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(54) **EQUIPMENT FOR UTILIZE VARIOUS TYPES OF FLANGE MOUNTED ELECTRICAL MOTOR VARIANTS IN SELF-SUPPORTING STEERABLE STRUCTURE**

(57) Technical solution to utilize electrical motor variants in self-supporting steerable structure is presented.

Disclosure is presenting the technical solution of utilizing flange mounted main components to form a self-supporting structure, which allow utilization of wide range of existing components in the market and their use in the underwater steerable unit. When main elements of disclosure are connected to together, these create a dry-channel self-supporting L-shape or D-loop structure, with possibility to use different variants of the electric motor type or size, cooling, feedback or manufacturer at moist, wet or underwater conditions. Structure provides a possibility to have steering surface and steering control interfaces for utilization as ships propulsion or underwater power generation unit.

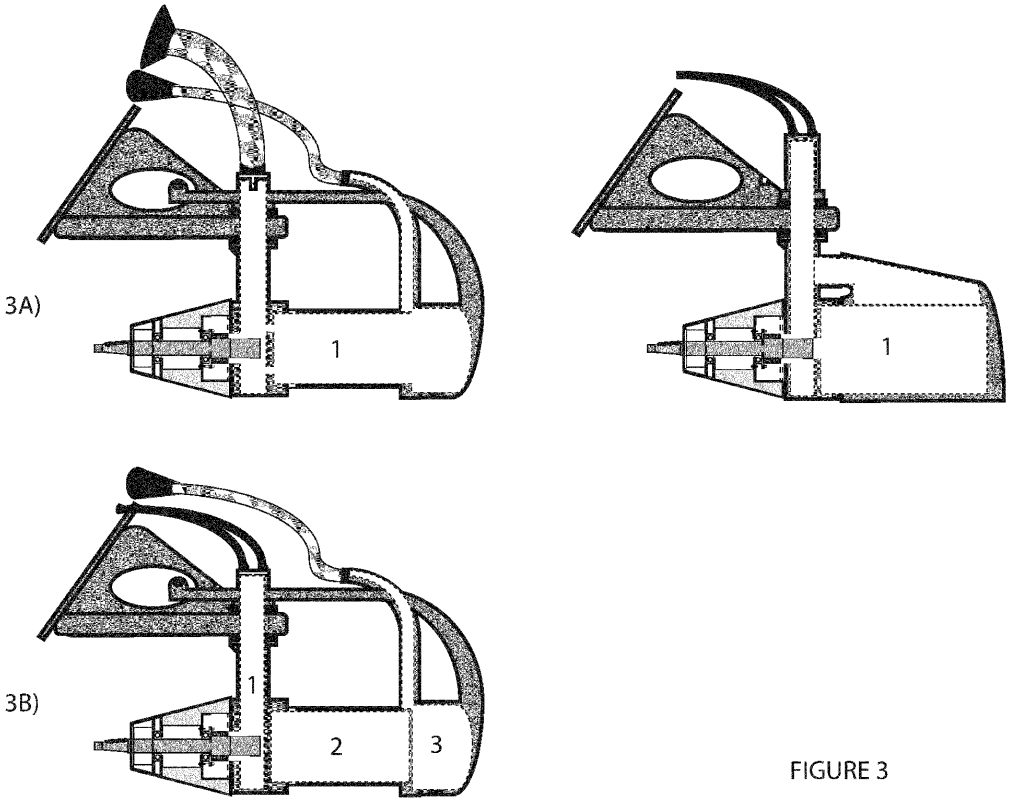


FIGURE 3

EP 3 992 074 A1

Description

Field of the disclosure

[0001] The disclosure concerns a an equipment for utilizing drive end flange mounted electrical motors, mainly referring to international mounting (IM) codes IM B5 (large flange mounting, also known IM 3001 mounting) and IM B14 (small flange mounting, also known IM 3601 mounting), but not limited to these, in a steerable application without strict need to use special formed electrical motor.

[0002] The disclosure may be used together with ship design including pulling propeller design with fixed pitch blades, in steerable underwater application.

[0003] The disclosure may be used together with underwater energy generation application, with reactive steering by water flow direction or by another steering application.

[0004] The disclosure may be used together with any other steerable electrical motor application in moist or wet conditions.

[0005] The disclosure may be used together with variable types of electric motors available on the market, with minor requirement to modify the industrial standard flange mounted motor design.

[0006] The disclosure may be used together with single or two bearing electrical motor designs.

[0007] The disclosure may be used in adaptive manner together with varying length and diameter of electrical motor, mainly considering drive end flange diameter up to SAE B5 M 660mm for frame size 315 electrical motors, but not limited to this, carried from the drive end flange. In case motor weight is drastically higher than propeller weight, the unit may be supported from non-drive end of motor with modifiable element, providing self-supporting installation against forces generated by ship movements and steering actions in the water.

[0008] The disclosure concerns a shafting between electrical motor and propeller.

[0009] Furthermore, the disclosure concerns utilization of flange mounted water-cooled, oil-cooled, oil-immersed or air-cooled electrical motor designs.

[0010] Furthermore, the disclosure concerns the motor and shaft support structure and equipment, which allows flange mounted electric motor dimension variants to be used with the same structural mounting interfaces and simultaneous control of the steering direction of the shaft while electrical motor is operated. Such variants may be in the motor length, diameter, weight, shaft end design, additional sealing systems, pressurization, cooling type or in-line reduction gear installation (also geared solution with full or hollow shaft are applicable).

[0011] Furthermore, the disclosure concerns steering element that is allowing variants to the motor dimensions and weight.

[0012] Furthermore, the disclosure concerns a structure, that is externally steered by steering system or by water movement.

Background

[0013] The specific background information provided in the description given below should not be construed as limiting the scope and/or the applicability of the appended claims:

1. Placing electrical motor directly onto the propeller shaft minimizes the number of moving parts, reduces transfer losses due to gearless operation and allows utilization of pulling propeller concept, which is considered one of the most efficient propeller utilization concepts.

2. Building an extended electrical motor shaft configuration, directly onto the propulsion electrical motor's rotor shaft for propeller connection, will require handling of the external forces by electrical motors bearings and additional thrust bearing for axial loads. From this point of view, the disclosure was designed with short middle shaft taking the forces and protecting the electrical motor outside the valuable active part.

3. Combination of pulling propeller concept and direct electrical motor on propeller shaft is considered one of the most efficient combinations to transfer energy from rotation to water, or vice versa.

4. This kind of installations are invented and are on the market. There are applications, where electrical motor is in-build inside of submersible propulsion or thruster unit ***(Publication*** US 3,791,331 FEB12 1974***. Publication*** US 2008/0293312 A1***, 10 Nov.27 2008.*** Publication US 9963212 B2, May8 2018***. Publication*** US 6692319 B2***, Feb.172004),*** formed to the *structure* ***(Publication*** KR 20070 111 883 A, Nov.22 2007***.)*** or exposed to water, but made to fit propulsor shape and desired propeller(s) performances by tailored motor design to match the particular power source and power control ***(Publication*** DE 102009033554A1, Jan.20 2011***. Patent*** 5923113, July 13, 1999***.).*** Common to these solutions is the need to utilize special shape and connection for electrical motor dedicated for the purpose (certain electrical motor shape only may be used in each model).

