



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
18.01.2017 Bulletin 2017/03

(51) Int Cl.:
B63H 5/15 (2006.01) B63H 5/16 (2006.01)

(21) Application number: **15177131.8**

(22) Date of filing: **16.07.2015**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA

(72) Inventors:
• **van Buren, Edwin Simon**
2935 VC Ouderkerk a/d IJssel (NL)
• **Groen, Niels**
2275 VE Voorburg (NL)

(74) Representative: **Nederlandsch Octrooibureau**
P.O. Box 29720
2502 LS The Hague (NL)

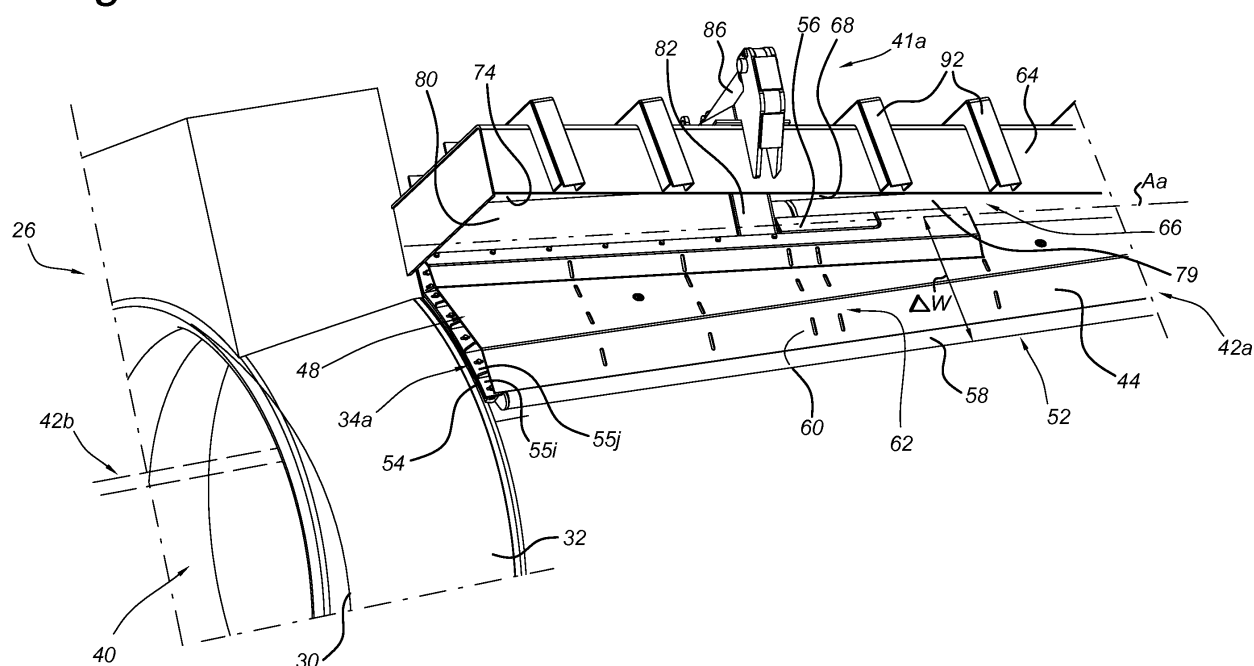
(71) Applicant: **Damen Marine Technology Holding B.V.**
2931 AD Krimpen aan de Lek (NL)

(54) **VESSEL WITH ADJUSTABLE FLOW TUNNEL**

(57) A tunnel member assembly (41a) adapted for attaching in or onto a hull of a vessel with a propeller that is rotatably mounted with respect to the hull and a nozzle (30) surrounding the propeller. The tunnel member assembly comprises a casing (64) adapted for mounting the tunnel member assembly in or onto the hull, and a tunnel member (42a), which is coupled to and moveable with respect to the casing between: - a retracted state,

wherein the tunnel member is removed from the nozzle, and - an extended state, wherein the tunnel member defines at least a part of an adjustable flow tunnel (40) for conveying a flow of water towards the propeller, and wherein the tunnel member abuts the nozzle to form a sealing engagement for maintaining an undeipressure inside the flow tunnel.

Fig. 3B



Description

TECHNICAL FIELD

[0001] The invention relates to a vessel comprising a hull with a propeller and an adjustable flow tunnel, and to a tunnel member assembly adapted for attaching in or onto a hull of a vessel. Furthermore, the invention relates to a method for retrofitting a vessel.

BACKGROUND ART

[0002] Various types of ships or vessels have been designed for transporting loads over water. Such ships may be specifically designed for operation in shallow water, for example for freight transport via inland water ways.

[0003] Ships for inland waterway navigation or "inland vessels" typically have a hull provided with one or more propellers, and a fixed flow tunnel, which forms one or more longitudinal recesses in the lower side of the hull for guiding more water towards the propeller(s). For efficiency reasons, the propellers of a shallow water vessel are typically relatively small. The flow tunnel improves the water flow towards the propellers, especially when the vessel moves through the water at a shallow draft, during which the propellers may be partially above the waterline. The term "draft" (or UK: "draught") of a vessel's hull refers to a vertical distance between the waterline and the bottom of the hull (e.g. the keel).

[0004] Such a conventional tunnel increases drag force exerted on the hull when the vessel moves through the water. Such drag is considered acceptable in comparison to the efficiency that is gained from use of the flow tunnel in shallow draft conditions.

[0005] When such an inland vessel is loaded with cargo, the draft will increase. In shallow waters, the hull may move closer towards the river bed. As inland vessels navigate in larger draft conditions for about 85 percent of the time, the presence of the flow tunnel becomes a disadvantage.

[0006] Patent application EP1300330A1 (AUG-SPURGER et al.) describes a ship provided with movable tunnel members that are arranged on a hull side near a propeller. These moveable tunnel members are configured to selectively form a flow tunnel to be able to adapt to varying water conditions. Depending on the draft, the tunnel may be retracted to avoid unwanted drag, or extended to improve the flow profile of the water towards the propeller.

[0007] EP1300330A1 does not describe how the adjustable flow tunnel could be arranged and modified in order to properly cooperate with various possible ship propeller designs. It would be desirable to provide an adjustable tunnel member arrangement that improves water flow characteristics and propeller efficiency for vessels with ducted propellers. The term "ducted propeller" (also known as a Kort nozzle) generally refers to a pro-

PELLER fitted with a nozzle i.e. a shell-like body that directly surrounds the propeller without physically touching it, and which does not follow the axial rotation of the propeller blades (although lateral rotation of the ducted propeller assembly as a whole may still be allowed e.g. for maneuvering purposes).

SUMMARY OF INVENTION

[0008] Therefore, according to a first aspect, there is provided a vessel that comprises a hull with a propeller that is rotatably mounted with respect to the hull, and a nozzle that surrounds the propeller. The vessel further includes at least one tunnel member, which is mounted moveable relative to the hull between: - an extended state wherein the tunnel member defines at least a part of an adjustable flow tunnel for conveying a flow of water towards the propeller, and wherein the tunnel member forms a sealing engagement with the nozzle for maintaining an underpressure inside the flow tunnel, and - a retracted state wherein the tunnel member is removed from the nozzle.

[0009] The application of such tunnel member(s) in a vessel allows temporary formation of a flow tunnel under different draft conditions. The flow tunnel may be formed by extending the tunnel member(s), preferably in the case that the vessel moves through relatively shallow water. The flow tunnel helps to confine a water flow towards the propeller, while it reduces or even eliminates inflow of air to the propeller via the region(s) where the nozzle and the tunnel member(s) are directly engaged. When the propeller is in motion (e.g. related to vessel propulsion), the rotating propeller generates a suction effect in the region before the propeller. When the flow tunnel is formed, the propeller motion creates a partial vacuum (underpressure) inside the flow tunnel. This partial vacuum helps to draw in surrounding water towards the propeller, which is beneficial for the propeller efficiency. The sealing engagement between the nozzle and the tunnel member in the extended state helps to reduce (or possibly even prevent) a flow of air from lateral regions around the hull into the tunnel region, even if the propeller and flow tunnel are (partially) above the waterline. Reduction (or prevention) of air flow into the flow tunnel facilitates in maintaining the underpressure, which enables a larger quantity and quicker inflow of water into the tunnel. The described sealing engagement assists in maintaining the partial vacuum in the tunnel, and hence in improving propeller efficiency.

[0010] In relatively deeper water, sufficient water from below the vessel may be conveyed towards the propeller without requiring deployment of the flow tunnel. In the latter situation, the flow tunnel may be removed by moving the tunnel member(s) into the retracted state, to reduce drag (flow resistance e.g. from cavitation effects that would otherwise be caused by tunnel members in the extended state). By means of the adjustable/retractable flow tunnel, the vessel will be able to propel itself

efficiently both in shallow water and in deeper water.

[0011] According to an embodiment, the tunnel member comprises an elongated shape and a trailing edge, wherein in the extended state, the trailing edge abuts the nozzle to establish the sealing engagement.

[0012] The trailing edge of the tunnel member forms a well defined region, which allows a robust sealing engagement with the nozzle.

[0013] According to a further embodiment, the trailing edge of the tunnel member comprises a seal member for establishing the sealing engagement in the extended state.

[0014] Vessels (boats, ships) and their propulsion components typically form large structures. As a result, the tunnel members are preferably relatively large to be able to form a flow tunnel with good flow regulation characteristics. Relatively large positioning tolerances may be involved in the manufacturing and assembly of such large structures. Application of a seal member along the trailing edge of the tunnel member may yield an efficient compensation mechanism for accommodating positioning tolerances between the tunnel member and the nozzle. The edge seal member may be easily manufactured as a (possibly piecewise) linear structure that is adapted to robustly provide the sealing effect for maintaining underpressure inside the flow tunnel during propeller rotation. Furthermore, the edge seal member may be implemented in an easily adjustable and replaceable manner.

[0015] According to an embodiment, the nozzle comprises a leading edge portion near a leading nozzle periphery. In the extended state, the trailing edge of the tunnel member abuts the leading edge portion of the nozzle to establish the sealing engagement.

