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(54) MOBILE ELECTROMAGNETIC MOORING SYSTEM FOR SERVICE VESSELS

(57) The invention relates to a Mobile Electromagnetic Mooring System consisting of a set of at least two electromagnetic grippers, powered by floating power buoys, connected with mooring lines to a set of at least two mooring winches located respectively on the bow and the stern of the ship, respectively, ensuring controlled constant tension on the mooring lines and allowing the free movement of an intervention vessel moored to a larger vessel along its side, The Mobile Electromagnetic Mooring System controlled by the intervention/service unit system is designed to fit a small intervention/service vessel which moors to the sides of larger vessels requiring intervention for repair, servicing, or transfer of cargo or people, without the need to involve a large number of crew members, and to significantly increase the level of safety of the crew by relocating a mooring point to the waterline during mooring operations. The invention allows a smaller intervention vessel moored to a larger vessel to move freely along its side without the need for interference by a crew of the serviced vessel,

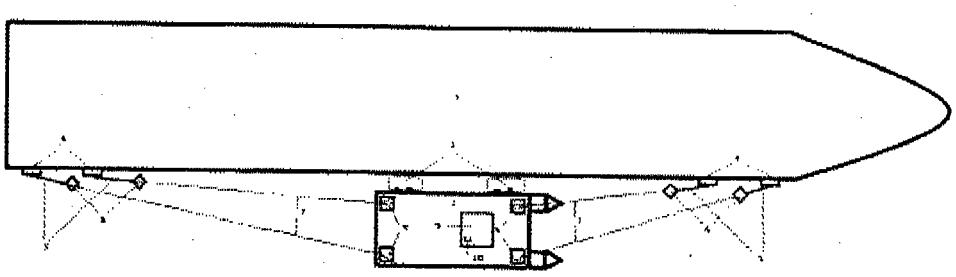

Fig. 1.

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Description

[0001] The invention relates to a Mobile Electromagnetic Mooring System for small watercraft, consisting of a set of at least two electromagnetic grippers, powered by floating power supply buoys, connected by mooring lines to a set of at least two mooring winches located on the bow and stern of the ship, respectively, ensuring controlled constant tension on the mooring lines and allowing for the free movement of an intervention/service vessel moored to a larger vessel along its side. The Mobile Electromagnetic Mooring System controlled by the intervention/service unit system is designed to fit a small intervention/service vessel that moors to the sides of larger vessels requiring intervention for repair, servicing, or the transfer of cargo or people, without the need to involve a large number of crew members during mooring operations.

[0002] Every type of ship must have appropriate mooring systems that, following the shutdown of its propulsion at the end of a voyage, allow it to be moored in order not to be exposed to the dangers associated with the negative influence of external factors, i.e., wind, water currents, and waves. Mooring systems secure the ship at the quay, its fixed and/or movable jetty, terminal, or loading berth in the port, or in the case of another ship, another fixed, mobile, or loading installation located on the shore, in an offshore sector, or a water basin, as in the solution according to the invention.

[0003] There are currently various systems and technical devices in used for mooring vessels, including single-point mooring systems implemented with a single mooring, tandem systems, mooring and transfer installations based on telescopic gangways with a single mooring point, bottom mooring and loading systems, and traditional multi-point mooring systems. There are also different systems used for mooring one ship to the stern and/or the side of another ship in the ship-to-ship (STS) system, implemented based on flexible connections with mooring lines (natural, synthetic, steel, and/or a combination) or based on rigid connections (e.g., mechanical connections of a barge with a pusher-type tug, connection of a Hiload DP1 unit with a tanker using the so-called Remora-type hydrostatic bottom suction, or connection of two ships with the use of electromagnetic mooring systems) [1].

