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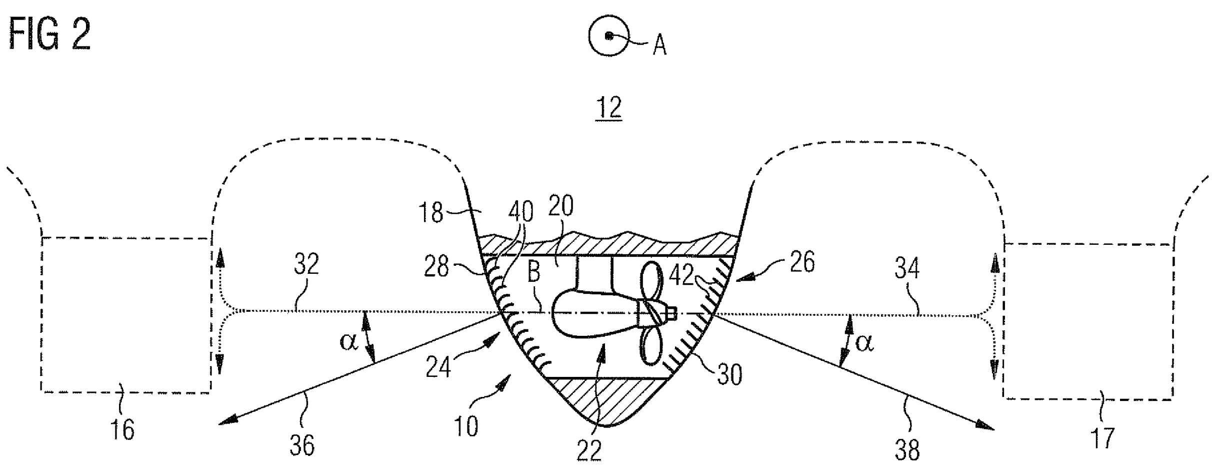
(54) Tunnel thruster system

(57) The present disclosure relates to a tunnel thruster system (10) of a vessel (1). Specifically, a tunnel thruster system may comprise a hull segment (18) extending along a longitudinal axis (A) of a vessel (1) and defining a passage (20) therethrough. The tunnel thruster system (10) may further comprise a propeller unit (22) disposed in the passage (20) and configured to generate a water jet in a first direction through the passage (20). At least one deflector (24, 26) may be disposed in the passage (20) and may be configured to deflect at least part of the water jet in a second direction different from the first direction for guiding the water jet at least in part around a flow obstacle (16, 17) defined by the vessel (1).

FIG 2



EP 2 923 942 A1

Description

Technical Field

[0001] The present disclosure relates to a thruster system for a vessel. More particularly, the present disclosure relates to a tunnel thruster system including a passage extending through a hull segment of a vessel.

Background

[0002] For improving maneuverability of a vessel, so-called tunnel thrusters (also referred to as transverse thrusters in literature) can be provided in a hull structure of the vessel. Particularly, tunnel thruster systems include a passage (tunnel) extending through a hull segment of the hull structure, for example in a transverse direction with respect to a vessel longitudinal axis. Typically, those tunnel thruster systems are positioned in a bow region and/or a stem region of the vessel. A propeller unit of the tunnel thruster system generates a water jet through the passage if activated. That water jet exits the passage in a starboard or port direction of the vessel, and, thus, causes a steering force that allows maneuvering the vessel without travelling forward or aft.

[0003] For example, EP 2 305 558 A1 discloses a tunnel thruster system for a vessel. The tunnel thruster system includes a thruster propulsion mechanism including a drive unit driving a transmission and propeller assembly located within a thruster tunnel. The thruster tunnel comprises a propeller section, and first and second tapered tunnel sections interconnected with one another by the propeller section. The propeller section and the first and the second tapered tunnel sections are oriented substantially transversely to a keel of the vessel and accommodate the transmission and propeller assembly. Each tapered tunnel section extends from the propeller section to a tunnel opening through a hull of the vessel.

[0004] The present disclosure is directed, at least in part, to improving or overcoming one or more aspects of prior devices.

Summary of the Disclosure

[0005] In one aspect of the present disclosure, a tunnel thruster system is disclosed. The tunnel thruster system may comprise a hull segment extending along a longitudinal axis of a vessel and defining a passage therethrough. The tunnel thruster system may further comprise a propeller unit disposed in the passage and configured to generate a water jet in a first direction through the passage. The tunnel thruster system may further comprise at least one deflector disposed in the passage and configured to deflect at least part of the water jet in a second direction different from the first direction.

[0006] In another aspect of the present disclosure, a vessel is disclosed. The vessel may include a tunnel thruster system that may comprise a hull segment extending along a longitudinal axis of the vessel and may define a passage therethrough. The tunnel thruster system may further comprise a propeller unit disposed in the passage and configured to generate a water jet in a first direction through the passage. The tunnel thruster system may further comprise at least one deflector disposed in the passage and configured to deflect at least part of the water jet in a second direction different from the first direction.

[0007] Other features and aspects of this disclosure will be apparent from the following description and the accompanying drawings.