[0016] Engagement between the trailing edge of the tunnel member and the leading edge portion of the nozzle allows establishment of a sealing engagement with good fluid dynamic characteristics (e.g. streamline), which may be easily optimized to reduce water drag effects.

[0017] According to an embodiment, the tunnel member and/or the hull comprise a longitudinal seal arrangement that is configured for establishing a further sealing engagement between the hull and the tunnel member in the extended state, for maintaining the underpressure inside the flow tunnel.

[0018] In the extended state of the tunnel member, the longitudinal seal arrangement establishes a fluid barrier in a longitudinal region wherein the tunnel member and hull are mutually coupled. This longitudinal seal arrangement reduces or even avoids air/gas from entering the flow tunnel along this coupling region, and hence facilitates in maintaining the desired underpressure inside the flow tunnel.

[0019] According to an embodiment, the hull is elongated along a longitudinal direction, and the tunnel member is rotatably mounted onto the hull about an axis that extends predominantly along the longitudinal direction to allow rotation of the tunnel member with respect to the hull between the retracted state and the extended state.

[0020] According to a further embodiment, the longitudinal seal arrangement is provided at or near the axis along which the tunnel member is rotatably coupled to the hull.

5 **[0021]** According to an embodiment, the tunnel member comprises an outer surface, which faces inwards to define part of the adjustable flow tunnel when the tunnel member is in the extended state, and which faces outwards away from the hull when the tunnel member is in the retracted state.

10 **[0022]** According to an embodiment, the vessel comprises a casing attached in or onto an attachment region of the hull. This casing defines a space for accommodating the tunnel member in the retracted state.

15 **[0023]** The casing may be designed to accommodate the tunnel member and its suspension mechanism, and possibly also an actuation mechanism for repositioning the tunnel member with respect to the hull, and/or a sealing mechanism for establishing fluid tight couplings between various moving parts. The casing allows manufacturing of a tunnel member assembly as a single unit separate from the vessel and its hull. The mechanical construction of the casing may be made sufficiently rigid in desired regions. Suitable actuation and sealing mechanisms may be provided on/in the casing, without having to substantially adapt the hull.

20 **[0024]** According to a further embodiment, the outer surface of the tunnel member is substantially level with an outer hull surface portion of the attachment region when the tunnel member is in the retracted state.

25 **[0025]** Leveling the tunnel member's outer surface with outer hull reduces drag when the tunnel member is in the retracted state. This leveling may for example be achieved by accommodation of the tunnel member inside the space of the casing, with the outer surface of the tunnel member spanning an outer aperture of the casing.

30 **[0026]** According to a further embodiment, the tunnel member comprises a shaft assembly that extends along the axis. This shaft assembly is rotatable with respect to the casing and configured for actuating the tunnel member between the retracted state and the extended state. The shaft assembly may be accommodated in a lateral region of the space, the lateral region extending predominantly along the longitudinal direction.

35 **[0027]** According to yet a further embodiment, the casing comprises a chamber that is arranged in or near an aft region of the space and which includes a transmission mechanism for exerting a torque on the shaft assembly.

40 **[0028]** The aft region of space in the casing corresponds to a hull location that is nearest to the ducted propeller assembly. The tunnel member will be subjected to considerable forces, e.g. from propeller-induced water flow and/or from water drag during transitioning between the retracted and extended states. Providing a chamber with transmission mechanism in this aft region takes the (limited) space in the vessel hull into account, while requiring only a relatively short axial distance over which the required torques are transferred to the tunnel mem-
45

ber.

[0029] The shaft assembly may comprise a drive shaft that is rotatably coupled at a leading wall of the chamber to form an extension of the chamber in the forward direction.

[0030] Alternatively or in addition, the drive shaft may be rotatably coupled to the casing by means of a sealed bearing arranged in or near the leading wall of the chamber, and configured for fluidly separating the space from the chamber.

[0031] The sealed bearing helps to avoid leakage of water from the space in the casing (which is associated with an outside of the hull) through the leading wall into the chamber (which is associated with an inside of the hull).

[0032] According to an embodiment, the tunnel member defines an elongated panel that is coupled along a first edge to the hull in a rotatable manner about the axis.

[0033] According to a further embodiment, the panel comprises a reinforcement member that extends along a free panel edge that is opposite to the axis.

[0034] The reinforcement member assists in maintaining the intended shape of the panel, even in the extended state of the tunnel member wherein the panel may be subjected to substantial hydrodynamic forces. This helps to maintain the sealing engagement between the nozzle and the tunnel member in the engaged state.

[0035] According to yet a further embodiment, the axis converges laterally inwards towards the nozzle as a function of position towards the aft direction, to reduce a width of the adjustable flow tunnel towards the aft direction when the tunnel member is in the extended state.

[0036] According to a further embodiment, the elongated panel has a transversal panel size defined in a direction extending from the axis perpendicularly towards a free lateral edge of the panel, wherein the transversal panel size increases as a function of position along the aft direction.

[0037] The increasing transversal panel size may compensate for a rising hull shape in a stern region, to allow the free lateral panel edge to be held substantially parallel with the waterline when the tunnel member is in the extended state. This is beneficial for the suction homogeneity of water into the flow tunnel.

[0038] According to a further embodiment, the shaft assembly and casing comprise the longitudinal seal arrangement along the axis. The longitudinal seal arrangement is configured for establishing a further sealing engagement between the casing and the tunnel member in the extended state, so as to maintain the underpressure inside the flow tunnel.

[0039] The shaft assembly may for example comprise a linear protrusion or ledge extending parallel with the axis, and the casing may comprise a linear gasket extending near the shaft assembly and parallel with the axis. This linear gasket and linear protrusion are configured to jointly establish the further sealing engagement as soon as the tunnel member has been moved into the

extended state. The linear gasket is preferably arranged on/in the casing because of the casing's mechanical robustness. This allows more accurate alignment of the flexible gasket material during installation and/or replacement, resulting in a more robust seal arrangement.

[0040] In the extended state of the tunnel member, the cooperation between the linear gasket and the linear protrusion establishes a fluid separation that reduces or even avoids air/gas from entering the flow tunnel, and hence facilitates in maintaining the desired underpressure inside the flow tunnel.

[0041] According to an embodiment, the hull comprises frames, and the casing comprises ribs for directly attaching to the frames. These frames and ribs may jointly form a framework for structurally reinforcing the hull.

[0042] Joining of the frames and ribs allows the casing and associated tunnel member (which may be subjected to considerable forces) to benefit from the mechanical robustness of the hull, thus lowering the probability for deformations and corresponding probability of reduced sealing effectiveness.

[0043] According to embodiments, the at least one tunnel member comprises a first tunnel member and a second tunnel member that are attached to the hull in separate attachment regions, wherein each of the two tunnel members is independently moveable between its extended state and retracted state, and engages in its extended state with a distinct opposite lateral peripheral portion of the nozzle to form a sealed engagement and to define a distinct lateral side of the adjustable flow tunnel.

[0044] According to alternative embodiments, the vessel comprises at least a second propeller that is rotatably mounted with respect to the hull at a lateral distance from the propeller, and a second nozzle surrounding the second propeller, wherein the at least one tunnel member comprises a first tunnel member that is attached to the hull in a first attachment region related to an outward starboard side of the first nozzle, and a second tunnel member that is attached to the hull in a second attachment region related to an outward port side of the second nozzle, wherein the two tunnel members are independently moveable between the corresponding extended states and retracted states, and wherein each tunnel member in its extended state engages with an outer peripheral portion of the associated nozzle.

[0045] In a second aspect of the invention, and in accordance with the advantages and effects described herein above, there is provided a tunnel member assembly, which is adapted for attaching in or onto a hull of a vessel. The vessel comprises a propeller that is rotatably mounted with respect to the hull, and a nozzle surrounding the propeller. The tunnel member assembly comprises: a casing adapted for mounting the tunnel member assembly in or onto the hull, and a tunnel member, which is coupled to and moveable with respect to the casing. The tunnel member is moveable between: - an extended state, wherein the tunnel member defines at least a part of an adjustable flow tunnel for conveying a flow of water

towards the propeller, and wherein the tunnel member abuts the nozzle to form a sealing engagement for maintaining an underpressure inside the flow tunnel, and - a retracted state, wherein the tunnel member is removed from the nozzle.

[0046] Embodiments of the tunnel member assembly according to the second aspect may comprise any or all of the features and details described with reference to the tunnel member(s) in the vessel embodiments according to the first aspect, and in accordance with the described advantages and effects.

[0047] For instance, in tunnel member assembly embodiments, a trailing edge of the tunnel member may comprise a seal member for establishing the sealing engagement in the extended state.

[0048] In alternative or further tunnel member assembly embodiments, the tunnel member and/or the casing may comprise a longitudinal seal arrangement that is configured for establishing a further sealing engagement between the casing and the tunnel member in the extended state, for maintaining the underpressure inside the flow tunnel.

[0049] According to an embodiment, the tunnel member comprises a shaft assembly that extends along and is rotatable about an axis with respect to the casing for actuating the tunnel member between the retracted state and the extended state.

[0050] The tunnel member may include an elongated panel that is coupled along a first panel edge to the casing in a rotatable manner about the axis.

[0051] Relating to the longitudinal seal arrangement, the shaft assembly may comprise a linear protrusion extending parallel with the axis, wherein the casing comprises a linear gasket extending near the shaft assembly and parallel with the axis, wherein the linear gasket and the linear protrusion are configured to jointly establish the further sealing engagement when the tunnel member moved into the extended state.

[0052] According to a further embodiment, the casing comprises a chamber that is arranged in or near an aft region of the space and which includes a transmission mechanism for exerting a torque on the shaft assembly.

[0053] According to yet a further embodiment, the shaft assembly comprises a drive shaft that is rotatably coupled at a leading wall of the chamber to form an extension of the chamber in the forward direction.

[0054] The drive shaft may be rotatably coupled to the casing by means of a sealed bearing arranged in or near the leading wall of the chamber, and configured for fluidly separating the space from the chamber.