5. There are invented azimuthal steering systems that are on the market, for the electrical propulsion units. These steerable units are having dedicated steering unit at upper part the propulsion structures, which carries the weight of the unit, including electrical motor and delivers necessary cooling and power through the turning steering unit. ***(Publication*** 20020197918, Dec.26, 2002***. Patent*** 5947779,

Sept.7 1999. ***Publication*** EP0831026A, Mar.25, 1998***).*** Common to these solutions is to build propulsor unit as one-unit hull housing the special electric motor design matching the hull. In the disclosure the standard suitable electrical motor is protected with minimum size flange connected cover hood. Opposite to these publications, electric motor is not designed for certain propulsor hull, but the general hull is designed to accommodate the electric motor.

6. Common to solutions in above publications (3 and 4) is increased steering vertical shaft diameter and/or arrangement size in comparison to traditional rudder shafts. When propulsive power distribution to water and steering ability are combined, this increases weight and volume of the propulsive unit and its displacement reservation in ship. In case of faster ship types, this principle requires extensive structural strengthening for higher steering forces or in case of smaller ships, outcomes total weight of the system, which is high in correlation to the vessel displacement.

7. Possibility to choose electrical motor type and manufacturer according to operational reason or commercial reason has been firstly limited by the requirement to match the form required by the installation, and secondly by the complete electrical propulsion system design, which should to be compatible to made electrical motor and it's possible dedicated sensors ***(Patent*** 15 6431928, May 3, 2001***).*** In the disclosure the electrical motor selection is not limited to certain feedback sensor or manufacturer.

8. Standard electrical motor use for propulsion purpose has been possible in the installation inside the vessel ***(Publication*** US 8,556,668 B2, Oct.15 2013***)*** or equivalent dry area limited out-side the water, from where the energy is transferred to water by means of variable methods. In the disclosure the electrical motor shafting to propeller is made in the underwater part by short middle shaft pointing forward. There it has roller bearings for rotational forces and two-direction thrust bearing protection against axial forced between propeller and electrical motor shaft. This installation allows utilization of the pulling propeller, without corner gears and in very weight-wise efficient manner.

9. When electrical motor is installed into the pulling propeller thruster application, at least limited steering-ability is usually required from the installation according to vessel type and operational requirements. Reference may be done with outboard boat motors which are widely used in the leisure boating. There the limited steering angle of propulsor is widely accepted manner of navigation. Electrical outboard propulsion version is available on the market ***(Publication*** US 2008/0293312 A1***, Nov.272008).*** Installation may also include fixed electrical motor and steering by means of traditional rudder or electrical motor installation inside the rudder ***(Publication*** KR101256240B1, Apr.23 2013***)*** In the disclosure the basic features of it (pulling propeller by electrical motor with flange connection and short middle shaft) differentiate it from the published solutions.

10. When electrical motor is installed into the underwater power production application, at least limited steering-ability is required from the installation according to water flow current direction. Installation direction and the height of the unit may require installation on the seabed ***(Publication*** KR20140034818A1, Mar.20, 2014***.)*** **or** under the floating element ***(Publication*** US20110101697A1, May 5, 2011***)*** or onto fixed surface, like ship, rig, barge, pier or other constructed structure.

Summary

[0014] The following presents a simplified summary of the invention embodiment.

[0015] The summary is not an extensive overview of the invention. It is neither intended to identify all key or critical elements of the invention nor to delineate the scope of the invention. The following summary merely presents the invention in a simplified form as a prelude to a more detailed description of exemplifying embodiments of the invention.

[0016] Disclosure is presenting main components connected in one or two ends of electrical motor. When connected to together in assembly order (figure 1), these create a L- or D-shape, self-supporting structure, with possibility to use different variants of the electric motor type or size, within the limits defined by the design.

[0017] ***Figure 1.*** Electrical motor is selected (line A, two types presented). Motor is flange mounted (line B) to *the DE channel piece,* which is providing standard SAE flange interface. *NDE channel piece* is flange connected (line C, long and short motor design presented). Depending the motor dimensions and forces defined by the vessel operation, this may be connected either directly to *motor stator frame* or to the *DE channel piece* as a cover hood and routing for main cables. In more demanding installations, *rudder element* (line D left) is separately flange connected to *NDE channel piece.* This is made to the correct dimensions and spring loaded downwards (line E left) and locked to *DE channel piece* by welding. Element forms a steering lever distributor for external steering pistons or wire. In smaller units the steering lever may be connected onto the *DE Channel pipe. Propeller shaft unit* is applied on the forward side, utilizing flange connection to DE channel piece and accommodates shaft connection according to motor design.

FIGURE 1

[0018] This self-supporting L-shape or D-loop is installed through the ship's hull connector or directly through ship's hull structure. This penetration interface requires to be designed against pending forces, weight carrying and lifting forces. The said L-shape or D-loop is steerable by external steering manners familiar from traditional rudder steering or from outboard motor steering (figure 2 presenting available steering angles for D-shape unit). *Connection pieces* (WHITE) are welded to strengthen the *Rudder element* and to join *DE channel piece* to *Rudder element* with sufficient welding contact for spring force and sufficient vertical surface for steering both elements by same steering movement. Length L defines the steering lever and allows steering force minimization.

[0019] Electric motor flange connections and protection hood flange, motor stator frame ends or electric motors end shields of said D-loop are made watertight by means of usual ship-building methods, such as sealed bolted flange connections (fine machined surfaces, O-rings and sealing material, tighten in design torque). From propeller direction, unit is water-tight by shaft sealing lip systems. For the additional safety against leakage, unit may be monitored by level switches and suction pipes or pressurized.

[0020] Said L-frame and D-loop may be utilized as a single confined space when electrical motor end shields are having openings, as presented in the figure 3A. This could be the case when air forced cooling is required for the electrical motor cooling. In case electrical motor end shields are closed and additional shaft sealing is considered, the D-loop contains three main spaces, as presented in the figure 3B. Cable connection, cooling piping/flexible piping and sensor wiring to the ship and cooling media distribution to/from ship are made via the channels provided by said "DE channel piece" and said "NDE channel piece".

FIGURE 3

Brief description of the figures

[0021] Exemplifying and non-limiting embodiments of the invention and their advantages are explained in greater detail below in the sense of examples and with reference to the accompanying drawings, in which:

Figure 4A presents steering options and connection pieces (1) and (2) for said D-frame.