Brief Description of the Drawings

[0008] The accompanying drawings, which are incorporated herein and constitute a part of the specification, illustrate exemplary embodiments of the disclosure and, together with the description, serve to explain the principles of the disclosure. In the drawings:

Fig. 1 shows a schematic drawing of a starboard side of a vessel including four tunnel thruster systems;
Fig. 2 shows a schematic drawing of a tunnel thruster system including two deflectors;
Fig. 3 shows a schematic drawing of two tunnel thruster systems with deflectors; and
Fig. 4 shows another schematic drawing of a tunnel thruster system, in which the deflector comprises a plurality of deflector plates.

Detailed Description

[0009] The following is a detailed description of exemplary embodiments of the present disclosure. The exemplary embodiments described therein and illustrated in the drawings are intended to teach the principles of the present disclosure, enabling those of ordinary skill in the art to implement and use the present disclosure in many different environments and for many different applications. Therefore, the exemplary embodiments are not intended to be, and should not be considered as, a limiting description of the scope of patent protection. Rather, the scope of patent protection shall be defined by the appended claims.

[0010] The present disclosure is based in part on the realization that in certain vessel configurations, a water jet generated by a tunnel thruster may be negatively affected by the vessel itself. Particularly, the water jet may at least partly impinge on a flow obstacle being part of the vessel such as a fin or a rudder. As the water jet impinges on the vessel, a counterforce against the desired steering force may be generated that negatively affects maneuverability of the vessel. Moreover, the water jet may be deflected by the hull structure in a manner causing disturbances during steering. To reduce the impingement of the water jet on the vessel, and, thus, to improve steering by means of a tunnel thruster, it is proposed to integrate a deflector into the tunnel thruster system. Said deflector facilitates deflecting the water jet in a direction that at least reduces impingement of the water jet on the vessel.

[0011] The present disclosure is further based in part on the realization that two tunnel thruster systems in a vessel may be arranged such that one tunnel thruster system negatively affects the other one. For example, two tunnel thruster systems may each include a passage. Both passages longitudinally extend along the same axis. If both tunnel thrusters systems are activated to generate a water jet in the same direction, the water jet of a first tunnel thruster systems is directed to the second tunnel thruster system. That water jet impinges on the second tunnel thruster system, and partially enters the passage of the second tunnel thruster system. Thus, generation of a water jet by the second tunnel thruster system may be negatively affected due to a higher inflow velocity.

[0012] In the following, an exemplary vessel including a plurality of tunnel thruster systems is described with reference to Fig. 1. Thereafter, exemplary tunnel thruster systems are described in more detail with reference to Figs. 2 to 4.

[0013] Fig. 1 schematically shows a vessel in a side view. The vessel is referred to in its entirety by reference numeral 1. Vessel 1 extends from a stem 2 to a bow 4 along a vessel longitudinal axis A.

[0014] Vessel 1 includes a main propeller 6 for propelling vessel 1 in a forward direction, and a rudder 8 for steering vessel 1 during forward travel. Both main propeller 6 and rudder 8 are disposed at stem 2.

[0015] Additionally, vessel 1 includes a plurality of tunnel thruster systems (transverse thruster systems) 10, two of which being provided at stem 2, the other two being provided at bow 4. Alternatively, vessel 1 may include more or less tunnel thruster system 10.

[0016] Tunnel thruster systems 10 are transversely provided in a hull structure 12 of vessel 1 with respect to vessel longitudinal axis A. Particularly, tunnel thruster systems 10 are provided in hull segments of hull structure 12, the hull segments extending along vessel longitudinal axis A, and tunnel thruster systems 10 being provided transversely with respect to vessel longitudinal axis A. As a result, tunnel thruster systems 10 extend between a port side and a starboard side of vessel 1 in the shown configuration of Fig. 1. If activated, tunnel thruster systems 10 generate a water jet resulting in a steering force which facilitate steering of vessel 1 without travelling forward or aft.

[0017] Generally, a passage of the tunnel thruster system 10 may extend through a hull segment of hull structure 12, for example, under an angle to vessel longitudinal axis A other than 180°, particularly within a range of 90° ± 30 °.

[0018] As is exemplary indicated in Fig. 1, tunnel thruster systems 10 at stem 2 are partially covered by a fin 14 of hull structure 12. For example, fin 14 may be provided in hull structure 12 for increasing stability of vessel 1, and/or to increase flow properties of vessel 1.

[0019] In vessels including conventional tunnel thrusters systems, that coverage by fin 14 may result in a loss of steering force generated by a respective tunnel thruster system as is described in greater detail in the following. To reduce those losses, tunnel thruster systems 10 at stem 2 are provided with a deflector 26 for deflecting a water jet as is also described in greater detail hereinafter.

[0020] Referring to Fig. 2, a tunnel thruster system 10 and flow obstacles 16, 17 (schematically indicated by dashed squares in Fig. 2) are depicted.

[0021] Tunnel thruster system 10 includes a hull segment 18 with a passage (tunnel) 20. Additionally, tunnel thruster system 10 comprises a propeller unit 22 disposed in passage 20, and deflectors 24, 26 also disposed in passage 20.