[0004] The effectiveness of these mooring systems will always be demonstrated by their reliability and their resistance to breaking forces resulting from the impact of unfavourable external factors such as wind, tides, tidal currents, water waves, and the related vertical and horizontal oscillations of ships moving on a wave, usually different for ships of various sizes, the influence of disturbing hydrodynamic forces generated by the propellers of other ships passing in close proximity to the vessel, the ship's trim, it's draft and freeboard height, and thus also different angles of the so-called "looking" and "bending" of traditional mooring lines used in the STS mooring system, In practice, however, due to variable loads, it is recommended to avoid mixed mooring techniques that use different types and categories of ropes, as this may cause uneven and/or excessive load on individual ropes, leading to their breakage and uncontrolled disconnection of previously moored vessels, exposing these vessels and their crews to danger [2].

[0005] In this respect, the issue of mooring a small intervention/service unit to the side of another ship with a very high freeboard becomes particularly dangerous. In such a situation the lines are usually directed at a very large vertical angle upwards from the service watercraft to the mooring bollards situated on the main deck of the serviced vessel, usually, a larger, longer vessel with a high freeboard, to which other vessels need to moor. Such a situation limits the correct distribution of the forces keeping the intervention/service unit at a stable mooring position at the side of the serviced vessel, exposing it, especially in the event of unfavourable hydrometeorological conditions in the area of work, to uncontrolled longitudinal and transverse displacements with dynamic oscillations of the ship on the wave and dynamic impacts of its hull against the larger serviced vessel.

[0006] An additional problem that arises in the case of an intervention/service unit performing underwater works due to damage to the serviced ship is the propulsion, which must always remain turned off for both the intervention/service unit and the serviced vessel. The propulsion on both units must be secured against any unwanted activation at least for the duration of time when divers are underwater and could be exposed to the associated dangers of injury or death. Therefore, such ships cannot support their mooring position by dynamic positioning (at a given position and/or course) using ship propellers. Of course, such practices are necessary to maintain the required safety procedures when performing underwater works. Therefore, the correct mooring of two ships side to side with the propulsors and water-jet propellers turned off is in this case crucial for the safety of divers below the water's surface. Approximately 300 people have died every year in accidents related to ship mooring. 95% of such accidents are directly related to the mooring lines, and 60% are related to the sudden release of energy stored in the extended mooring line, which returns to its original length during breaking and the ends of the ropes retract in the direction where they were secured [3].

[0007] Therefore, mooring two ships of different and/or similar dimensions for transhipment and/or service always requires special techniques and extreme caution to ultimately avoid damage to the units throughout the approach or breakage of the lines due to excessive loads during their securing. Such mooring can be done in three ways: (a) in port, using the so-called double berth, where one of the ships is already berthed to the quay and the other is moored to its outer side on the side opposite from the quay, (b) at anchorage, when one of the ships is at anchor and the other is approaching and mooring to the ship already anchored, (c) when mooring operations are

being carried out when both ships are in motion in the water and/or over the ground (drifting).

[0008] The mooring arrangement depends on the size of the ships involved in the planned mooring operations. A manoeuvring vessel shall approach a vessel at anchor or when drifting and maintain a steady course with the smallest possible approach angle. The approach area is normally behind the traverse of the vessel approached by the manoeuvring unit. As the manoeuvring vessel approaches, it steers a course parallel to that of the other vessel and reduces the horizontal distance between the vessels. After reaching the appropriate distance, the manoeuvring vessel uses the motions of the engine and rudder to reduce the distance smoothly and with the lowest possible speed, until the fenders located on their sides come into contact. Thus, the two ships connect in parallel and the ropes pass according to the mooring plan. It is a very difficult and demanding operation for both the person manoeuvring the vessel and the crews of each unit responsible for the quick and safe mooring of such ships.