[0055] In a third aspect of the invention, and in accordance with the advantages and effects described herein above, there is provided a method for retrofitting a vessel with at least one tunnel member assembly according to (embodiments of) the second aspect.

[0056] The longitudinal seal arrangement for an adjustable flow tunnel is itself believed to be inventive in and of its own right in the present context, and may be

subject of a divisional application. So according to further aspect that may be subject of another application, there is provided a vessel, comprising a hull with a propeller that is rotatably mounted with respect to the hull, and a tunnel member. The tunnel member comprises a longitudinal seal arrangement, and the tunnel member is mounted moveable relative to the hull between: - an extended state, wherein the tunnel member defines at least a part of an adjustable flow tunnel for conveying a flow of water towards the propeller, wherein the longitudinal seal arrangement establishes a sealing engagement between the hull and the tunnel member in the extended state, for maintaining the underpressure inside the flow tunnel, and - a retracted state, wherein the tunnel member is removed from the propeller.

[0057] Embodiments of this further aspect may comprise combinations of any or all of the features and details described and claimed herein with reference to the tunnel member(s), and in accordance with the described advantages and effects.

BRIEF DESCRIPTION OF DRAWINGS

[0058] Embodiments will now be described, by way of example only, with reference to the accompanying schematic drawings in which corresponding reference symbols indicate corresponding parts, and in which:

Figure 1 schematically shows a side view of a vessel according to an embodiment;

Figures 2a and 2b schematically depict rear views of the vessel in Figure 1;

Figure 3a and 3b show an embodiment of a tunnel member in a retracted state and in an extended state respectively;

Figure 4 shows a cross-sectional top view of the tunnel member from Figures 3a and 3b;

Figure 5 shows a cross-sectional perspective side view of a part of the tunnel member from Figures 3a and 3b, and

Figure 6 shows a cross-sectional front view of a part of the tunnel member from Figures 3a and 3b.

[0059] The figures are meant for illustrative purposes only, and do not serve as restriction of the scope or the protection as laid down by the claims.

DESCRIPTION OF EMBODIMENTS

[0060] The following is a description of certain embodiments of the invention, given by way of example only and with reference to the figures.

[0061] It may be helpful to an understanding of the invention to set forth definitions of certain terms to be used herein. The adjective "leading" refers herein to a direction that predominantly faces towards the "fore" or "forward" direction i.e. the bow of the vessel. Conversely, the adjective "trailing" refers herein to a direction that predom-

inantly faces towards the "aft" direction i.e. towards the stern of the vessel. The term "athwartship" refers to opposite directions toward the sides of a vessel. In particular, the term "aport" means towards the port side of the vessel, and "astarboard" means towards the starboard side of the vessel.

[0062] In the next figures, Cartesian coordinates will be used to describe spatial relations for exemplary embodiments.

[0063] Reference symbol X is used to indicate a longitudinal direction, which corresponds to the elongated direction of the vessel hull. Prepositions "front" and "rear" pertain to this longitudinal direction X, and correspond to the forward direction and the aft direction of the hull respectively.

[0064] Reference symbol Y is used to indicate a lateral direction that is perpendicular to the longitudinal direction X. This lateral direction Y generally relates to the terms "left" and "right". The lateral direction Y relates to the athwartship directions ("aport" i.e. towards the port side +Y of the vessel, and "astarboard" means towards the starboard side -Y).

[0065] Reference symbol Z is used to indicate a vertical direction that is perpendicular to X and Y. Prepositions "above" and "below" pertain to the vertical direction Z.

[0066] It should be understood that the directional definitions and preferred orientations presented herein merely serve to elucidate geometrical relations for specific embodiments. The concepts of the invention discussed herein are not limited to these directional definitions and preferred orientations. Similarly, directional terms in the specification and claims, such as "longitudinal", "leading", "trailing", "top", "bottom", "left", "right", "up", "down", "upper", "lower", "proximal", "distal" and the like, are used herein solely to indicate relative directions and are not otherwise intended to limit the scope of the invention or claims.

[0067] Figure 1 schematically shows a perspective view of a vessel 10, which in this exemplary embodiment forms a ship for inland waterway navigation. The vessel 10 comprises a hull 12 with an elongated shape along a longitudinal direction X, which corresponds to the (main) propulsion direction of the vessel 10. The hull 12 defines a bow 14 in a forward direction +X, a stern 16 in an aft direction -X, and a keel 18 on a lower side of the hull 12.

[0068] The hull 12 comprises multiple frames 20, which extend in lateral and vertical directions Y, Z. These frames 20 provide structural reinforcement of the hull 12, and the outer contours of the frames 20 jointly determine part of an exterior shape of the hull 12.

[0069] On a lower side of the stern 16, the hull 12 comprises a ducted propeller assembly 26 and a rudder 38, which may be formed in various ways known in the art. The ducted propeller assembly 26 comprises a propeller 28, a propeller shaft 36, and a nozzle 30. The propeller 28 is fixed to the propeller shaft 36 to form a body that is rotatably coupled to the hull 12. The propeller 28 is rotatable with respect to the hull 12 about a (virtual)

propeller axis Ap. The nozzle 30 forms a non-rotating shell that surrounds the propeller 28.

[0070] Two tunnel members 42a, 42b are provided, which are coupled to the hull 12. The tunnel members are non-distinctively indicated by reference number 42 whenever appropriate. Only a starboard tunnel member 42a is visible in Figure 1.

[0071] In this exemplary embodiment, each tunnel member 42 comprises an elongated panel 44 that is pivotably coupled to the hull 12 along respective axes Aa, Ab (jointly indicated by the reference symbol A). Each respective axis Aa, Ab extends with a largest component in the longitudinal direction X. Slight tilting of the axes Aa, Ab with respect to the longitudinal direction X and towards the transversal and vertical directions Y,Z may be allowed, as explained further below. Each of the pivotable couplings allows the respective tunnel member 42 and panel 44 to be rotated with respect to the hull 12 between the retracted state (Figures 2a and 3a) and the extended state (Figures 2b and 3b).

[0072] The tunnel members 42 are coupled to the hull 12 in respective hull attachment regions 22a, 22b. For this purpose, the tunnel members 42 are accommodated in casings 64a, 64b (see e.g. Figures 3a-3b) that are mechanically fixed to the hull 12 in the respective attachment regions 22. Each casing 64 forms a unit that is adapted for accommodating the corresponding tunnel member 42.

[0073] The casing 64 and its corresponding tunnel member 42 jointly form a tunnel member assembly 41. Such a tunnel member assembly 41 may be built into a new vessel, e.g. by forming the casing 64 as a part of the hull 12, or may be used to retrofit an existing vessel by appropriate adaptation of the hull (i.e. by attaching the tunnel member assembly 41 in or onto the hull).

[0074] The casings 64 are receded with respect to the outer surface of the hull 12. In this example, the casing 64 comprises ribs 92, which are adapted for direct mechanical attachment to the frames 20 of the hull 12, to form a framework for structurally reinforcing the hull 12. The reinforcement ribs 92 extend around the casing 64 on a side corresponding to an inward side of the hull 12. Each of these casings 64 defines a space 66 for accommodating the corresponding tunnel member 42 in the retracted state.

[0075] Each attachment region 22 with casing 64 is directly surrounded by a respective outer surface portion 24 of the hull 12. The panel 44 of the corresponding tunnel member 42 comprises an outer surface 60 and an inner surface 62 (also see Figures 3a-3b).

[0076] Figures 2a and 3a depict the tunnel members 42 in the retracted state. In this retracted state, the panels 44 of the tunnel members 42 are removed from the nozzle 30 and accommodated flush with the hull 12. When the tunnel member 42 is in the retracted state, the panel 44 of the tunnel member 42 extends predominantly athwart outwards along with the hull 12, in such a manner that the outer surface 60 of the panel 44 is substantially level

with the corresponding outer hull surface portion 24 (see Figure 2a). This retracted configuration helps to reduce water drag forces on the tunnel members 42 during movement of the vessel 10. In the retracted state of the tunnel members 42, the outer surfaces 60 face outwards away from the hull 12. In this example, the outer surface 60 resembles the local contour of the respective outer surface portion 24 of the hull 12, which may be smoothly curved.

[0077] Figures 2b and 3b depict the tunnel members 42 in the extended state. In this extended state, the panels 44 of the tunnel members 42 form an adjustable/removable flow tunnel 40 for conveying a predominantly longitudinal flow of water towards the propeller 28. In the extended state of the tunnel member 42, the panel 44 of each tunnel member 42 protrudes outwards away from the outer hull surface portion 24, in this case in a downwards-athwart direction, with the outer surfaces 60 facing downwards and inwards. The outer surfaces 60 of the two tunnel members 42 and a lower stern region of the hull 12 jointly define the flow tunnel 40. In this extended state, the tunnel members 42 abut the nozzle 30 to form a sealing engagement, which serves to reduce lateral flows of air into the flow of water towards the propeller 28, and to maintain an underpressure inside the flow tunnel 40.

[0078] The rotation axis A of the corresponding tunnel member 42 is oriented predominantly along the longitudinal direction X, but may have a slight tilt that converges laterally towards a longitudinal centerline of the hull 12 as a function of position towards the aft direction -X. In the case that the tunnel members 42 are in the extended state (see Figure 2b), a width ΔY of the adjustable flow tunnel 40 will converge as a function of position towards the aft direction (negative -X). This gradual reduction of the tunnel width ΔY causes a flow of water towards the propeller 28 to converge laterally, so as to allow the water (which is relatively incompressible) to lift upwards and cover a larger vertical cross-sectional portion of the propeller 28. The rotation axis A of the corresponding tunnel member 42 may additionally have a tilt upwards as a function of position towards the aft direction -X, resulting from an inclined shape of the hull 12 near the stern 16.