[0022] Hull segment 18 forms part of hull structure 12 of vessel 1. As noted above, hull segment 18 defines passage 20 that extends through hull segment 18 along a passage central longitudinal axis B. Specifically, passage 20 extends between a first opening 28 in an outer face of hull segment 18 and a second opening 30 in an outer face of hull segment 18. As is indicated in Fig. 2, passage central longitudinal axis B may run in a direction perpendicular to vessel longitudinal axis A.

[0023] Further, passage 20 may have a constant diameter along central longitudinal axis B, or may have a changing diameter along central longitudinal axis B, for example at least partially tapering to a middle section that accommodates propeller unit 22.

[0024] Propeller unit 22 is capable to generate a water jet through passage 20 for steering vessel 1 without contributing to a forward or aft travel of vessel 1. Propeller unit 22 is driven by a drive unit (not shown in further detail in Fig. 2) to which propeller unit 22 is connected, for example via a transmission unit (also not shown in Fig. 2). Said drive unit may be, for example, an electric drive.

[0025] In the embodiment shown in Fig. 2, propeller unit 22 comprises one propeller with four propeller blades. Alternatively, propeller unit 22 may comprise more than one propeller, each propeller may be equipped with any number of propeller blades.

[0026] For steering vessel 1, propeller unit 22 may generate a water jet in a first direction, for example a starboard side direction. That water jet exits passage 20 through second opening 30 in hull segment 18. For steering vessel 1 in the opposite direction by tunnel thruster system 10, propeller unit 22 may generate a water jet in a second direction, which is oppositely directed to the first direction. For example, the second direction may be a port side direction. That water jet exits passage 20 through first opening 28. Depending on the configuration of propeller unit 22, such a reversal of a water jet direction may be performed by reversing a rotational direction of propeller unit 22, and/or by varying a propeller blade pitch of propeller unit 22. In the latter case, a so-called variable pitch propeller may be used as propeller unit 22. In other embodiments, propeller unit 22 may be capable to generate a water jet in one direction only without the possibility to reverse the same.

[0027] In the shown schematic vessel configuration of Fig. 2, upon generation by propeller unit 22, the water jet is directed in a first direction to either a first or a second flow obstacle 16, 17.

[0028] Flow obstacles 16, 17 may be any part of vessel 1 being at least partially disposed in the first direction of the water jet generated by propeller unit 22 and flowing through passage 20 before passing deflector 26 or 28. For example, flow obstacles 16, 17 may be a fin structure (as schematically indicated in Fig. 1 by reference numeral 14), a rudder, a propeller, a driving shaft for a propeller, another tunnel thruster system, or any other structure of vessel 1, which may interfere a water jet generated by tunnel thruster system 10.

[0029] In case the water jets would exit passage 20 in the first direction, which is directed to flow obstacle 16 or 17 - as it may be the case in prior art configurations - the water jet would at least partially impinge on the flow obstacle 16 or 17 (schematically indicated as undeflected theoretical water jets in Fig. 2 by dotted lines 32 and 34). That impingement would generate a counterforce acting against the desired steering force. Thus, steering of vessel 1 by tunnel thruster system 10 may be negatively affected.

[0030] To at least reduce that impingement, a first and a second deflector 24, 26 are disposed in passage 20 of tunnel thruster system 10. Both deflectors 24, 26 are configured to deflect at least part of the water jet in a second direction different from the first direction as the water jet would otherwise impinge at least in part on respective flow obstacle 16, 17.

[0031] In some embodiments, only one deflector may be disposed in passage 20. For example, position of tunnel thruster system 10 and configuration of vessel 1 may be such that only one flow obstacle 16 or 17 exists in the first direction. As a further example, propeller unit 22 may be capable to generate a water jet in one direction only, in which - downstream of propeller unit 22 - a deflector may be disposed in passage 20.

[0032] In the shown configuration of Fig. 2, deflectors 24, 26 deflect the water jet in a downward direction (indicated by solid lines 36, 38 in Fig. 2) to guide the water jet at least partially around respective flow obstacle 16, 17. Additionally or alternatively, deflectors 24, 26 may deflect the water jet in any other direction such as a sideward direction, and/or an upward direction with respect to the first direction of the water jet before passing respective deflector 24, 26. In particular, the deflection direction caused by deflector 24, 26 may be set depending on the position, dimension, orientation and shape of flow obstacle 16, 17.

[0033] In some embodiments, deflectors 24, 26 may not deflect the entire water jet, but only part of it. Specifically, that part of the water jet may be deflected, which would otherwise impinge on flow obstacle 16, 17. Deflectors 24, 26 may only partly extend across a cross sectional area of passage 20 when viewed in direction along central longitudinal axis B. For example, deflectors 24, 26 may extend across three-quarters (3/4), two-thirds (2/3), one-half (1/2), one-third (1/3), or one-quarter (1/4) of a cross sectional area of passage 20 when viewed in direction along central longitudinal axis B.

