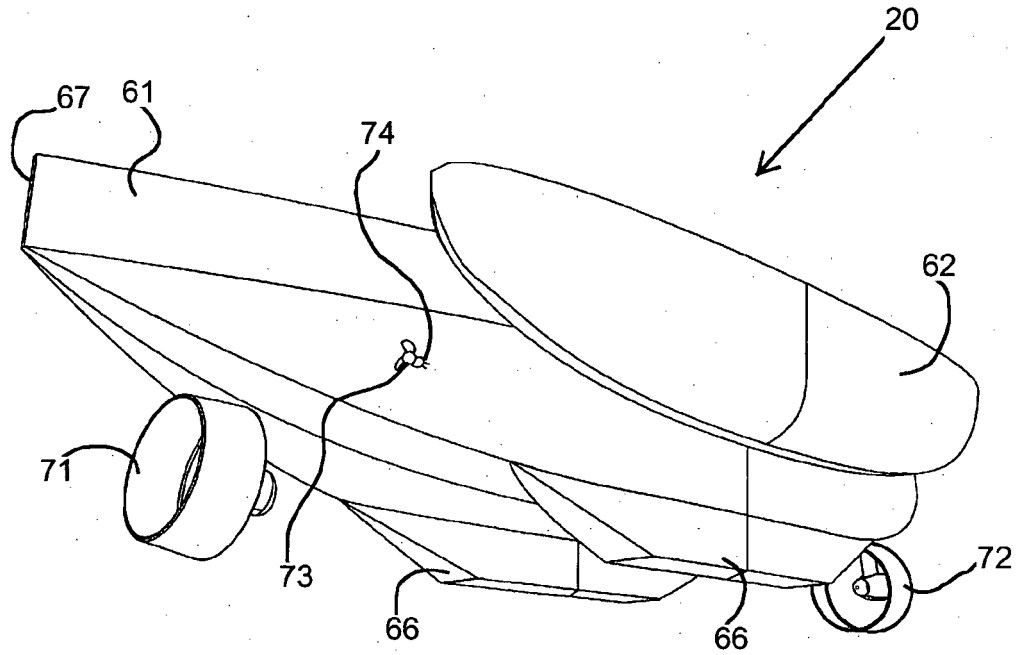

20
67
61
74
62
71
73
72
66
66

Fig. 3

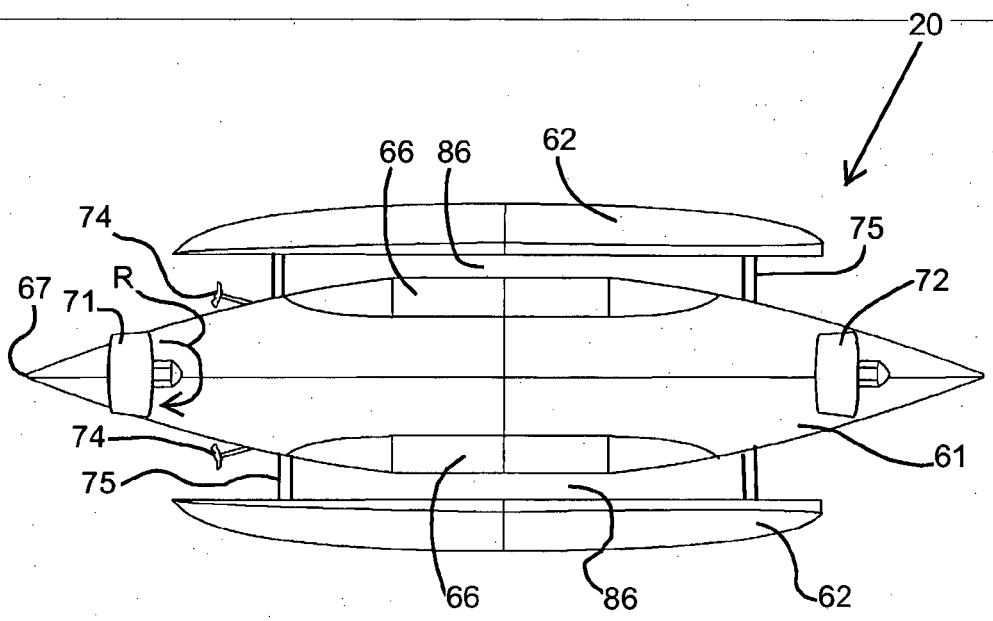

20
66
86
62
74
75
R
67
71
72
74
61
75