- Steering by wire or by steering pistons is made connection steering force onto the tensioned and strengthened *Rudder element*. This has lever arm length (Ls) to steer the unit by turning from the Rudder elements end. Required steering force is delivered to *DE channel pipe* (10) by means of *Connection piece (1)*.
- Ship design and selected electric motor defines the required height of the *DE channel pipe* (10) below and under the connection point to the *ship's hull* (A). Propeller position defining *Shoulder* (9) is welded to the correct level. Between *ship's hull* (A) and *Shoulder (9), lower slide bearing* (8) is used to carry load hits upwards. Above the *ship's hull* (A), the *upper slide bearing* (7) is carrying the unit weight against the hull and acting as support bearing against pending forces. Unit is locked on the height position by *Propulsor nut* (5) and *washer ring* (6). *Propulsor nut* (5) is tightened to the design torque and welded in place. Then *DE channel pipe* (10) is cut from *excess height* (3) and *slot* (4) for the *connection piece* (1) is sawed. Final assembly stage is to weld the *connection piece* (1) around, to slot and on top of Rudder element.
- Installation for steering motors interface follows the same pattern. *Connection piece* (2) is designed to carry steering loads from steering motors to slot and to the Rudder element.

Figure 4B presents steering option and steering piece (1) for said L-frame. As the DE channel piece is sole route for main cabling, cooling and signal wiring, the steering gear type of rudder control is not feasible. Interface for cables, cooling and signal wires (13) is the second flange connection for the *Cover hood.* Form, shape and diameter may be altered according to need.

Figure 5 presents installation for Electrical motor type A, where air cooled type induction motor (1) is selected. Motor is of length L1 and of diameter d1. Motor is equipped with forced air-cooling blower (2) that is in the NDE shaft end. As the forced cooling is serving for zero speed operation also it is kept, but fan cover (3) is removed for the installation. Forced cooling dimensioning may be reduced, as the surrounding water acts efficiently as general cooling media.

[0022] Motor (1) is connected to *DE channel pipe* flange connection (6) with bolted connection. Flange water tightness is secured by O-ring and sealing silicone. Propeller side of the *DE channel pipe* flange (5) is prepared for the shaft lip sealing system and shaft protect elements. Air space inside *DE channel pipe* may be pressurized against leakage, through *Connection piece* (10).

[0023] Non-drive end (NDE) of the motor is connected to the NDE Channel piece (7) utilizing the connection location of the fan cover (3) and additional bolting. Motor cables, that are coming from NDE, above Cooling air blower (2) are guided to the channel pipe (11) from where they are led to the ships side via watertight flexible ducting. Cooling air is either delivered through this pipe (11)

or through the DE channel unit pipe (4), from where this is ducted to the vessel side through the connection piece (10). Forced air fan may be located also on the ship side.

[0024] *NDE-support element with rudder surface* is bolt connected onto the rudder side flange (9) interface of the NDE channel piece. Form and rudder steering surface may be modifiable according to the application and strength dimensioning of the installation.

[0025] **Figure** 6 presents installation for Electrical motor type B, where water-jacket cooled type permanent magnet synchronous motor (12) is selected.

[0026] Motor is of length L2 and of diameter d2. Motor is equipped with cooling water plugs (13) that are in the stator frame. Additional thrust 5 bearing element (14) is added.

[0027] As the water-jacket cooling is serving for zero speed operation also, it is kept, but heat transfer dimensioning may be reduced, as the surrounding water acts efficiently as general cooling media. Motor (12) is connected to *DE channel pipe* (15) flange connection with bolted connection. Direction of bolting is from the propeller side, as the electrical motor diameter d2 is very close to counter flange side. Flange water tightness is secured by O-ring and sealing silicone.

[0028] Propeller side of the *DE channel pipe* (15) flange is prepared for the shaft lip sealing system and shaft protect elements. Air space inside *DE channel pipe* may be pressurized against leakage, through *Connection piece (17).*

[0029] DE channel pipe (15) has two additional bushings (16) for cooling water circulation that is done from the vessel side. Motor cooling circuit is connected to these and protected with hydrodynamically shaped cover.

[0030] Non-drive end (NDE) of the motor is connected to the NDE Channel piece (19) utilizing the connections in the thrust bearing element (14). Motor cabling, that is coming from NDE, above thrust bearing is guided to the channel pipe (19) from where they are led to the ships side via watertight flexible ducting.

[0031] *NDE-support element with rudder surface* is bolt connected onto the rudder side flange interface of the NDE channel piece. Form and rudder steering surface may be modifiable according to the application and strength dimensioning of the installation. On the top of the unit, Connection piece (17) is welded onto the position 20 slot of the *DE Channel pipe* (15). Welding seam is made around the piece and onto the full distance, both sides and end, across *NDE sup-port element* (20). Strengthening bars (18) are added onto *NDE support element* (20). Welding seam is made full distance, both sides and end, across the *NDE support element* (20).

[0032] **Figure** 7 presents the connection of the *Propeller cone* (1), including the *propeller shaft* (2) and propeller connection interface (3). Shaft end (motor end) is designed according to electrical motor shaft, either cylindrical with key(s) or DIN Spline, which are providing practical installation possibilities. There is sufficient axial clearance in the joint, which prevents propeller axial forces to be delivered from *Propeller Cone* to electric motor rotor. Shaft is supported by roller bearings (4) and axial movements are transferred to structure by two-directional thrust bearings (5), which also holds the shaft and propeller from moving in either axial direction. Propeller end is designed according to standard propeller connection (6) options.

[0033] Water tightness is secured by shaft mechanical sealing (7), which may include emergency inflatable element. Leakage to the structure may be measured from unit bilge (8) by level sensors and by suction pipes. Propeller cone connected to DE Channel piece by bolting on the flange connection, which has O-rings (9).

[0034] **Figure 8** presents underwater power generation installations options, which are demonstrating the possibility to install steerable unit standing up or hanging down, keeping the steering ability according to self-guided orientation to the water flow.

Description of the exemplifying embodiments

[0035] The specific examples provided in the description given below should not be construed as limiting the scope and/or the applicability of the appended claims. Lists and groups of examples provided in the description given below are not exhaustive unless otherwise explicitly stated.

Example 1: Ship's, barge, rig or boats propulsion unit application

Example 2: Part of ship's, barge, rig or boats propulsion system

Example 3: Power generation, subsea current power station

Example 4: Power generation, river current energy power station

Example 5: Power generation, tide or wave energy power station

Example 6: Power generation, bridge integrated underwater element including power generation

Example 7: Autonomous unit or Remotely operated vehicle (ROV) propulsion

Example 8: Part of turn-able or retractable thruster arrangement, such as in tender boats, where propulsion is lifted when tender boat is put in storage inside the main vessel or in river boats when shallow water operation is required

Abstract of the disclosure:

[0036] Technical solution to utilize electrical motor variants in self-supporting steerable structure is presented.
[0037] Disclosure is presenting the technical solution of utilizing flange mounted main components to form a self-supporting structure, which allow utilization of wide range of existing components in the market and their use in the underwater steerable unit. When main elements of disclosure are connected to together, these create a dry-channel self-supporting L-shape or D-loop structure, with possibility to use different variants of the electric motor type or size, cooling, feedback or manufacturer at moist, wet or underwater conditions. Structure provides a possibility to have steering surface and steering control interfaces for utilization as ships propulsion or underwater power generation unit.
[0038] The figure proposed to be presented with the abstract: Figure 3.