[0034] The strength or extent of the water jet deflection caused by deflector 24, 26 can be represented by an angle α confined between the first direction of respective undeflected theoretical water jet 32, 34 and the second direction of respective deflected water jet 36, 38. Angle α is greater than 0° such as within a range between 3° to 45°, particularly within a range between 5° to 20°, more particularly about 12°.

[0035] In the shown configuration of Fig. 2, deflectors 24, 26 comprise a plurality of spaced apart deflector plates 40 and 42, respectively. Said plates 40, 42 may be arranged in parallel and may have any outer shape and/or inclination angle for deflecting the water jet. For example, those deflector plates may have a flat outer shape as illustrated for plates 42 in Fig. 2, or may have a curved outer shape as illustrated for plates 40 in Fig. 2. In some embodiments, deflector plates having different shapes may be integrated in the same deflector.

[0036] Neighboring deflector plates 40, 42 may be spaced apart from one another within a millimeter or centimeter range, for example, between 10 cm and 25 cm. Further, deflector plates 40, 42 may be made of a steel alloy, composite, polymer, or bronze.

[0037] Furthermore, plates 40, 42 may radially extend from central longitudinal axis B of passage 20, for example in a horizontal direction (as depicted in Fig. 2), in a vertical direction, and/or in any diagonal direction. Deflector plates 40, 42 are connected to an inner face of passage 20, and, thus, to hull segment 18.

[0038] In some embodiments, deflector 24 and/or 26 may be configured to not equally deflect its respective water jet, but to deflect part of the water jet stronger than a remaining part of the same water jet. For example, plates 40, 42 of respective deflectors 24, 26 may not be equally inclined, and/or not equally curved.

[0039] Additionally or alternatively, deflectors 24, 26 may split the water jet into two or more jets with different flow directions. In other words, deflectors 24, 26 may deflect at least part of the water jet in a third direction different from both the first direction and the second direction. For example, again, plates 40, 42 of respective deflectors 24, 26 may not be equally inclined, and/or not equally curved. Splitting into two water jets may be facilitated, for example, by providing a first subgroup of plates 40, 42 and a second subgroup of plates 40, 42. That first subgroup may have an inclination and/or curved outer shape deflecting the part of the water jet passing the first subgroup in another direction than the second subgroup deflecting the remaining part of the water jet. For instance, the first subgroup may deflect part of the water jet in a downward direction, and the second subgroup may deflect part of the water jet in any other direction.

[0040] In some embodiments, deflector 24 and/or 26 may be adjustable to adjust a deflection angle α. For example, an inclination angle of at least a subgroup of plates 40, 42 may be adjustable.

[0041] Referring to Fig. 3, an exemplary tunnel thruster arrangement is depicted, in which two tunnel thrusters systems are positioned in a vessel such that each may constitute a flow obstacle for the other tunnel thruster system.

[0042] Specifically, first hull segment 18 of first tunnel thruster system 10 is embodied as a fin. Similarly, second hull segment 18' of second tunnel thruster system 10 is also embodied as a fin. Both first and second hull segment 18, 18' form part of hull structure 12 of vessel 1.

[0043] It is noted that, if activated, both tunnel thruster systems 10, 10' generate a water jet in the same direction for steering vessel 1. Particularly, tunnel thruster systems 10, 10' may either both generate a water jet in a starboard side direction, or in a port side direction of vessel 1.

[0044] As schematically indicated in Fig. 3, first propeller unit 22 may generate a water jet in a first direction (schematically indicated by dotted line 34). The water jet flowing in that first direction would impinge on "downstream" second tunnel thruster system 10' if not being deflected by first deflector 26 in a second direction (schematically indicated by solid line 38).

[0045] Similarly, if steering vessel 1 in the other direction, second propeller unit 22' of second tunnel thruster system 10' generates a water jet directed to "downstream" first tunnel thruster system 10. To at least reduce impingement of the water jet onto first tunnel thruster system 10, second deflector 26' of second tunnel thruster system 10' deflects the water jet in a second direction (indicated by solid line 38') different from the direction before passing second deflector 26' (indicated by dotted line 34').

[0046] Impingement of the water j et on vessel 1 may negatively affect steering of vessel 1. Additionally, as shown in Fig. 3, the water jet of one tunnel thruster system 10 or 10' may enter passage 20' or 20 of other tunnel thruster system 10' or 10, and, thereby, may negatively affect generation of a water jet therein. For example, an inflow velocity into the "downstream" tunnel thruster system may be increased, which may decrease efficiency of the "downstream" thruster tunnel thruster system. Changed inflow conditions may lead to cavitation resulting in noise, vibrations, erosion, and/or lowered efficiency.

[0047] In the configuration shown in Fig. 3, there are only flow obstacles in one direction for each tunnel thruster system 10, 10'. Accordingly, only one deflector 26, 26' may be necessary per tunnel thruster system 10, 10'.

[0048] Referring to Fig. 4, an exemplary tunnel thruster system with a deflector is shown without a hull segment.