66
86
62

Fig. 4

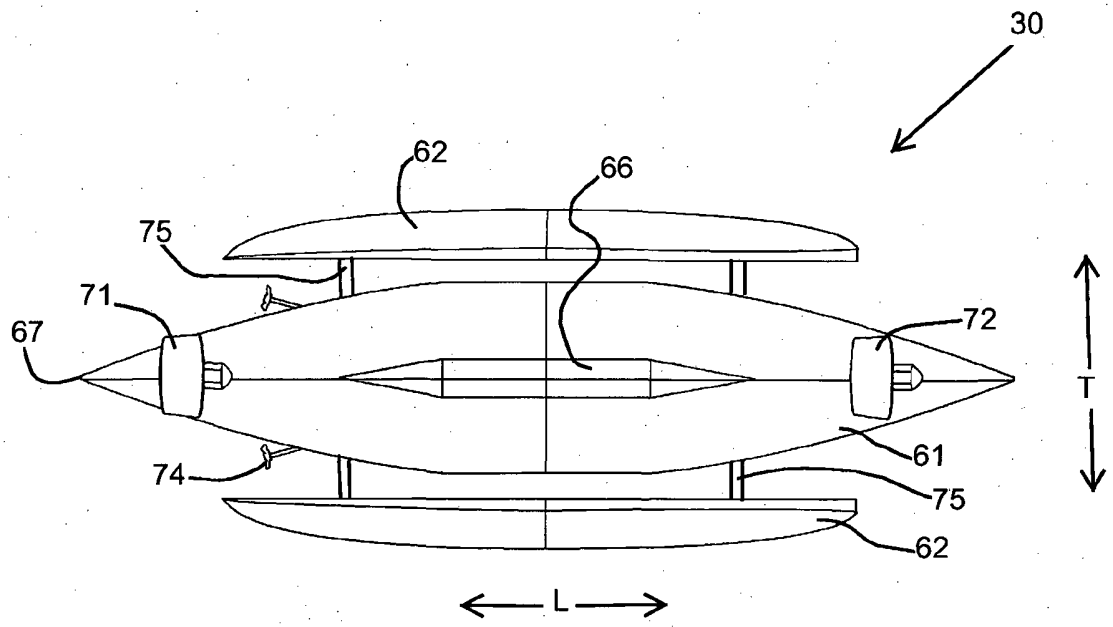


Fig. 5

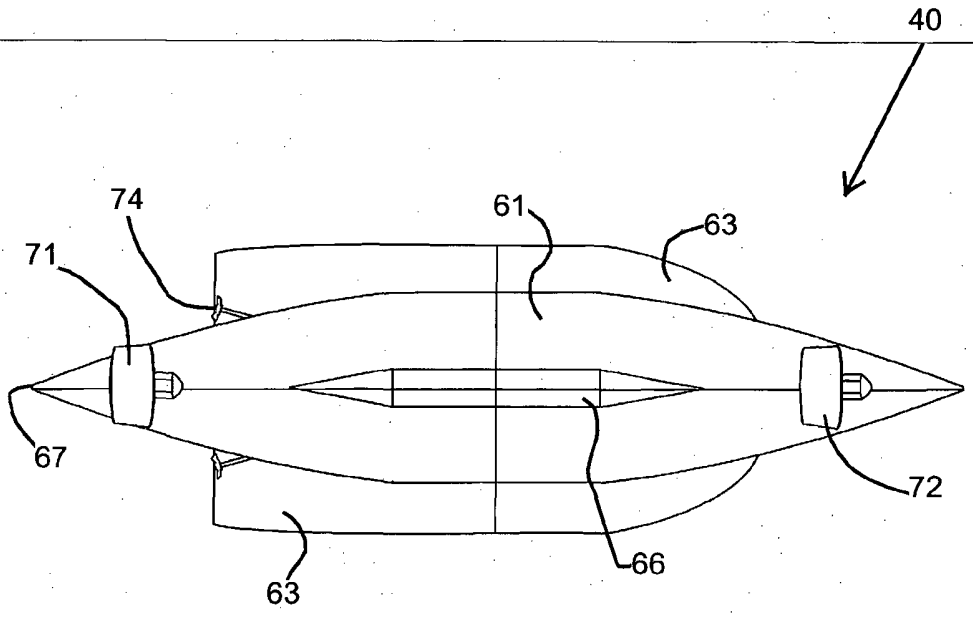


Fig. 6

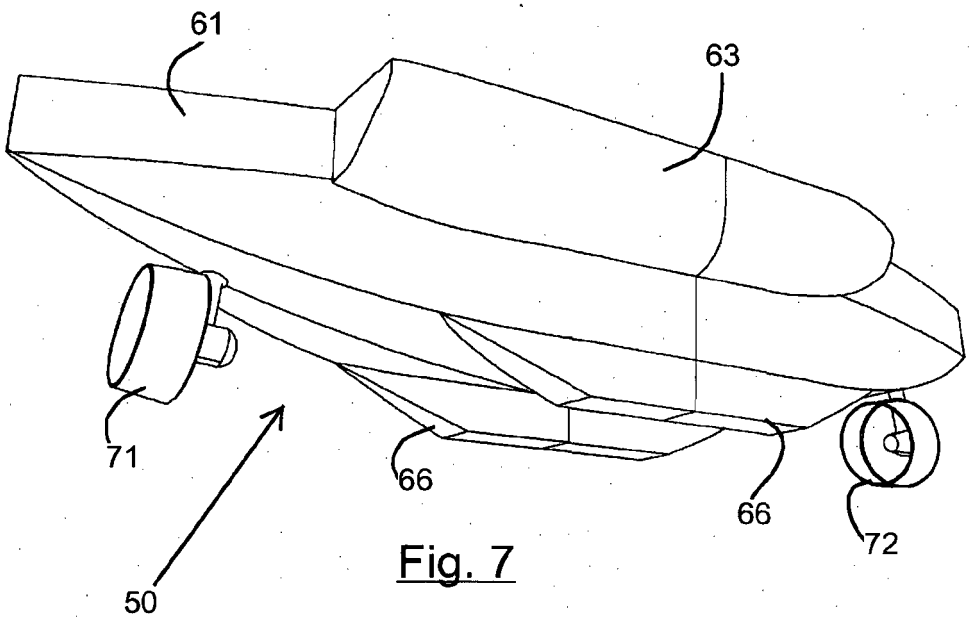