[0079] As is illustrated by Figure 3b, the panel 44 of each tunnel member 42 has a trailing edge 48 that faces towards the aft direction -X. In addition, the nozzle 30 comprises upper edge portions 34 near a leading nozzle periphery 32. In the extended state, the trailing edge 48 of each panel 44 abuts the respective (leading) upper edge portions 34 of the nozzle 30 to establish the sealing engagement. In the extended state, the panel 44 forms a forward extension of the upper edge portion 34 of the nozzle 30. The trailing edge 48 of the panel 44 comprises a seal member 54 for establishing the sealing engagement between the nozzle 30 and the tunnel member 42 in the extended state. The trailing edge 48 and seal member 54 provided thereon can be retracted along with the panel 44 to assume the retracted state wherein the panel

44 and seal member 54 are removed from the nozzle 30. In this example, the seal member 54 is formed by flexible patches that jointly define a piecewise flexible surface for bridging local gaps between the trailing edge 48 of the panel 44 on the one hand, and the corresponding leading upper edge portion 34 of the nozzle 30 on the other hand. Such local gaps may e.g. result from manufacturing tolerances. The seal member 54 has adjustment mechanisms 55i for dynamically adjusting the locations of the individual seal member patches with respect to the panel 44, to improve the sealing engagement between the trailing edge 48 of the panel 44 and the nozzle 30 after installation of the tunnel member assembly 41 into/onto the hull 12.

[0080] Also in this example, the elongated panel 44 has a panel width ΔW corresponding with a size of the panel 44 along a direction extending from the axis A perpendicularly towards an outer lateral edge 52 of the panel 44. The elongated panel 44 has an increasing panel width ΔW as a function of position along the aft direction -X. This increasing panel width ΔW compensates for the upwards diverging shape of the stern 16. As a result, the outer lateral edge 52 of the panel 44 is still able to extend predominantly along the water line when the tunnel member 42 is in the extended state.

[0081] Figure 4 shows a cross-sectional top view of the tunnel member 42 from Figures 3a and 3b. In this example, the panel 44 of the tunnel member 52 has a polygonal cross-sectional shape, with decreasing transversal size as a function of forward position along the rotation axis A (which largely corresponds to the longitudinal direction X). A perimeter of the panel 44 may be roughly divided into a leading panel edge 46 (located on a forward side), the trailing panel edge 48 opposite to the leading panel edge 46, an inner lateral panel edge 50 located near the panel rotation axis A, and the outer lateral panel edge 52, which forms a free edge opposite to the inner lateral panel edge 50.

[0082] The tunnel member 42 may comprise a reinforcement member 58 that extends along the free (outer) lateral panel edge 52. In the exemplary embodiment of Figure 4, the reinforcement member 58 comprises a hollow rod. In alternative embodiments, the reinforcement member may comprise a bar, a tube, or other elongated structure with a considerable mechanical stiffness. The reinforcement members 58 assists in maintaining the generally straight shape of the panels 44 (predominantly) along the longitudinal direction X, even when the tunnel members 42 are in the extended state wherein the panels 44 may be subjected to substantial forces caused by water currents and turbulences. This shape stability helps to keep the panels 44 relatively fixed with respect to the nozzle 30, which in turn helps to keep the sealing engagement between the panels 44 and nozzle 30 intact.

[0083] In the exemplary embodiment shown in Figure 4, the tunnel member 42 comprises a shaft assembly 77, 78, 79 that is directed along the axis A. This shaft assembly 77-79 is fixed to the panel 44 and rotatable with

respect to the casing 64. The shaft assembly 77-79 is configured for actuating the tunnel member 42 and panel 44 between the retracted state and the extended state. This shaft assembly 77-79 comprises a drive shaft 77 and a further shaft 78, which in this example are both rotationally symmetric solid bodies. The two shafts 77, 78 form two spatially separated suspension points for pivotably connecting the panel 44 to the casing 64, so as to allow rotation about the axis A. A mutual distance between the two shafts 77, 78 may be in the order of several meters, for example about 4 meters. The shaft assembly 77-79 further comprises a tubular pivot support 79, which forms a connecting structure between the shafts 77, 78 on the one hand and the panel 44 on the other hand. The tubular pivot support 79 forms an extension of the shafts 77, 78 in the direction along the rotation axis A. The tubular pivot support 79 forms a support structure with which the panel 44 is mechanically coupled. This shaft assembly 77-79 is accommodated in a laterally inwards region 68 of the space 66 and extends along the axis A (which in this case is predominantly along the longitudinal direction X) through the space 66.

[0084] In this example, each casing 64 comprises a chamber 80 that is arranged near a corner where an inner lateral region 68 of the space 66 meets an aft region 74 of the space 66. This chamber 80 includes a transmission mechanism 84 for exerting a torque on the drive shaft 77 (see Figure 5). The drive shaft 77 is rotatably coupled to a leading wall 82 of the chamber 80, and extends away from the chamber 80 in the forward direction along the axis A. A rotation bearing with sealing mechanism 83 is provided in the leading wall 82. This sealed bearing 83 allows rotation of the drive shaft 77 with respect to the leading wall 82 and the corresponding casing 64, while avoiding leakage of water in the space 66 (i.e. resulting from submersion of the hull 12) though the leading wall 82 into the chamber 80 (which may correspond to the inner side of the hull 12). A similar wall and sealing bearing configuration may be provided at the further shaft 78, for similar purposes. Due to the presence of the chamber 80, the space 66 in the casing 64 will have a stepped profile 76 in an inner lateral region 68. Similarly, the panel 44 of the tunnel member 42 has a matching stepped profile 56 along an inner lateral edge 50.

[0085] Figure 5 shows a cross-sectional perspective side view of a part of the tunnel member embodiment 42 from Figures 3a and 3b. Figure 5 depicts the rotation bearing with sealing mechanism 83 around the drive shaft 77 in more detail. Here, the transmission mechanism 84 for exerting torque on the drive shaft 77 comprises a crank assembly 84 that is directly coupled to the drive shaft 77, which in this case is actuated by a piston 84 with a piston cylinder attached to the casing 64. A shortening stroke of the piston 84 will force the crank assembly 84 inwards. As a result, the drive shaft 77 will be rotated about the axis A to urge the tunnel member 42 from the depicted position into the extended state. Conversely, an expanding stroke of the piston 84 will

force the crank assembly 84 outwards. As a result, the drive shaft 77 will be rotated about the axis A to urge the tunnel member 42 back into the retracted state.

[0086] Figure 6 shows a cross-sectional front view of a part of the tunnel member 42a from Figures 3a and 3b. In this example, the casing 64 of the tunnel member 42 comprises a linear gasket 88, which is formed a linear structure that extends along inner lateral region 68 of the accommodation space 66 defined by the casing 64. In this case, the linear gasket 88 comprises a bar with a polygonal shape and a resilient material. This linear gasket 88 extends longitudinally through the space 66 near the shaft assembly 77-79 and parallel with the rotation axis A. In addition, the panel 44 comprises a rigid ledge 90. This ledge 90 is provided at the inner lateral panel edge 50, and extends longitudinally along the shaft assembly 77-79 and parallel with the rotation axis A. The linear gasket 88 and ledge 90 are configured to cooperate so as to establish a further sealing engagement when the tunnel member 42 is in the extended state. Preferably, the linear gasket 88 and ledge 90 extend along the entire inner lateral panel edge 50, to ensure proper sealing along this entire length if the tunnel member 42 is in the extended state. Rotation of the panel 44 about the axis A from the retracted state (shown in Figure 6) into the extended state (via rotation along the solid arrow in Figure 6) will eventually cause the ledge 90 to engage with the linear gasket 88 along their respective lengths. The resulting sealing engagement yields a fluid separation between the inner lateral region 68 of the space 66 on the one hand, and an outer lateral region 70 of the space 66 on the other hand. In the extended state of the tunnel member 42, the inner lateral region 68 of the space 66 will become associated with the outer surface 60 of the panel 44, and hence will correspond with the inside of the flow tunnel 40. In contrast, the outer lateral region 70 of the space 66 will stay associated with the inner surface 62 of the panel 44, and hence will remain outside the flow tunnel 40. The fluid barrier provided by the cooperating linear gasket 88 and ledge 90 ensures that air/gas accumulated in the space 66 will be prevented from entering the flow tunnel 40 via region near the axis A, and hence facilitates in maintaining the desired underpressure inside the flow tunnel 40. Preferably, the linear gasket 88 and ledge 90 extend along the entire inner lateral panel edge 50, to ensure proper sealing along the entire length thereof, if the tunnel member 42 is in the extended state.

[0087] The present invention may be embodied in other specific forms without departing from its spirit or essential characteristics. The described embodiments are to be considered in all respects only as illustrative and not restrictive. The scope of the invention is therefore indicated by the appended claims rather than by the foregoing description. It will be apparent to the person skilled in the art that alternative and equivalent embodiments of the invention can be conceived and reduced to practice. All changes which come within the meaning and range of equivalency of the claims are to be embraced within

their scope.

[0088] Although the exemplary embodiments in the detailed description related to ships for inland waterway navigation, the principles of the adjustable/retractable flow tunnel described herein and defined in the claims also pertain to other types of vessels, like sea-going boats and ships, and more particularly to short sea boats and ships.

[0089] Vessels may generally be provided with at least one, but preferably two (or even more) tunnel members.

[0090] In the embodiments described herein above with reference to Figures 1-6, a first tunnel member 42a and a second tunnel member 42b are attached in separate attachment regions 22a, 22b of the hull 12, in a laterally symmetric configuration leading/flanking the ducted propeller assembly 26. Each of the two tunnel members 42a, 42b is independently moveable manner between its extended state and retracted state. Each tunnel member 42a, 42b engages in its extended state with a distinct leading edge portion 34a, 34b of the same nozzle 30 of the ducted propeller assembly 26, to form a sealed engagement. The tunnel members 42a, 42b in the single-propeller embodiments described herein above define opposite lateral sides of the same adjustable flow tunnel 40.