[0049] Here, deflector 26 includes a plurality of flat shaped deflector plates 42 arranged in parallel and extending in opening 30 of passage 20 in a horizontal direction. To enhance stability of deflector plates 42, struts 44 connecting deflector plates 42 to one another and to hull segment 18 are provided.

[0050] As is exemplary depicted in the configuration of Fig. 4, deflector 26 may also function as a protective grid in opening 30 of passage 20. Said protective grid may protect tunnel thruster system 10 from entering of solid objects in the water, for example, icing, which may damage propeller unit 22.

Industrial Applicability

[0051] The tunnel thruster system as generically disclosed herein is applicable in vessels for improving maneuverability of the vessel. Particularly, the herein disclosed tunnel thruster system is applicable in vessels including at least one flow obstacle for a water jet generated by the tunnel thruster system. That flow obstacle may result from a design of the vessel and may be, for example, a fin or another tunnel thruster system.

[0052] As recited herein, a deflector installed in a passage of a tunnel thruster system facilitates deflecting a water jet generated by a propeller unit of the tunnel thruster system. Due to the deflection, the water jet is redirected such that the same flows around a flow obstacle positioned in direction of the water jet before passing the deflector. Thus, impingement of the water jet on the flow obstacle is at least reduced, which results in a lowered counterforce on the desired steering force.

[0053] As one skilled in the art will appreciate, also deflection of the water jet will result in steering force losses. Accordingly, deflection angle α may be chosen to balance between losses due to impingement and losses due to deflection. In embodiments including adjustable deflectors, the individual losses due to deflection and impingement are adjustable to set a desired balance for a specific situation.

[0054] As used herein, the terms "upward direction", "downward direction", and "sideward direction" are used with respect to a water jet direction before deflection (also referred to as first direction herein). In other words, upward direction means in direction to a water surface, and downward direction means in direction to a sea bed.

[0055] Moreover, as used herein, terms relating to spatial relationships such as parallel and perpendicular, and values and value ranges recited herein may not necessarily be interpreted in a strict mathematical sense, but may be used in a context allowing for certain tolerances. Those tolerances are particularly determined in that the functional feature associated with the mathematical relationship and/or value may be still fulfilled.

[0056] Although the preferred embodiments of this invention have been described herein, improvements and modifications may be incorporated without departing from the scope of the following claims.

Claims

1. A tunnel thruster system (10) comprising:

a hull segment (18) extending along a longitudinal axis (A) of a vessel (1) and defining a passage (20) therethrough;
a propeller unit (22) disposed in the passage (20) and configured to generate a water jet in a first direction through the passage (20); and
at least one deflector (24, 26) disposed in the passage (20) and configured to deflect at least part of the water jet in a second direction different from the first direction.

2. The tunnel thruster system (10) of claim 1, wherein the passage (20) extends through the hull segment (18) under an angle with respect to the longitudinal axis (A), or in a direction substantially perpendicular to the longitudinal axis (A).

3. The tunnel thruster system (10) of claim 1 or 2, wherein the second direction is a downward direction, sideward direction, and/or upward direction with respect to the first direction.

4. The tunnel thruster system (10) of any one of the preceding claims, wherein the at least one deflector (24, 26) is further configured to deflect at least part of the water jet in a third direction different from both the first direction and the second direction.

5. The tunnel thruster system (10) of any one of the preceding claims, wherein the at least one deflector (24, 26) is adjustable to adjust a deflection angle (α) of the water jet.

6. The tunnel thruster system (10) of any one of the preceding claims, wherein the at least one deflector (24, 26) comprises a plurality of deflector plates (40; 42).

7. The tunnel thruster system (10) of claim 6, wherein the plurality of deflector plates (40; 42) radially extend from a central longitudinal axis (B) of the passage (20).

8. The tunnel thruster system (10) of claim 6 or 7, wherein the plurality of deflector plates (40; 42) have a flat outer shape, and/or a curved outer shape.

9. The tunnel thruster system (10) of any one of claims 6 to 8, wherein the plurality of deflector plates (40; 42) are arranged in parallel.

10. The tunnel thruster system (10) of any one of claims 6 to 9, wherein
at least one of the plurality of deflector plates (40; 42) has a different inclination angle with respect to at least one other deflector plate (40; 42); and/or
at least one of the plurality of deflector plates (40) has a differently curved outer shape with respect to at least one other deflector plate (40; 42).

11. The tunnel thruster system (10) of any one of claims 6 to 10, further comprising at least one strut (44) disposed in the passage (20) and connecting at least one of the plurality of deflector plates (40; 42) to the hull segment (18) for increasing stability.

12. The tunnel thruster system (10) of any one of the preceding claims, wherein the at least one deflector (24, 26) extends at least partly across a cross sectional area of the passage (20) when viewed in direction along a central longitudinal axis (B) of the passage (20).

13. The tunnel thruster system (10) of any one of the preceding claims, wherein the at least one deflector (26; 28) is further configured to function as a protective grid for the tunnel thruster system (10).

14. The tunnel thruster system (10) of any one of the preceding claims, wherein the at least one deflector (26; 28) is disposed in the passage (20) between propeller unit (22) and an opening (30) of the passage (20) in the hull segment (18).