List of reference publications, in the order of appearance:

[0039]

1. Publication US 3791331 FEB12 1974.
2. Publication US 2008/0293312 A1, Nov.27 2008
3. Publication KR101256240B1, April 23 2013
4. Publication US 9963212 B2, May8 2018
5. Publication US 6692319 B2, Feb.17 2004
6. Publication KR 20070 111 883 A, Nov.22 2007
7. Publication DE102009033554A1, Jan.20 2011
8. Patent 5923113, July 13, 1999.
9. Publication 20020197918, Dec.26, 2002
10. Patent 5947779, Sept.7, 1999
11. Publication EP0831026A2, Mar. 25 1998
12. Patent 6431928, May 3, 2001
13. Publication US 8556668 B2, Oct.15 2013
14. Publication KR20140034818A1, Mar.20, 2014
15. Publication US20110101697A1, May 5, 2011

Claims

1. Technical solution providing a possibility to utilize variants of flange mounted electric motors in underwater steerable application.

2. Technical solution of utilizing self-supporting flange installation to provide dry channel individually to both ends of underwater steerable electric motor.

3. Technical solution to utilize short axial force distribution preventing middle shafting arrangement between pulling propeller and electrical propulsion motor.

4. Utilization of electrical motors stator frame as a part of self-supporting and tensioned structure in steerable underwater applications.

5. Technical solution to join flange connected parts to form a propulsion unit with steering ability.

6. Technical solution of utilizing self-supporting flange installation of electric motor to provide vertical shaft installation for collecting wave or tide energy.

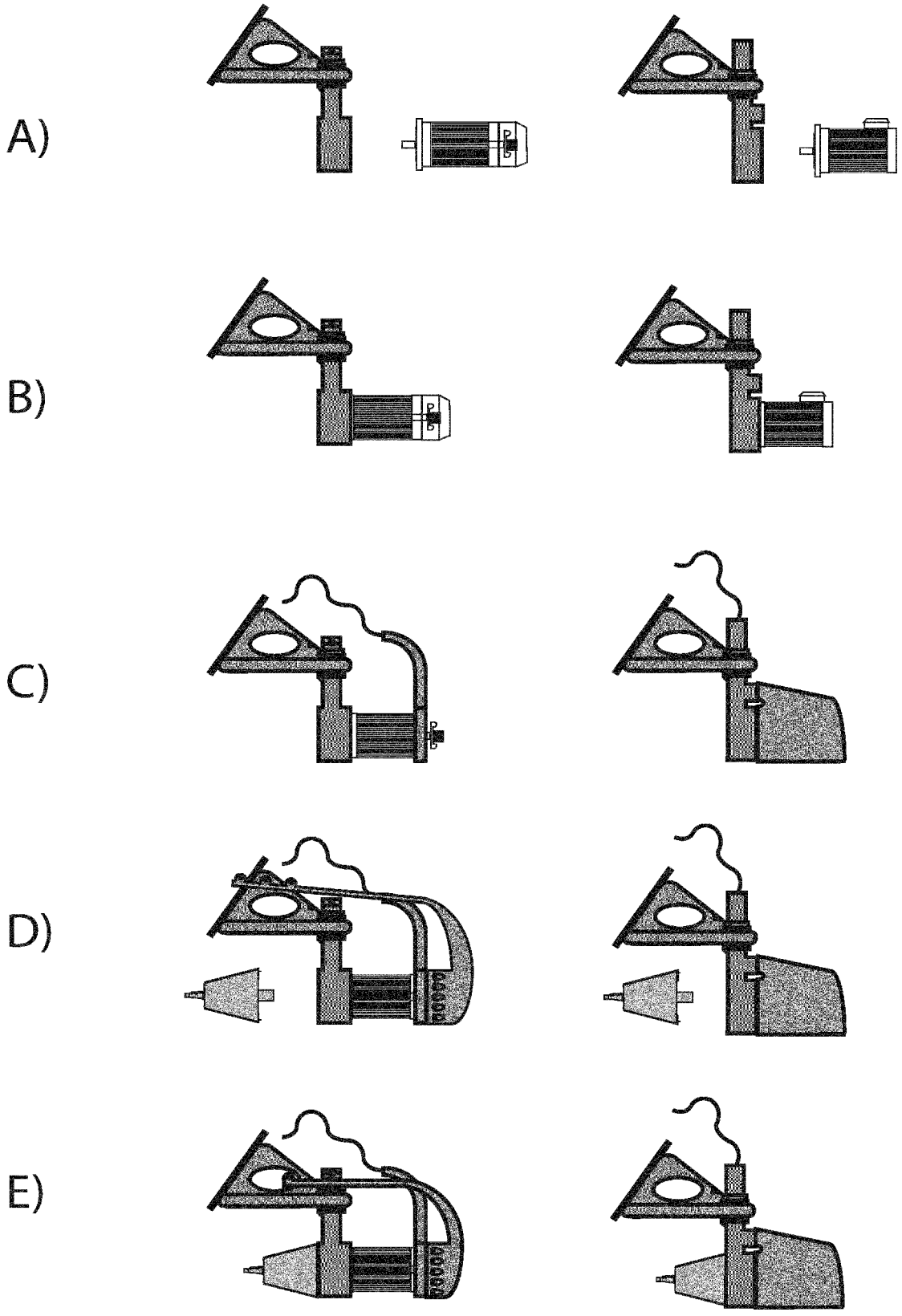


FIGURE 1
Equipment for utilize various types of flange mounted electrical motor variants in self-supporting steerable structure.