[0091] In alternative embodiments, the vessel may comprise a plurality of propellers (e.g. two or three propellers) that are rotatably mounted with respect to the hull. The vessel may also comprise a plurality of nozzles, surrounding a corresponding one of the plurality of propellers, to form a plurality of ducted propeller assemblies. These ducted propeller assemblies may be laterally spaced across the hull (e.g. at the stern) at lateral mutual distances, preferably in an athwart symmetric arrangement. Here, a first tunnel member may be provided that is attached to the hull in a first attachment region associated with an outermost starboard-side nozzle, and a second tunnel member may be provided that is attached to the hull in a second attachment region associated with an outermost port-side nozzle. The two tunnel members may be independently moveable between their corresponding extended states and retracted states. The first tunnel member is configured to engage in its extended state with a leading peripheral portion of the outermost starboard-side nozzle, on an outer starboard side thereof. In contrast, the second tunnel member is configured to engage in its extended state with a leading peripheral portion of the outermost port-side nozzle, on an outer port side thereof. The first tunnel member and second tunnel member in the extended states may jointly form a flow tunnel that forms two outer flow boundaries with respect to all nozzles of the plurality of ducted propeller assemblies.

[0092] Yet in further vessel embodiments, pairs of tunnel members may be provided for each of a plurality of ducted propeller assemblies, to be able to selectively form (adjustable/retractable) flow tunnels around each individual ducted propeller assembly.

[0093] Moreover, pairs of tunnel members may be provided in association with a predetermined group or groups of ducted propeller assemblies, to selectively form (adjustable/retractable) flow tunnels around such a predetermined group or groups, while leaving the other ducted propeller assemblies exposed.

[0094] Any or all features relating to the tunnel member and tunnel member assembly that have been described herein above and defined in the claims with respect to single-propeller configurations may also be present in the multi-propeller configurations.

[0095] Also, it will be appreciated that the present invention need not be limited to tunnel members formed by rigid panels that are rotatable with respect to the hull of the vessel. The tunnel members may for example be formed with rigid panels that are mounted in a slidably extendable/retractable manner on or into the hull, and configured to transition between the extended state and retracted state. Alternatively, the tunnel members may be formed by inflatable panels that are mounted on or into the hull with inflation mechanisms (e.g. controlled compressors and valves).

[0096] Finally, the vessel with a hull and propeller, and comprising an adjustable tunnel member with longitudinal seal arrangement that is configured for establishing a further sealing engagement between the hull and the tunnel member in the extended state, for maintaining an underpressure inside the flow tunnel, may be implemented as an improvement in and of its own, and its various embodiments may be subject of a divisional application.

LIST OF REFERENCE SYMBOLS

[0097]

10	vessel (e.g. ship or boat)
12	hull
14	bow
16	stern
18	keel
20	hull frame
22	attachment region
24	outer surface portion
26	ducted propeller assembly (e.g. Kort nozzle)
28	propeller
30	nozzle
32	leading nozzle periphery
34	leading nozzle edge portion
36	propeller shaft
38	rudder
40	flow tunnel (adjustable and/or retractable)
41	tunnel member assembly
42	tunnel member
44	panel
46	leading panel edge
48	trailing panel edge
50	first lateral panel edge (e.g. inner rotatable panel edge)

52	second lateral panel edge (e.g. outer deflectable panel edge)	
54	seal member (e.g. edge seal with curved flexible patches)	
55	adjustment mechanism	5
56	stepped panel region	
58	reinforcement member (e.g. rod)	
60	outer surface	
62	inner surface	
64	casing (e.g. panel housing)	10
66	accommodation space	
68	inner lateral region	
70	outer lateral region	
74	aft region	
76	stepped region	15
77	drive shaft	
78	further shaft	
79	pivot support (e.g. tubular panel support structure)	
80	chamber	20
82	leading chamber wall	
83	sealed bearing (shaft seal)	
84	transmission (e.g. crank assembly)	
86	actuator (e.g. piston)	
88	linear gasket (e.g. resilient strip)	25
90	linear protrusion (e.g. ledge)	
92	reinforcement rib	
Ap	propeller axis	
A(a-b)	tunnel member axis	
X	longitudinal direction (forward/aft directions $\pm X$)	30
Y	transversal direction (athwart directions $\pm Y$)	
Z	vertical direction	
ΔY	tunnel width	
ΔW	transverse panel size	35

Claims

1. A vessel (10), comprising a hull (12) with:
 - a propeller (28) that is rotatably mounted with respect to the hull;
 - a nozzle (30) surrounding the propeller, and
 - a tunnel member (42), which is mounted moveable relative to the hull between:
 - a retracted state, wherein the tunnel member is removed from the nozzle, and
 - an extended state, wherein the tunnel member defines at least a part of an adjustable flow tunnel (40) for conveying a flow of water towards the propeller, and wherein the tunnel member forms a sealing engagement with the nozzle for maintaining an underpressure inside the flow tunnel.
2. The vessel (10) according to claim 1, wherein the tunnel member (42) comprises an elongated shape and a trailing edge (48), and wherein in the extended state, the trailing edge abuts the nozzle (30) to establish the sealing engagement.
3. The vessel (10) according to claim 2, wherein the trailing edge (48) of the tunnel member (42) comprises a seal member (54) for establishing the sealing engagement in the extended state.
4. The vessel (10) according to any one of claims 2-3, wherein the nozzle (30) comprises a leading edge portion (34) near a leading nozzle periphery (32), and wherein in the extended state, the trailing edge (48) of the tunnel member (42) abuts the leading edge portion of the nozzle to establish the sealing engagement.
5. The vessel (10) according to any one of claims 1-4, wherein the tunnel member (42) and/or the hull (12) comprise a longitudinal seal arrangement (88, 90) that is configured for establishing a further sealing engagement between the hull and the tunnel member in the extended state, for maintaining the underpressure inside the flow tunnel (40).
6. The vessel (10) according to any one of claims 1-5, wherein the hull (12) is elongated along a longitudinal direction (X), wherein the tunnel member (42) is rotatably mounted onto the hull about an axis (A) that extends predominantly along the longitudinal direction, and which allows rotation of the tunnel member with respect to the hull between the retracted state and the extended state.
7. The vessel (10) according to any one of claims 1-6, comprising a casing (64) attached in or onto the hull (12), wherein the casing defines a space (66) for accommodating the tunnel member (42) in the retracted state.
8. The vessel (10) according to claim 7, as far as dependent from claim 6, wherein the tunnel member (42) comprises a shaft assembly (77, 78, 79) that extends along the axis (A), wherein the shaft assembly is rotatable with respect to the casing (64) and configured for actuating the tunnel member between the retracted state and the extended state.
9. The vessel (10) according to claim 8, wherein the casing (64) comprises a chamber (80) that is arranged in or near an aft region (74) of the space (66) and which includes a transmission mechanism (84) for exerting a torque on the shaft assembly (77, 78, 79).
10. The vessel (10) according to claim 9, wherein the shaft assembly (77, 78, 79) comprises a drive shaft

(77) that is rotatably coupled at a leading wall (82) of the chamber (80) to form an extension of the chamber in a forward direction (+X).

11. The vessel (10) according to claim 10, wherein the drive shaft (77) is rotatably coupled to the casing (64) by means of a sealed bearing (83) arranged in or near the leading wall (82) of the chamber (80), and configured for fluidly separating the space (66) from the chamber. 5
12. The vessel (10) according to any one of claims 6-11, as far as dependent from claim 6, wherein the tunnel member (42) defines an elongated panel (44) that is coupled along a first panel edge (50) to the hull (12) in a rotatable manner about the axis (A). 10
13. The vessel (10) according to any one of claims 8-12, as far as dependent from claim 8, wherein the shaft assembly (77, 78, 79) and the casing (64) comprise the longitudinal seal arrangement (88, 90) along the axis (A), wherein the seal arrangement is configured for establishing a further sealing engagement between the casing and the tunnel member (42) in the extended state, for maintaining the underpressure inside the flow tunnel (40). 20
14. The vessel (10) according to claim 13, wherein the shaft assembly (77, 78, 79) comprises a linear protrusion (90) extending parallel with the axis (A), wherein the casing (64) comprises a linear gasket (88) extending near the shaft assembly and parallel with the axis, wherein the linear gasket and the linear protrusion are configured to jointly establish the further sealing engagement when the tunnel member (42) is moved into the extended state. 25
15. The vessel (10) according to any one of claims 12-14, wherein the panel (44) comprises a reinforcement member (58) that extends along a free panel edge (52) that is opposite to the axis (A). 30
16. A tunnel member assembly (41) adapted for attaching in or onto a hull (12) of a vessel (10) with a propeller (28) that is rotatably mounted with respect to the hull and a nozzle (30) surrounding the propeller, wherein the tunnel member assembly comprises: 35
- a casing (64) adapted for mounting the tunnel member assembly in or onto the hull, and 40
- a tunnel member (42), which is coupled to and moveable with respect to the casing between: 45
- a retracted state, wherein the tunnel member is removed from the nozzle, and 50
- an extended state, wherein the tunnel member defines at least a part of an adjustable flow tunnel (40) for conveying a flow of 55

water towards the propeller, and wherein the tunnel member abuts the nozzle to form a sealing engagement for maintaining an underpressure inside the flow tunnel.

17. A method for retrofitting a vessel (10) with a hull (12) comprising a propeller (28) that is rotatably mounted with respect to the hull, and a nozzle (30) surrounding the propeller, wherein the method comprises:

- providing a tunnel member assembly (41) according to claim 16, wherein the tunnel member assembly includes a casing (64) and a tunnel member (42);
- attaching the casing (64) in or onto the hull, so as to allow the tunnel member to move respect to the hull between:

- a retracted state, wherein the tunnel member is removed from the nozzle, and
- an extended state, wherein the tunnel member defines at least a part of an adjustable flow tunnel (40) for conveying a flow of water towards the propeller, and wherein the tunnel member abuts the nozzle to form a sealing engagement for maintaining an underpressure inside the flow tunnel.