15. A vessel (1) including a tunnel thruster system (10) comprising:

a hull segment (18) extending along a longitudinal axis (A) of the vessel (1) and defining a passage (20) therethrough;
a propeller unit (22) disposed in the passage (20) and configured to generate a water jet in a first direction through the passage (20); and
at least one deflector (24, 26) disposed in the passage (20) and configured to deflect at least part of the water jet in a second direction different from the first direction.

FIG 1

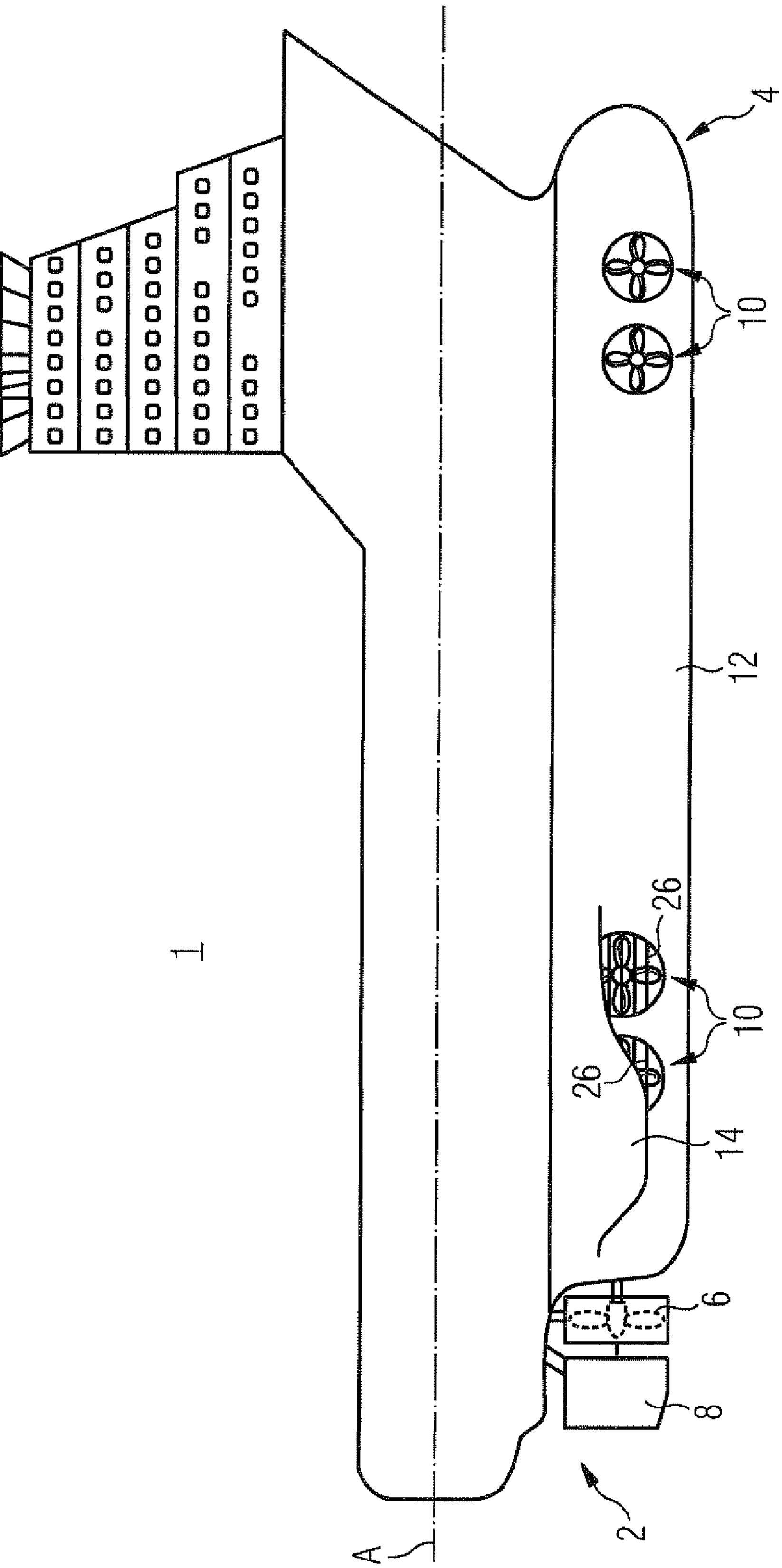


FIG 2

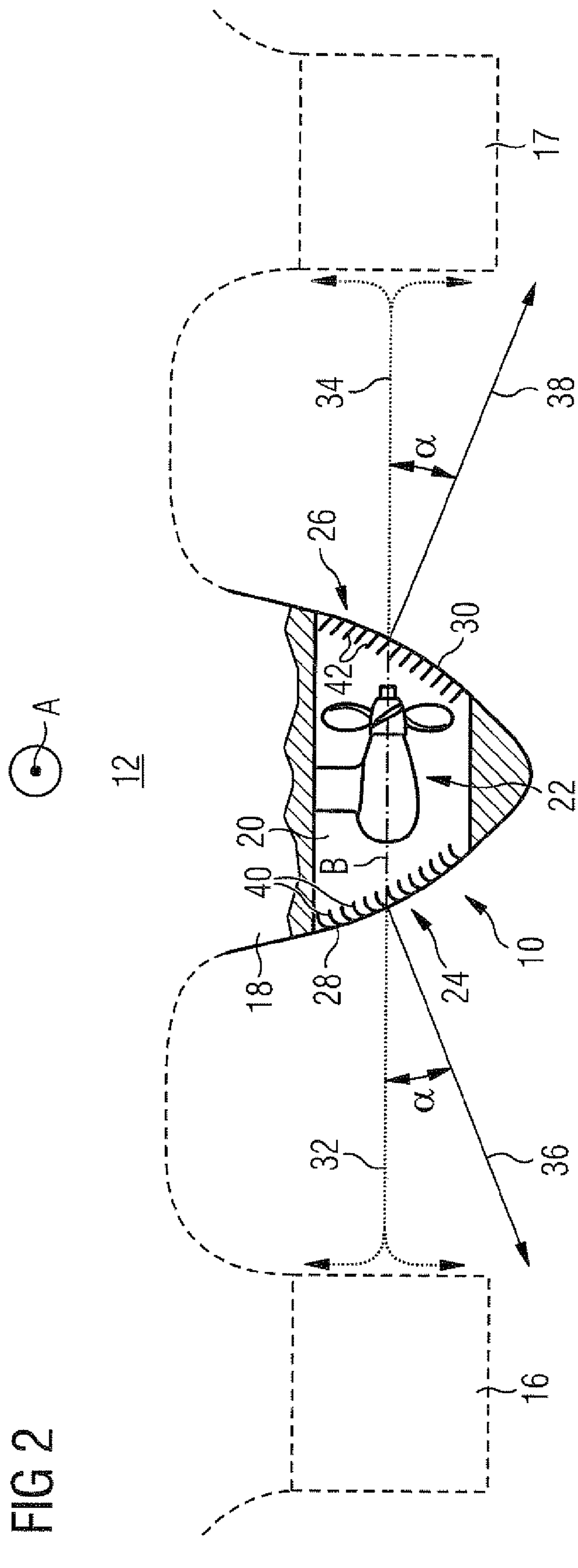


FIG 3

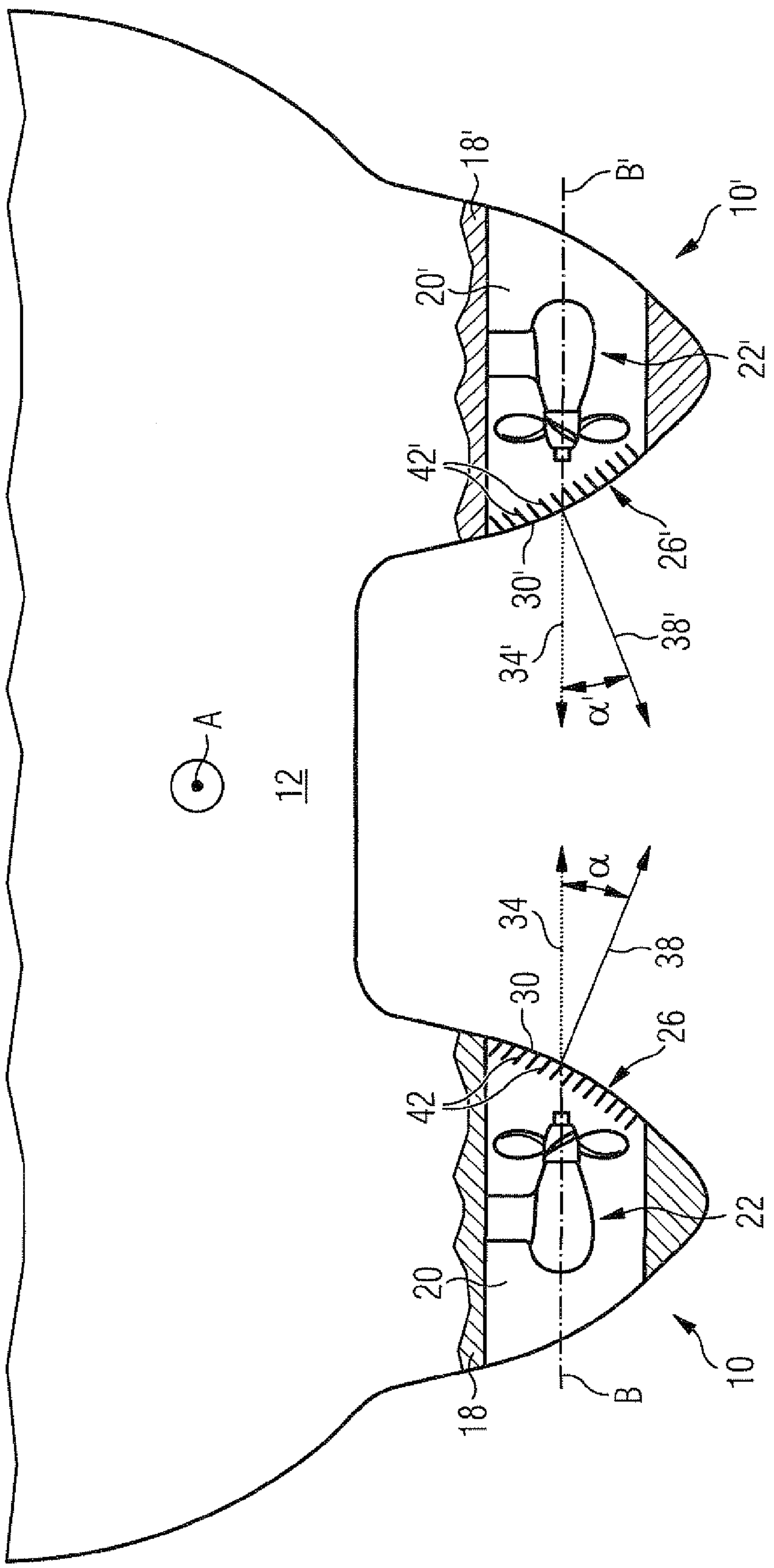
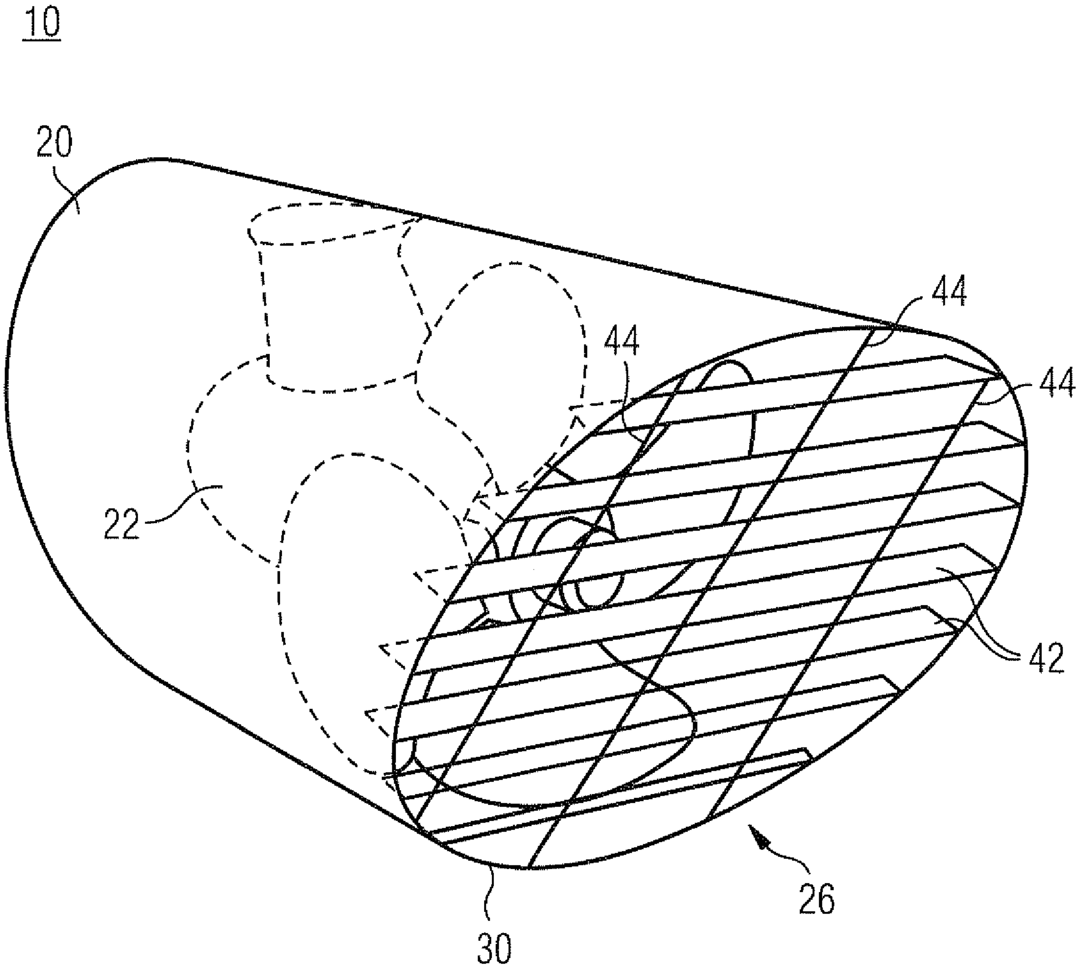


FIG 4



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EUROPEAN SEARCH REPORT

Application Number
EP 14 16 2417

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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X	US 3 008 443 A (KARL BLICKLE) 14 November 1961 (1961-11-14) * column 3, lines 6-42; figures *	1-15	
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TECHNICAL FIELDS SEARCHED (IPC)

B63H

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	23 July 2014	Vermeulen, Tom

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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