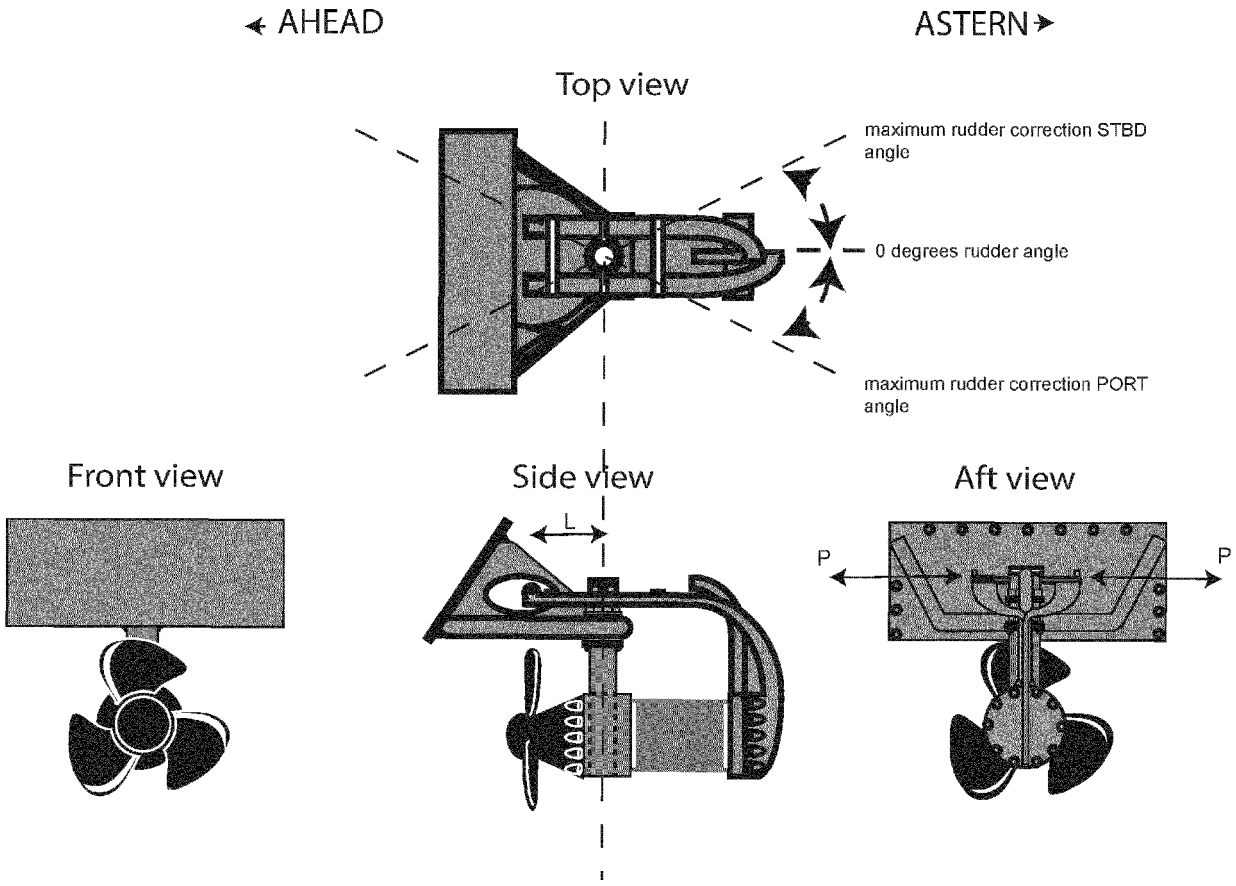
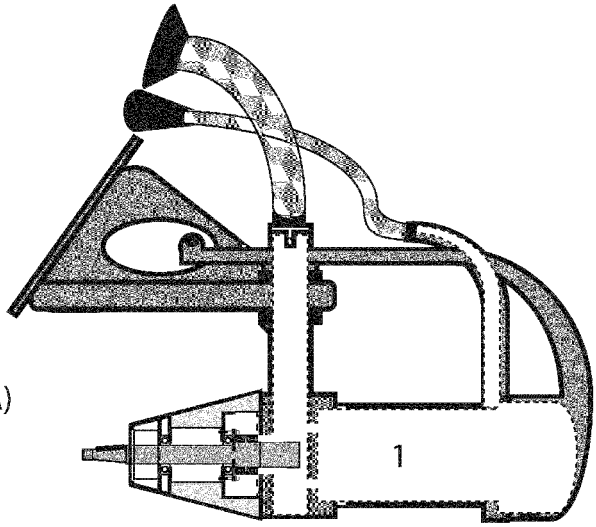
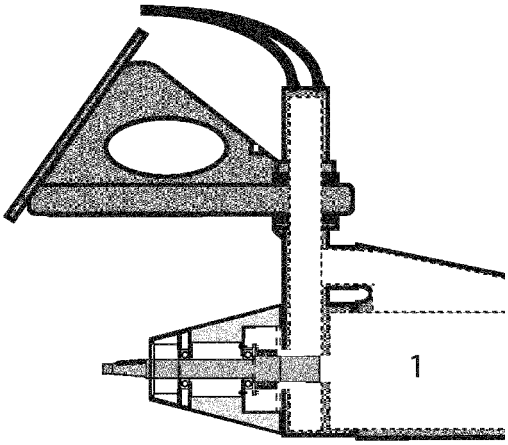


Figure 2:
(BLUE) Connection to ships hull
(BLACK) Propeller arrangement
(GREY) DE channel piece
(BEIGE) NDE channel piece and Rudder element
(WHITE) Connection pieces to form a D-loop
(GREEN) Electrical motor
(P) Connection point for external steering (for example ydraulic cylinder or wire)
(L) Steering lever arm distance

3A)





3B)