Fig. 1

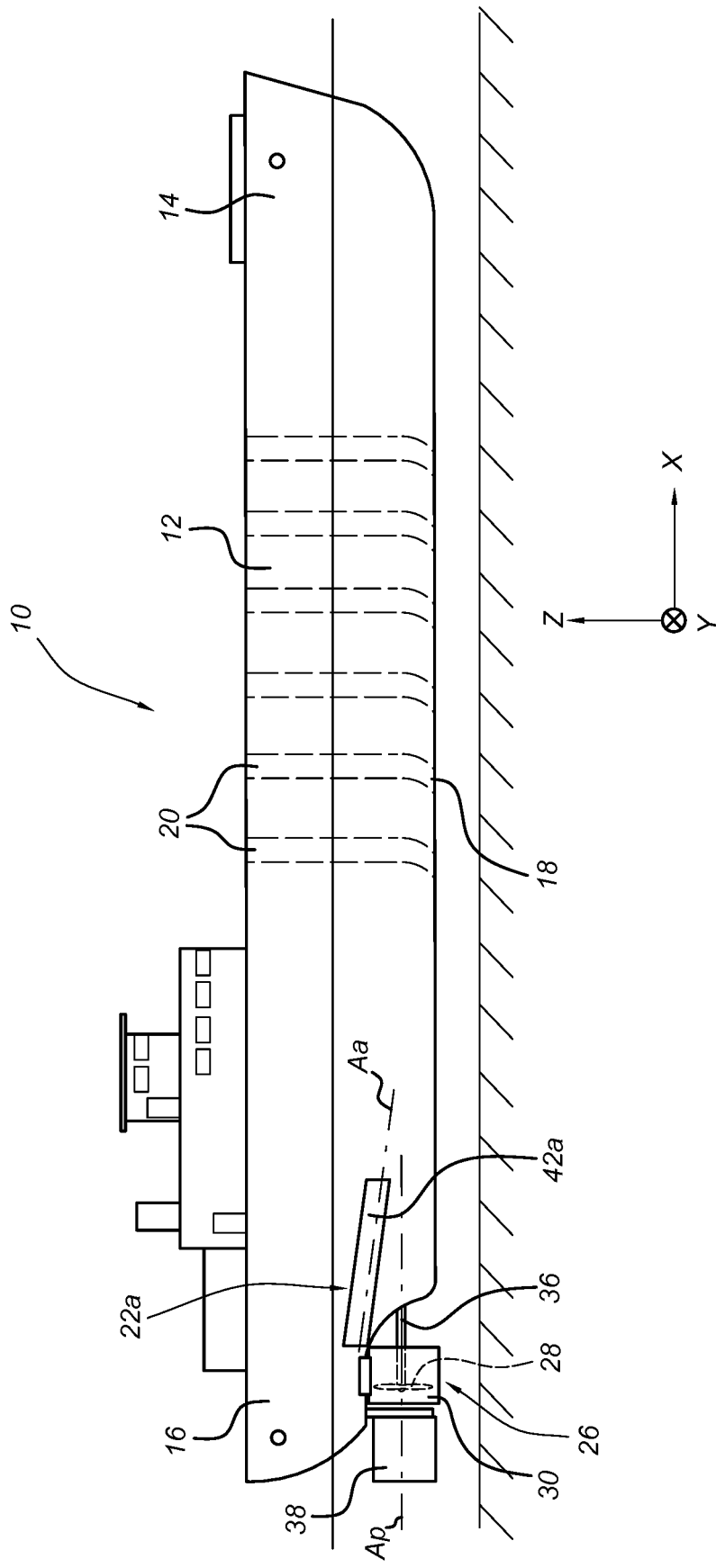


Fig. 2a

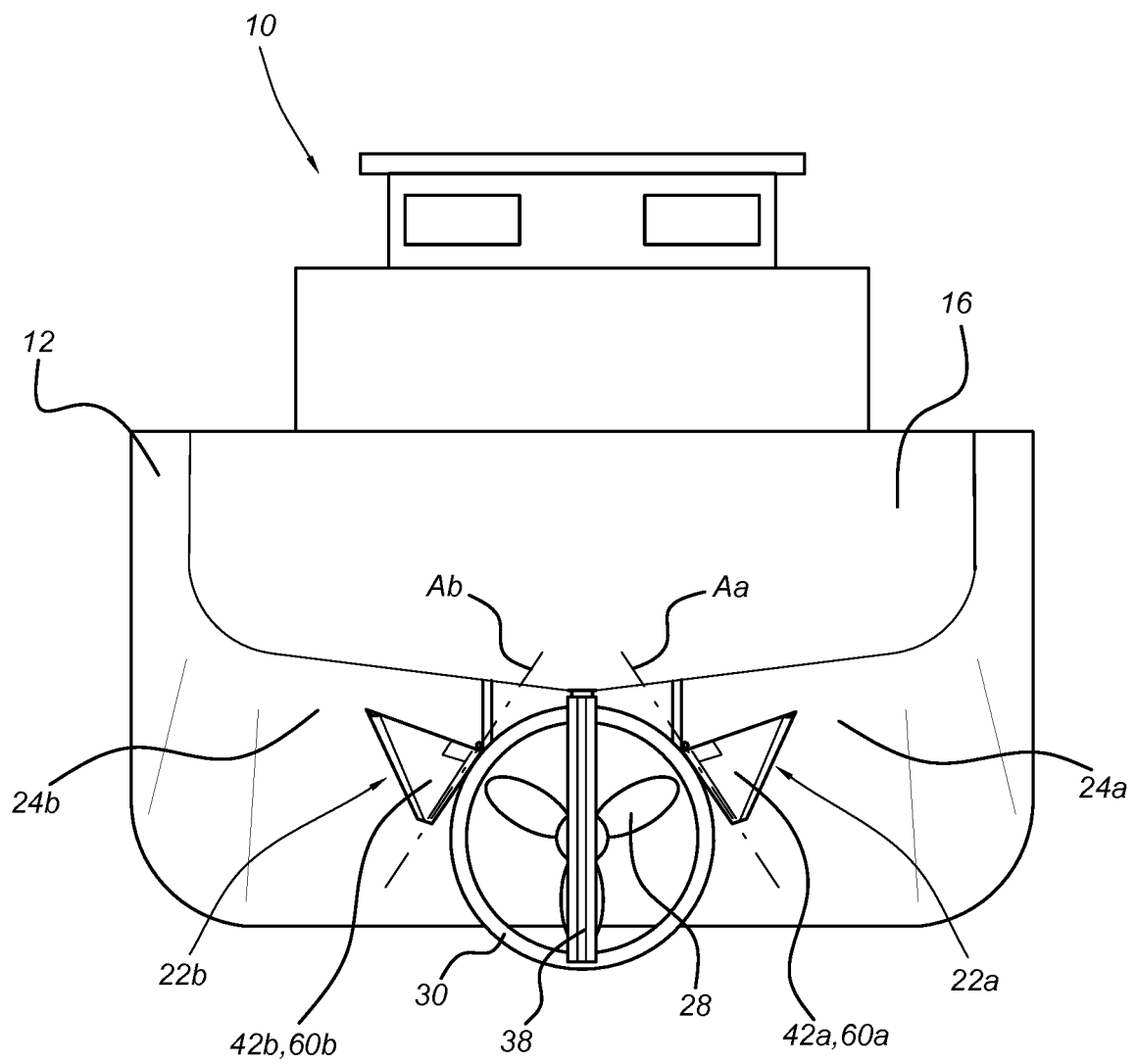


Fig. 2b

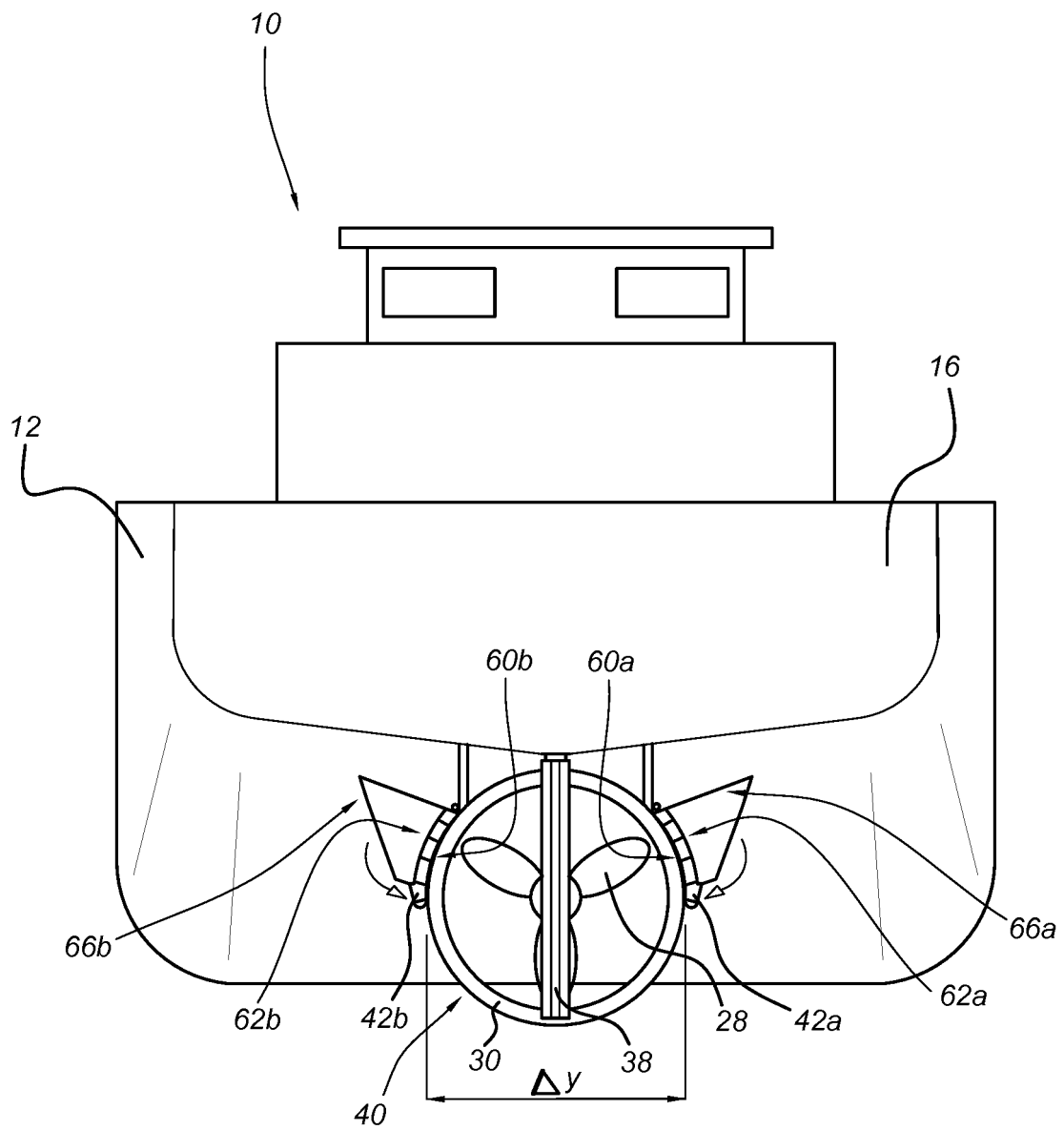