[0009] The currently proposed mooring systems, in particular with regard to small intervention, diving, service and cargo or people transfer units where it is also crucial to perform underwater repair works, pose many problems, including: (a) they increase the risk of the mooring breaking or sliding off, which may result in serious injury or death to crew members; (b) they cause a high angle of the mooring lines directed upwards to the main deck of the serviced mothership with high freeboard, which has a significant impact on the level of stresses and breaking forces (loads) generated there, and in combination with unfavourable hydrometeorological conditions (e.g. strong wind, current and sea wave) may cause significant mutual vertical and horizontal oscillations of both units with dynamic impacts of the intervention/service unit against the serviced hull with the possibility of breaking the mooring lines and drifting of the previously moored unit; (c) the prolonged time of the required emergency response usually increases the risk of more serious consequences of an accident, e.g., in the event of a dangerous cargo leak from damaged bottom tanks. The fast mooring and movement of an intervention/service vessel along the side of a ship in need (e.g., to locate damage) is usually time-consuming, and in emergencies, every minute counts, especially in the case of ships with damaged hull plating. There is also the necessity to engage many people from the crews of both involved vessels in the mooring, unmooring, and moving the intervention/service watercraft along the side of the serviced ship. During an accident, the crew of a damaged ship is usually involved in performing other tasks related to the breakdown, performing other official duties, including saving lives and property. On the other hand, the process of mooring and moving the intervention/service unit alongside the serviced ship is very time-consuming and requires the involvement of a few additional people on the serviced ship and the intervention unit. This issue has not been fully resolved to date.

[0010] Patent description PL232697 describes a known device for mooring a watercraft, which is a fender with a front panel containing at least one electromagnetic module connected to the electric power supply of this module, the front panel having elements for fixing the panel to the berth which include shock-absorbers. This device is both a mooring device and a fender.

[0011] The description of the utility model Ru.59099 details a floating object mooring device in the form of a pivoting arm, consisting of a catch and a cooperating mooring cylinder to which the piston rod is attached. The solution enables quick and reliable fixing of the mooring vessel relative to the quay. These are large-size port facilities and cannot be used in ship-to-ship operations.

[0012] Three known solutions use the electromagnetic mooring arms disclosed in patent descriptions: EP2844542, CN108674582, and WO2012060511. However, the main disadvantages of the above-mentioned systems are, on the one hand, their extensive dimensions, which prevent them from being used on smaller vessels not exceeding 24 m in length, and, on the other hand, the inability to move the moored vessel horizontally along the mooring system

[0013] The Mobile Electromagnetic Mooring System solution, tackles the problems and requirements of small intervention/service watercraft, including work dive boats, during mooring to a larger serviced unit.

[0014] The Mobile Electromagnetic Mooring System allows the intervention/service vessel to move freely along the serviced unit, which eliminates the risks associated with the possibility of breaking the mooring lines and minimizes crew interference involved in the mooring process and/or mutual movement of these ships, which in turn has a very positive effect on the general safety and speed of mooring operations carried out on the side (mooring and unberthing).

[0015] The essence of the invention is a Mobile Electromagnetic Mooring System mounted in the overwater zone located above the waterline of the small intervention/service vessel, equipped on the approach side with mobile pneumatic distance fenders, and at least two mooring winches located at each end of the intervention vessel, mounted with a system of constant tension mooring ropes, the ends of which are attached to floating power supply buoys via insulated power cables with mooring ropes positioned horizontally in electromagnetic grippers, controlled from the central control panel of the intervention/service vessel,

[0016] Preferably, each set of at least two electromagnetic grippers is provided with an electromagnet powered by at least two floating power supply buoys, all single electromagnetic grippers being powered by a single floating power supply buoy using an insulated power cable. Preferably, each of the electromagnetic grippers is provided with an emergency electromagnetic release for activation in the central control panel of the intervention/service vessel.

[0017] Preferably, each mooring winch is equipped

with an integrated system to measure and maintain constant tension on each mooring line connected to the floating power supply buoy through a common control panel located with the emergency electromagnetic release in the central control panel of the intervention/service vessel,

[0018] In a variant according to the invention, preferably each floating power supply buoy is equipped with a photovoltaic panel-assisted power supply to allow operation for at least 10 hours. Preferably, the power supply is a battery or a power source supplied by an intervention/service or serviced unit.

[0019] Preferably, the Mobile Electromagnetic Mooring System is intended to equip a small surface intervention unit mooring to the side of larger vessels to carry out servicing, repairs, or the transfer of cargo or people.