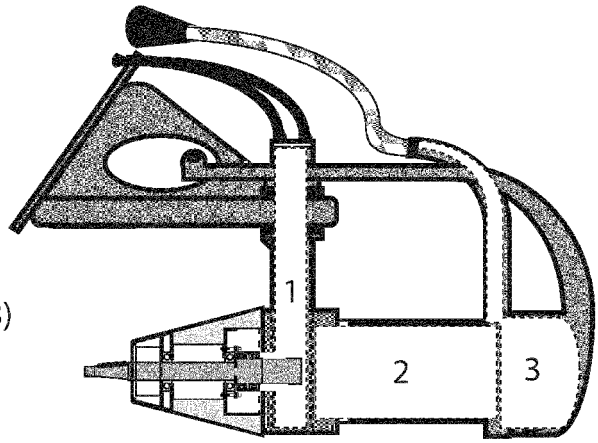


FIGURE 3

FIGURE 4A

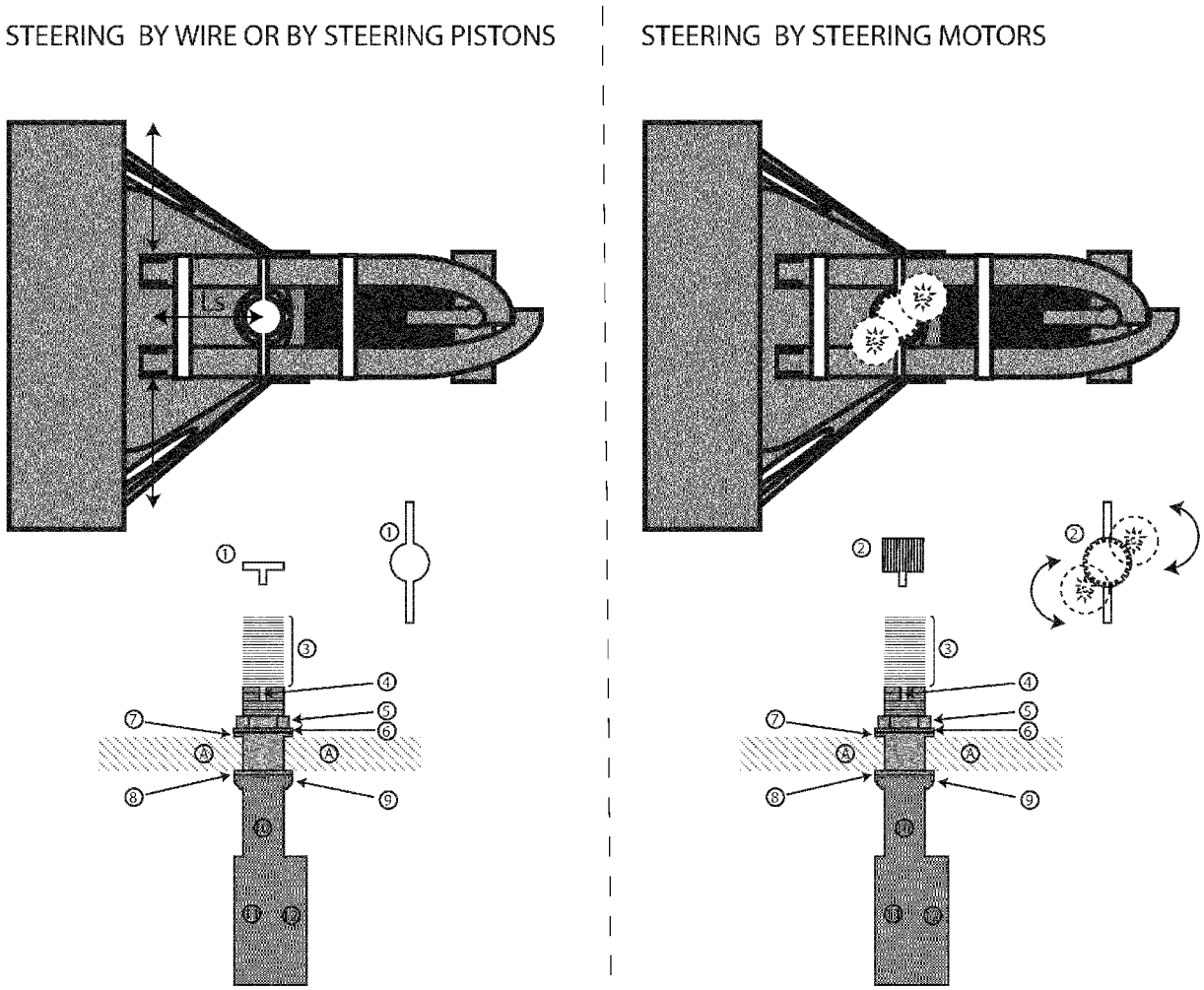

STEERING BY WIRE OR BY STEERING PISTONS
STEERING BY STEERING MOTORS
LS

FIGURE 4B

STEERING BY WIRE OR BY STEERING PISTONS

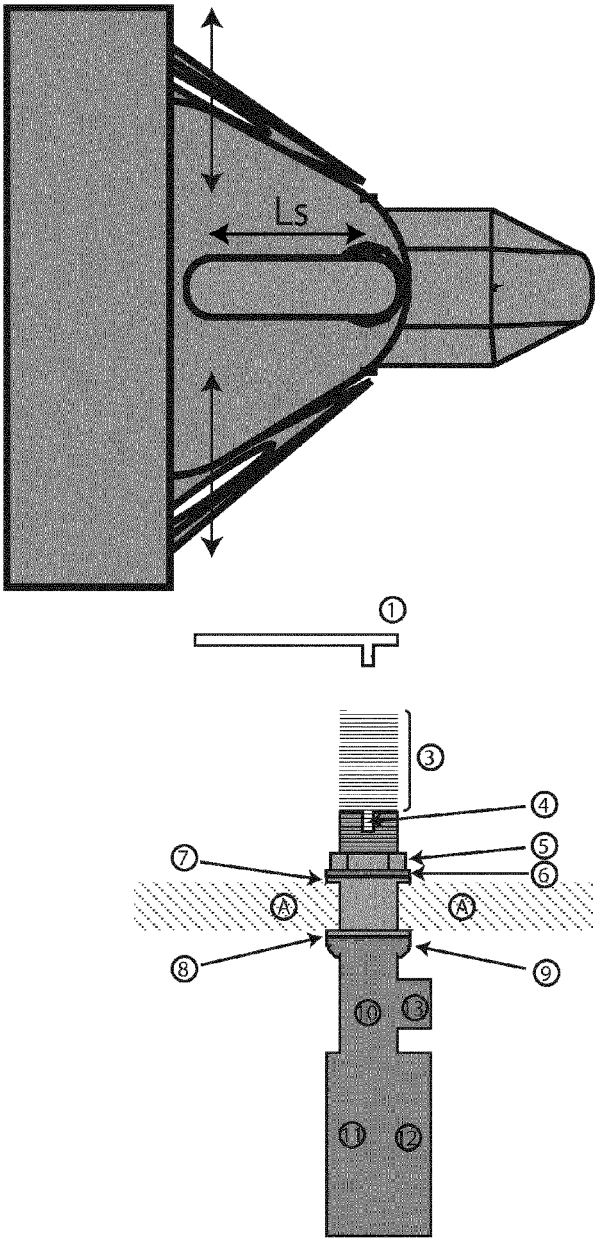


FIGURE 5

INSTALLATION MOTOR TYPE A:

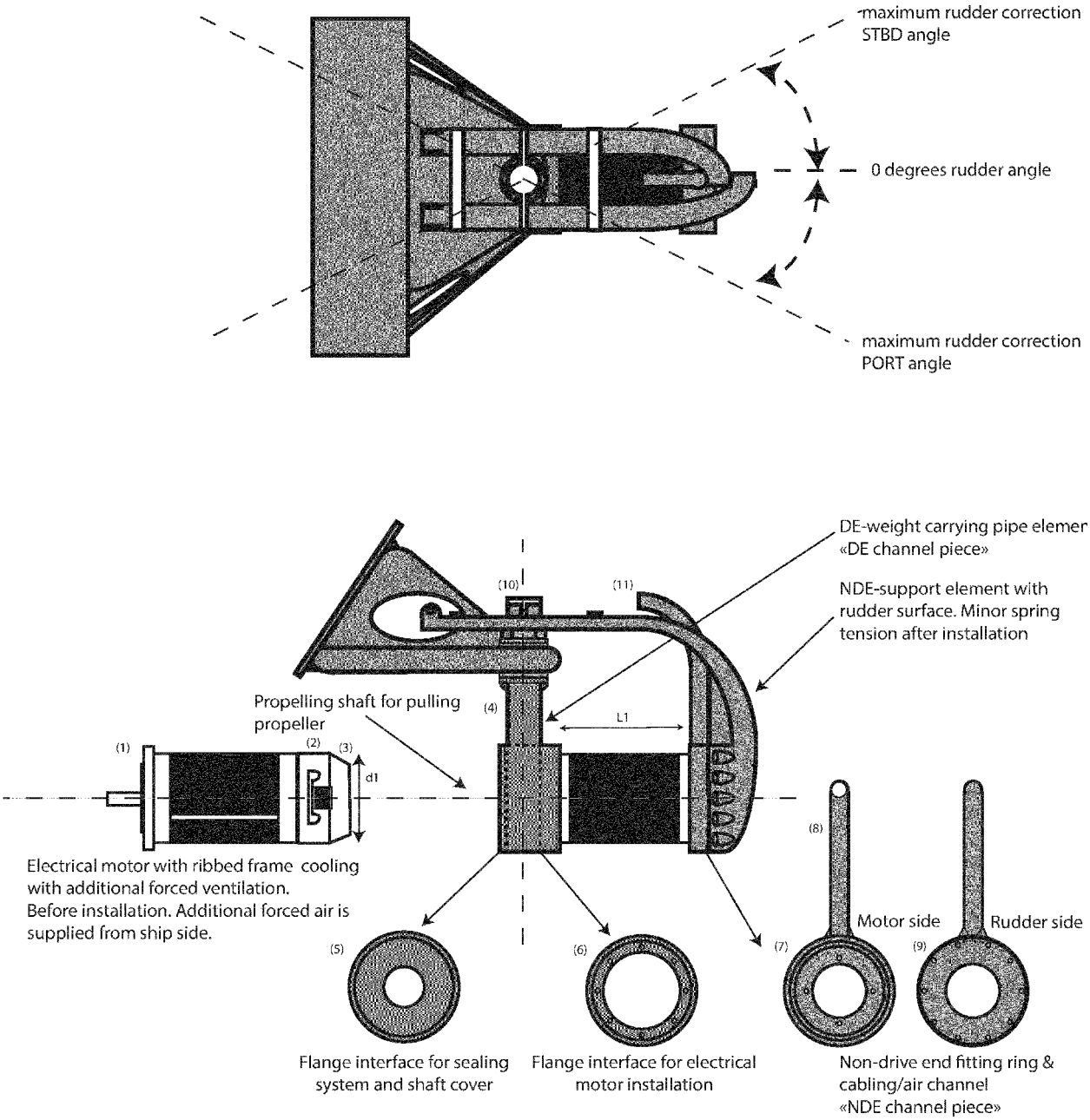
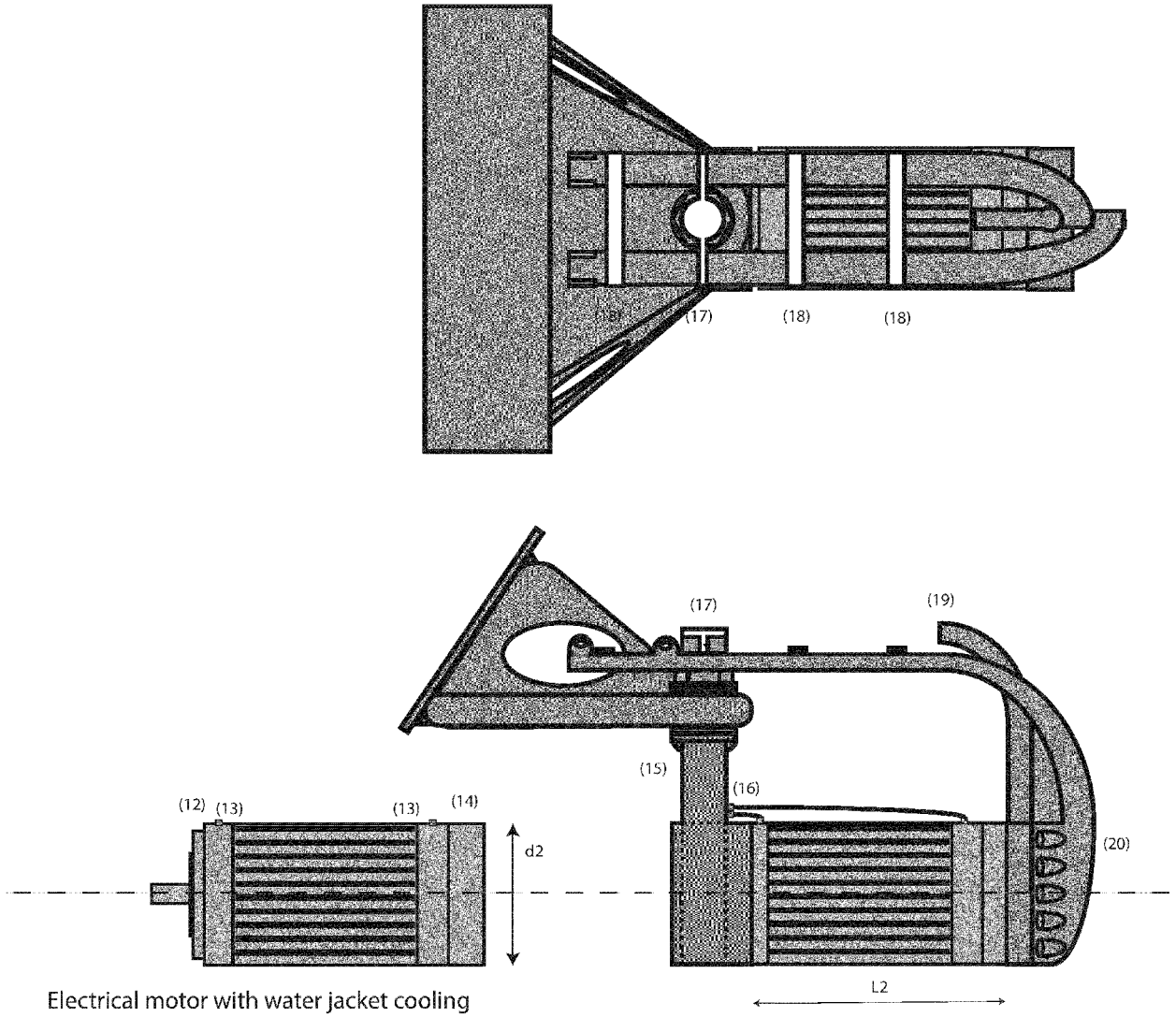


FIGURE 6

INSTALLATION MOTOR TYPE B:



Electrical motor with water jacket cooling and additional thrust bearing.
Before installation. Required minimum cooling water flow is prodived from ship side.