Fig. 3A

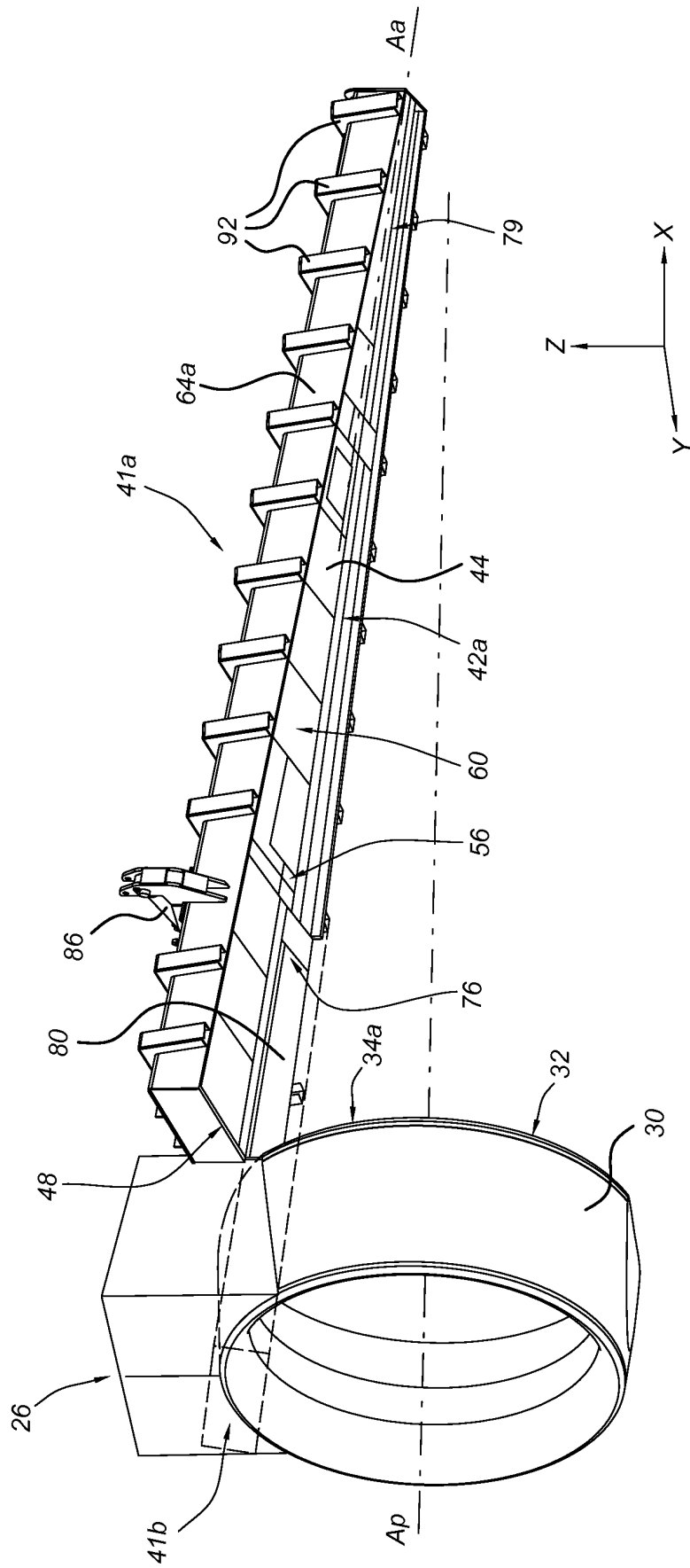


Fig. 3B

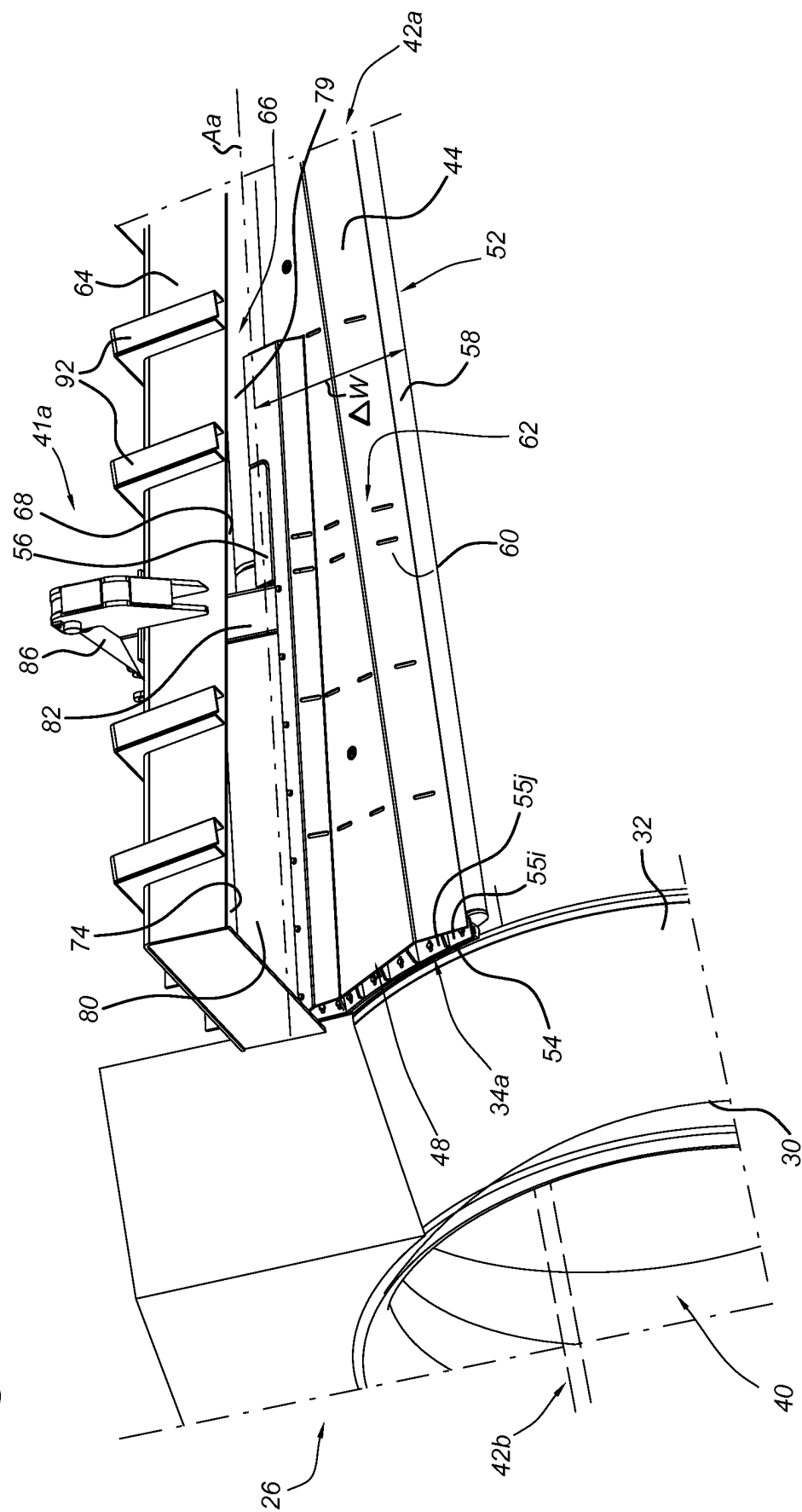
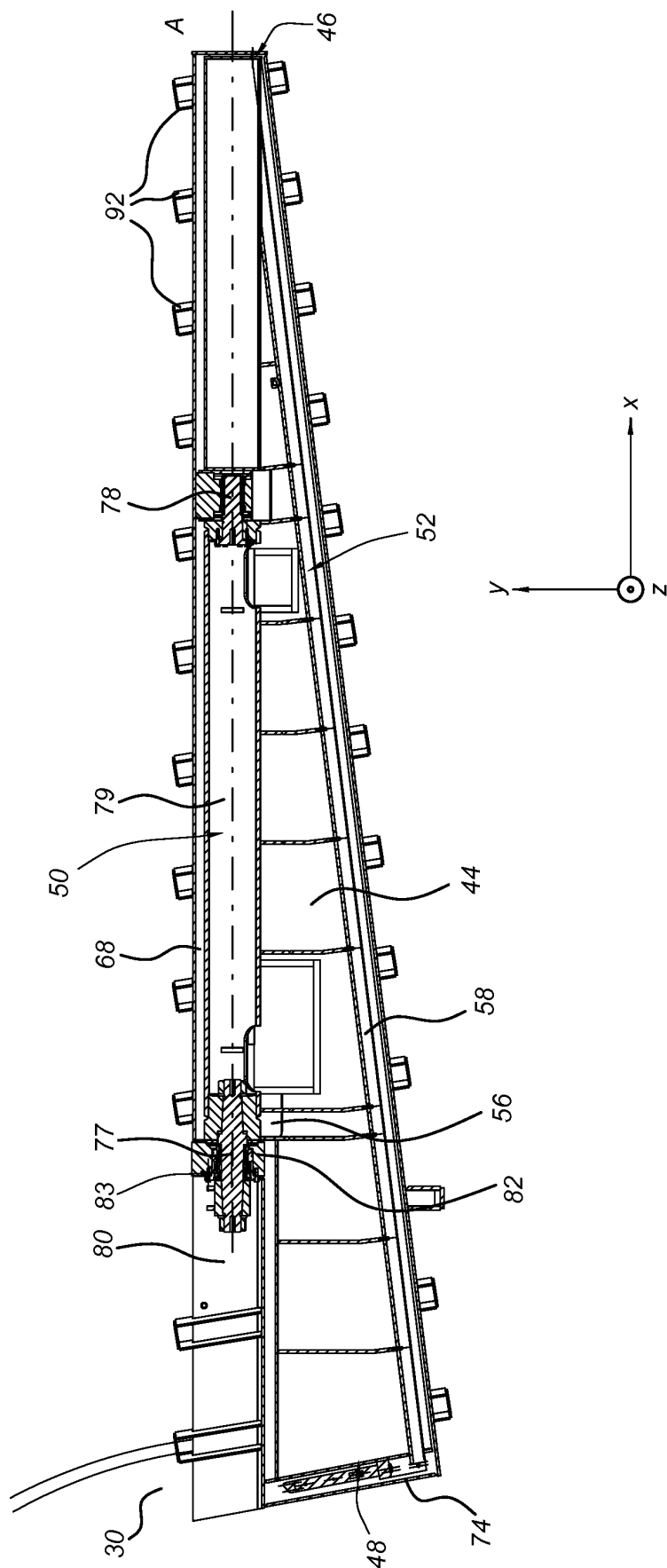