Fig. 7

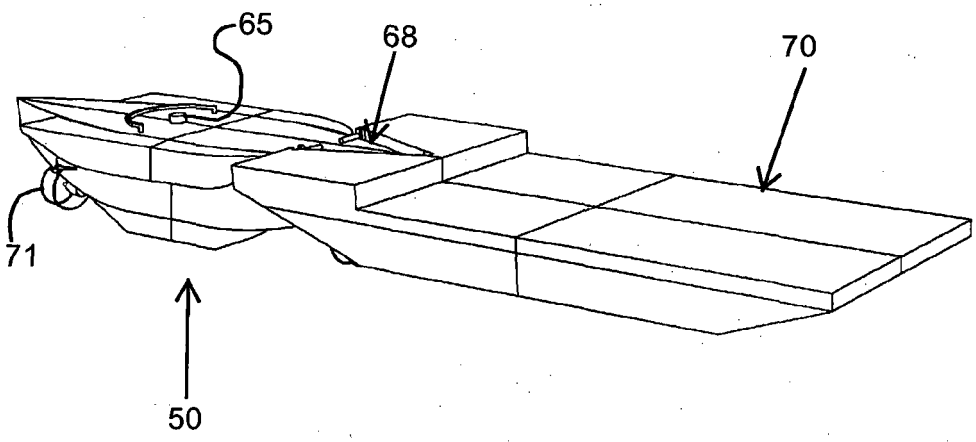


Fig. 8

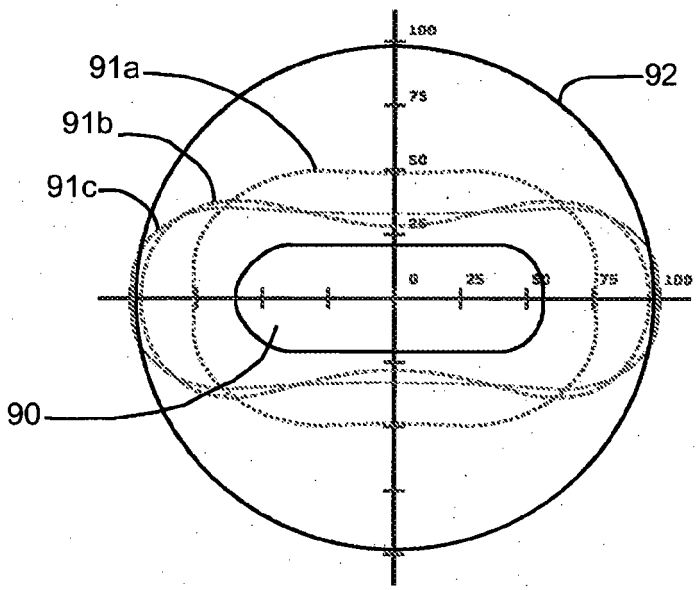

91a
91b
91c
90
92
100
75
50
25
0
25
50
75
100

Fig. 10

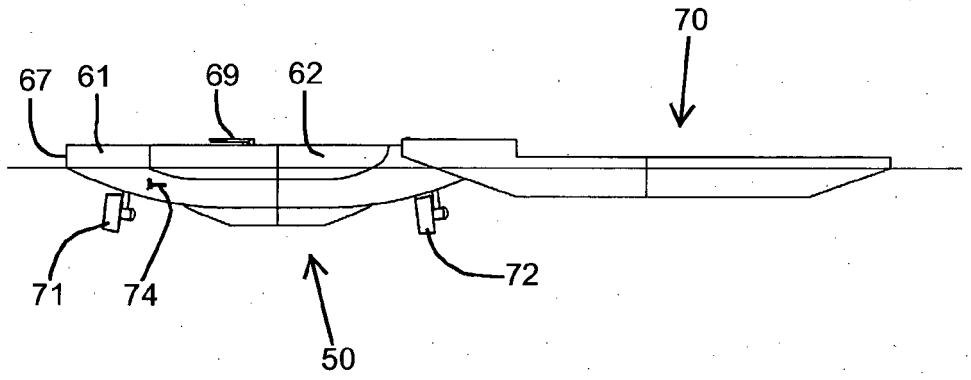

67
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74
72
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Fig. 9