Figure 7

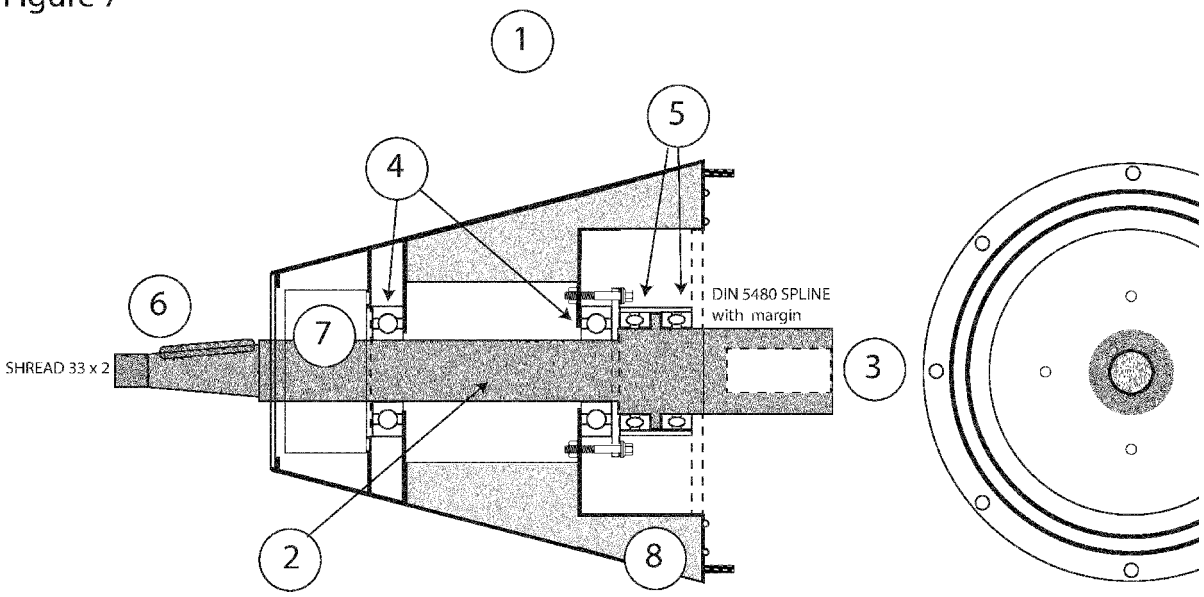
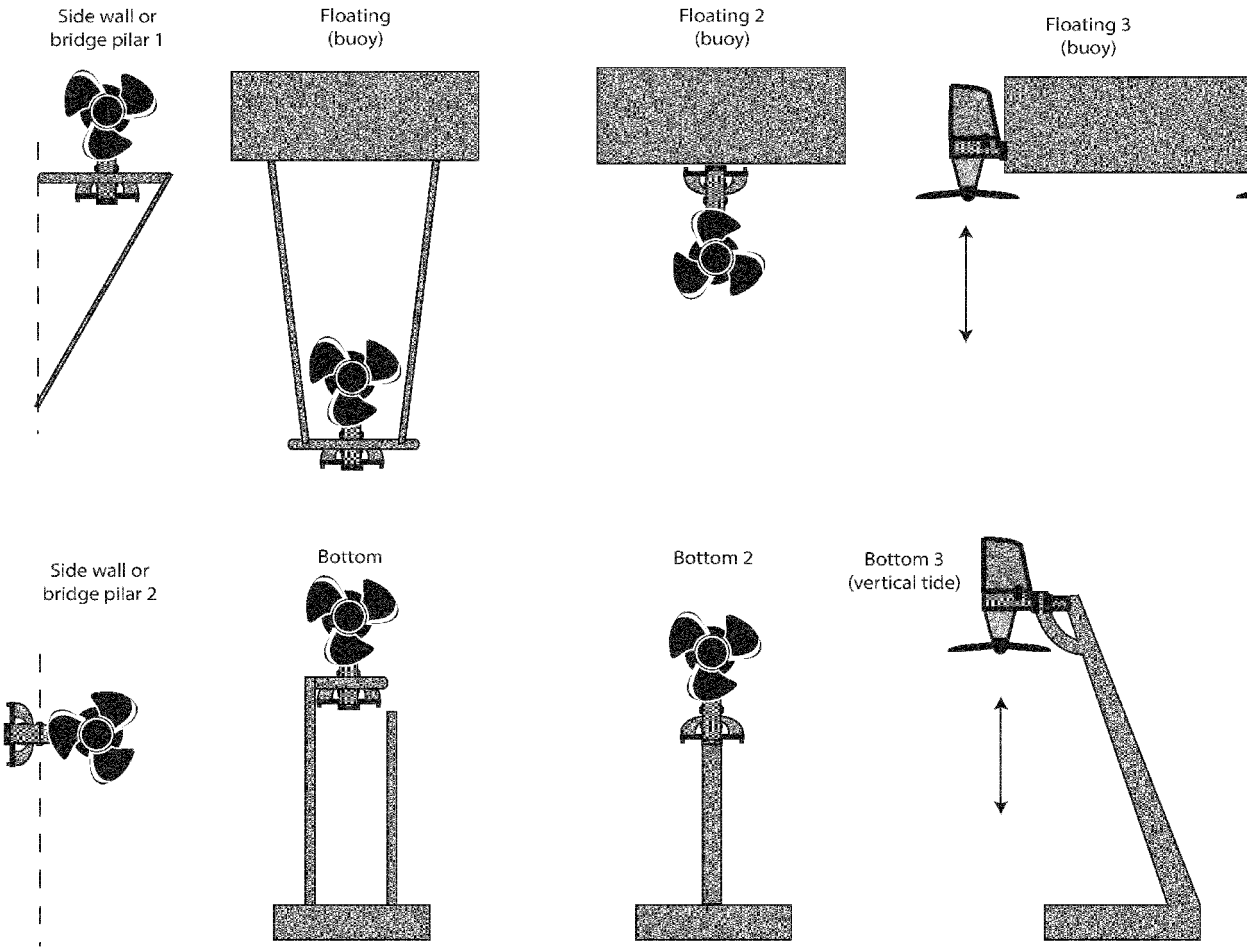

1
5
4
6
7
DIN 5480 SPLINE
with margin
SHREAD 33 x 2
3
2
8
Side view
View from DE Char

Figure 8


Side wall or bridge pilar 1
Floating (buoy)
Floating 2 (buoy)
Floating 3 (buoy)
Side wall or bridge pilar 2
Bottom
Bottom 2
Bottom 3 (vertical tide)

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PARTIAL EUROPEAN SEARCH REPORT

under Rule 62a and/or 63 of the European Patent Convention. This report shall be considered, for the purposes of subsequent proceedings, as the European search report

Application Number
EP 20 02 0500

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 5 445 545 A (DRAPER RANDAL K [US]) 29 August 1995 (1995-08-29) * claims; figures *	1	INV. B63H20/32 B63H21/17
X	WO 01/54973 A1 (ABB AZIPOD OY [FI]; VARIS JUKKA [FI]) 2 August 2001 (2001-08-02) * claim 8; figure 1 *	1	
X	WO 01/54972 A1 (ABB AZIPOD OY [FI]; VARIS JUKKA [FI]) 2 August 2001 (2001-08-02) * claims; figures 1-3 *	1	
X	US 2 429 774 A (SCHULTZ GEORGE E ET AL) 28 October 1947 (1947-10-28) * figure 1 *	1	
X	US 3 954 082 A (ROLLER WILLIAM G ET AL) 4 May 1976 (1976-05-04) * figure 2 *	1	
			TECHNICAL FIELDS SEARCHED (IPC)
			B63H

INCOMPLETE SEARCH

The Search Division considers that the present application, or one or more of its claims, does/do not comply with the EPC so that only a partial search (R.62a, 63) has been carried out.

Claims searched completely :

Claims searched incompletely :

Claims not searched :

Reason for the limitation of the search:

see sheet C

Place of search	Date of completion of the search	Examiner
The Hague	27 May 2021	Knoflacher, Nikolaus

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
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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

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INCOMPLETE SEARCH
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Application Number
EP 20 02 0500

Claim(s) completely searchable:
1

Claim(s) not searched:
2-6

Reason for the limitation of the search:

The subject-matter of claims 2-6 so unclear (Article 84 EPC) that it cannot be searched.

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 20 02 0500

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27-05-2021

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