Fig. 4



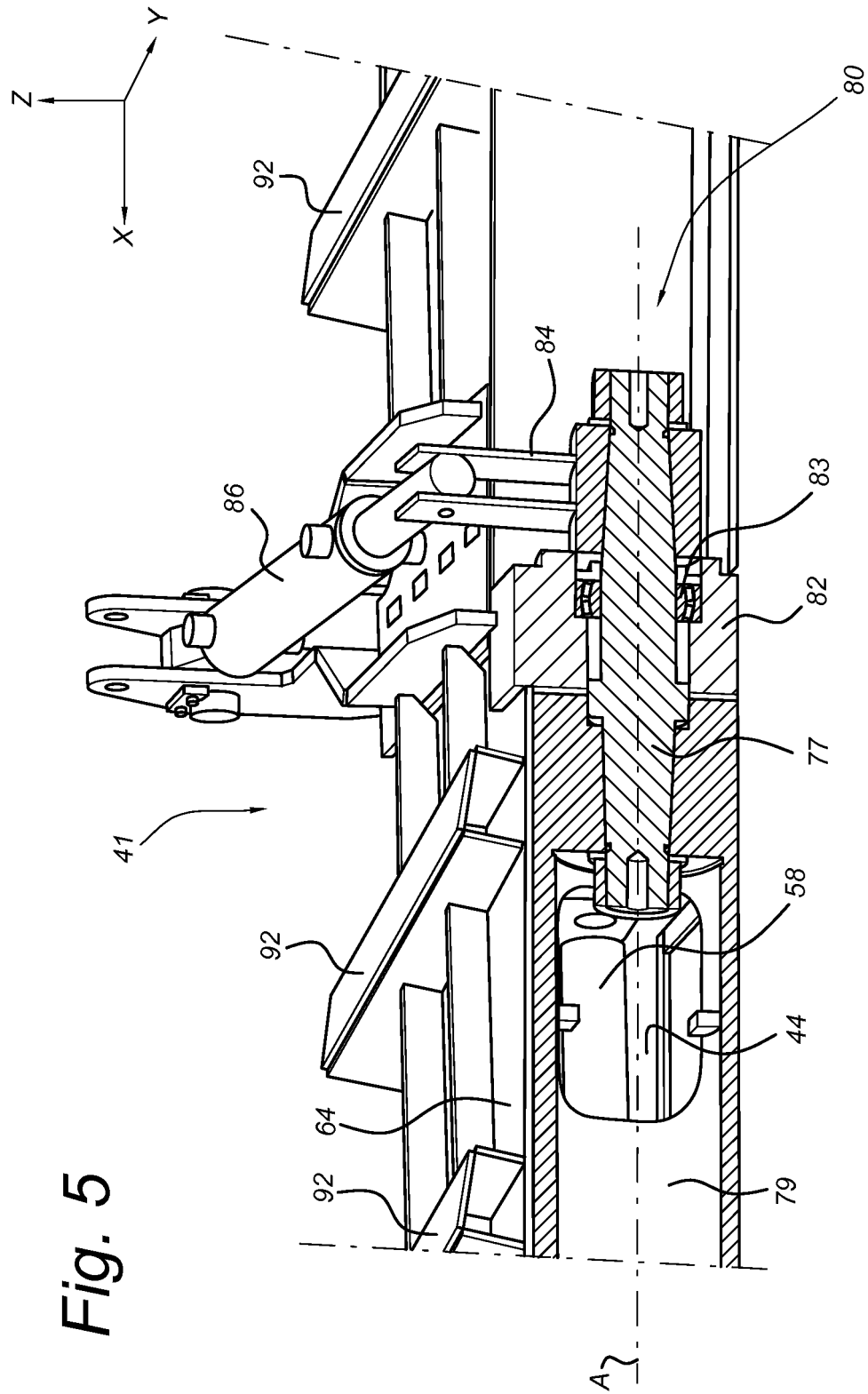
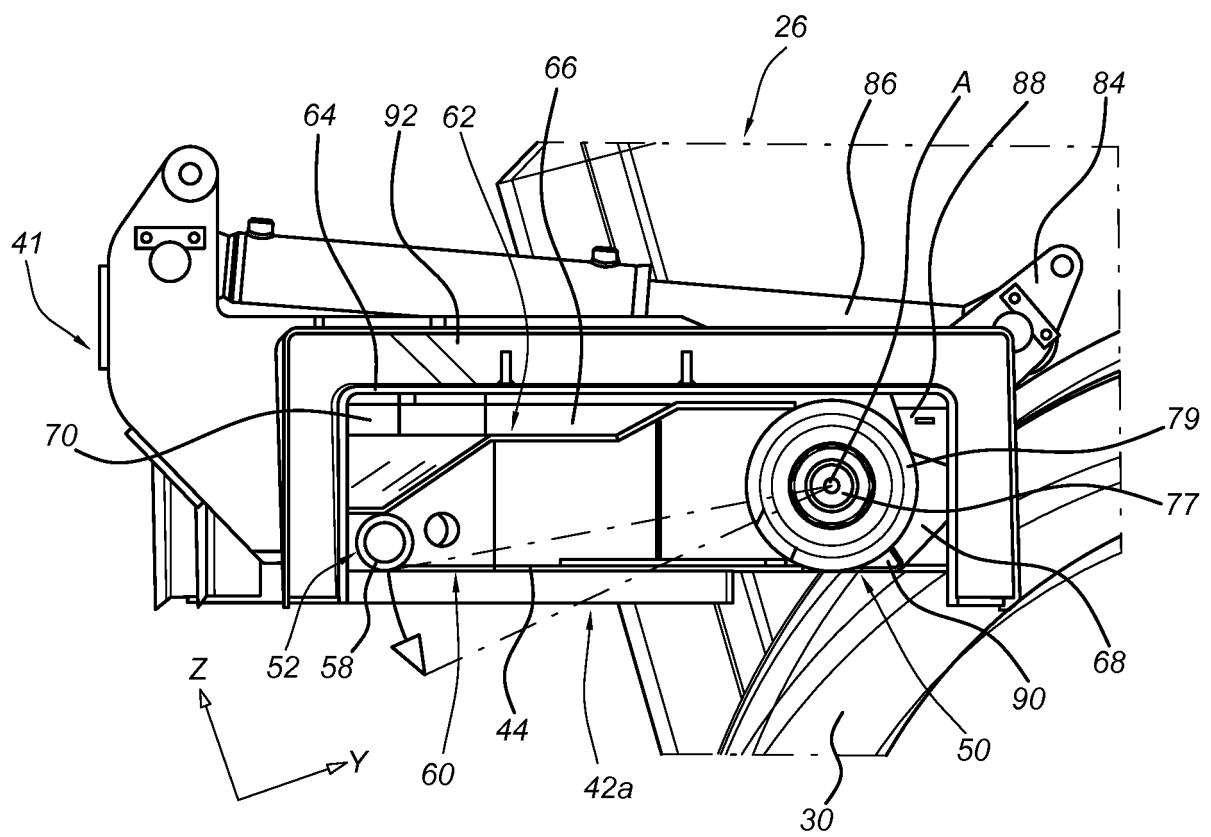


Fig. 5

Fig. 6





EUROPEAN SEARCH REPORT

Application Number
EP 15 17 7131

5

10

15

20

25

30

35

40

45

50

55

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 3 635 186 A (GERMAN WILLIAM H) 18 January 1972 (1972-01-18) * the whole document *	1-17	INV. B63H5/15 B63H5/16
A	NL 1 034 333 C2 (HRP HOLDING B V [NL]) 11 March 2009 (2009-03-11) * column 2, line 15 - line 17 * * column 2, line 25 - line 28 *	1-17	
A	US 4 977 845 A (RUNDQUIST CARL E [US]) 18 December 1990 (1990-12-18) * column 6, line 36 - line 44 * * column 3, line 50 - line 57 * * column 8, line 5 - line 25 * * figures *	1-17	
A	GB 1 121 821 A (HOVERMARINE LTD) 31 July 1968 (1968-07-31) * the whole document *	1-17	
			TECHNICAL FIELDS SEARCHED (IPC)
			B63B B63H
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 13 January 2016	Examiner Barré, Vincent
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

 1
EPO FORM 1503 03/82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 15 17 7131

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

13-01-2016

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 3635186	A	18-01-1972	NONE
NL 1034333	C2	11-03-2009	NONE
US 4977845	A	18-12-1990	NONE
GB 1121821	A	31-07-1968	NONE

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- EP 1300330 A1, AUGSPURGER [0006] [0007]