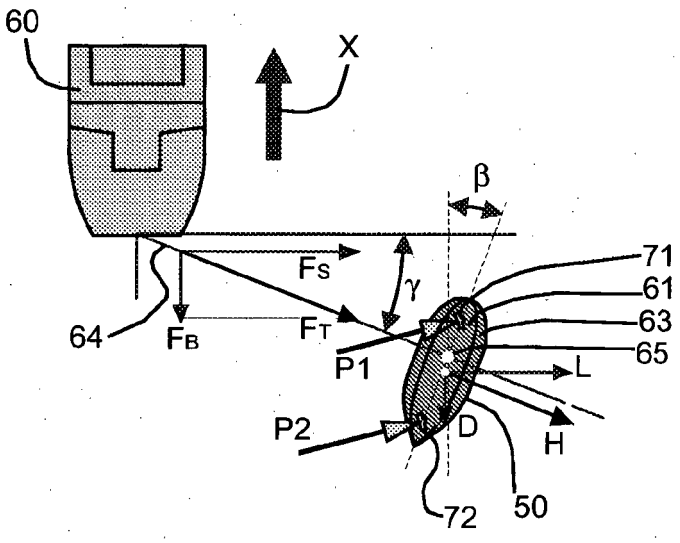


Fig. 11B

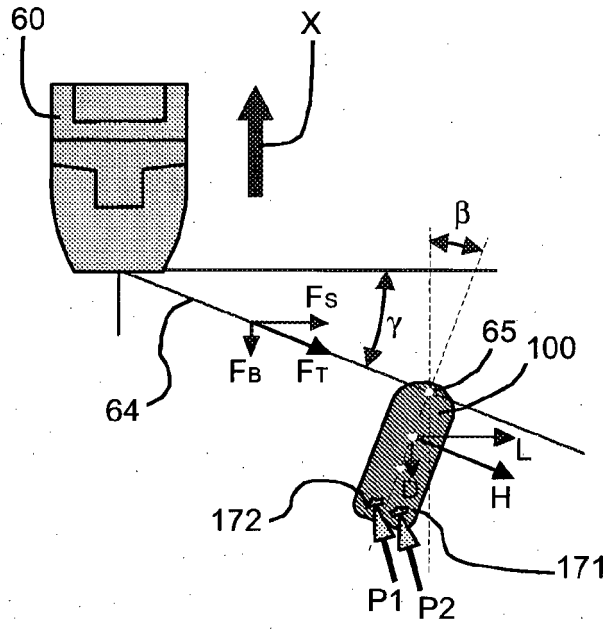


Fig. 11A (Prior Art)

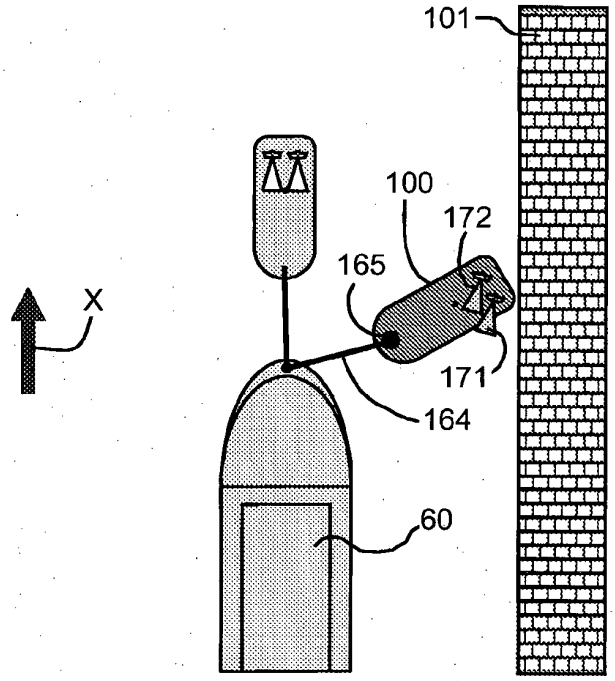


Fig. 12A (Prior Art)

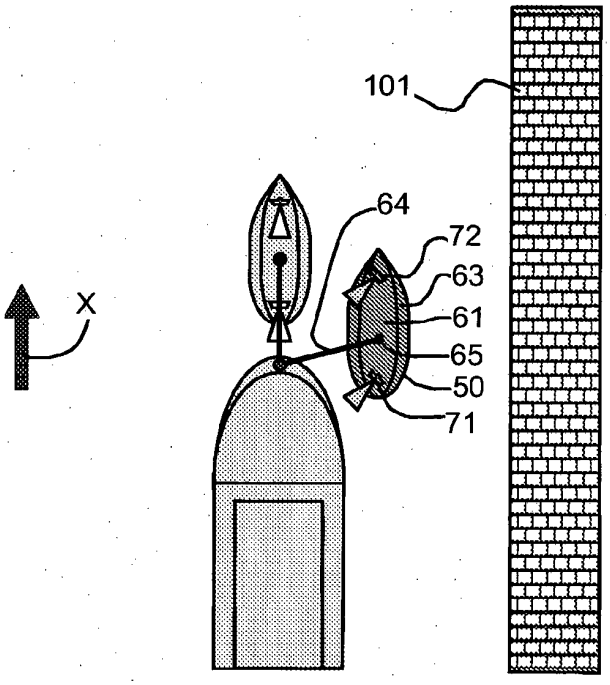


Fig. 12B

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- NL 1023447 **[0002] [0003] [0032]**
- NL 2003746 **[0032] [0038]**