[0020] The main advantages of the presented solution are the reduction of the probability of an accident related to operations on the mooring lines by reducing the *"high viewing angles"* and the breakage of the mooring lines. In classic systems, the mooring lines look up to the ship's main deck, usually with a very high freeboard. In a Mobile Electromagnetic Mooring System, the mooring lines look horizontal and are attached to the mobile electromagnetic grippers attached to the hull of the intervention vessel. Through the reduction of the level of stresses and loads generated on the mooring ropes located in the horizontal position of the Mobile Electromagnetic Mooring System and the limitation of inertial movement of the unit, the risk of accidents related to operations on mooring ropes is reduced to a minimum. An additional advantage of the system according to the invention is the short time of mooring and unberthing operations, as well as the unnecessity of the crew of a damaged/serviced ship to interfere with mooring operations. The valuable importance is the movement of the intervention unit along the side of a larger vessel to carry out the necessary work without the interference of the crew of the serviced vessel and to improve the safety of the underwater diver. The central control panel of the Mobile Electromagnetic Mooring System guarantees quick disconnection of the electromagnetic grippers with floating power supply buoys, and the use of conventional mooring winches ensures the mobility of the system. The solution according to the invention allows the intervention unit to be attached to a larger ship with a steel hull, even if it is contaminated, which in standard conditions makes such operations difficult.

[0021] The subject of the invention is shown as an example in the drawing, in which Fig. 1 shows a Mobile Electromagnetic Mooring System (variant with four mooring points) - top view in the side-to-side system. Fig. 2 shows a Mobile Electromagnetic Mooring System - vertical view from the bow and/or stern, Fig. 3 shows a Mobile Electromagnetic Mooring System - a view in the vertical plane from the ship's side, Fig. 4 shows a Mobile Electromagnetic Mooring System in operation mounted on the intervention/service vessel, Fig. 5 shows a Mobile Electromagnetic Mooring System (variant with two mooring points) - top view in the side-to-side system, Fig. 6 shows a Mobile Electromagnetic Mooring System - bow/stern vertical view, Fig. 7 shows a Mobile Electromagnetic Mooring System - vertical view from the ship's side

[0022] Figure 1 shows the Mobile Electromagnetic Mooring System according to the invention fitted on the side of an intervention/service vessel 2 and equipped with mobile pneumatic spacer fenders 3. In an exemplary embodiment, the Mobile Electromagnetic Mooring System according to the invention comprises four electromagnetic grippers 4, four floating power supply buoys 6, and four mooring winches 8, the four electromagnetic mooring grippers 4 being equipped with a system of electromagnets enabling mooring to the side of another vessel. As shown in Fig. 1, Fig. 2, and Fig. 3, each of the grippers is connected to the floating power supply buoy 6 by an insulated power cable and a mooring rope 5 and, optionally, another power supply system connected to the grippers directly from the serviced vessel 1, each of the grippers 4 is also equipped with an emergency electromagnetic release, which is activated remotely from the deck of the intervention/service unit 2. Figures 1 and 3 show that four floating power supply buoys 6 powering electromagnetic grippers 4 are equipped with batteries and photovoltaic panels that recharge the batteries located inside the buoy, with each floating power supply buoy 6 connected by an insulated power cable and a mooring rope 5 to an electromagnetic gripper 4 and by a mooring rope 7 to a mooring winch 8 on the intervention/service unit 2. As shown in Fig. 1, four mooring winches 8, are equipped with an integrated measurement system that maintains constant tension on the mooring lines 7 connected to the floating power supply buoys 6, which also allows the intervention/service unit 2 to move freely along the side of the service unit 1 through the control panel located together with the emergency electromagnetic release panel 9 in the wheelhouse 10 of the intervention/service unit 2. The mooring operation of an intervention/service vessel 2 equipped with a Mobile Electromagnetic Mooring System has been shown in Fig. 4.

[0023] Using its propulsion system, he intervention/service vessel 2 approaches the side of the service unit 1 by its stern at the point closest to the bow of that vessel. Two electromagnetic grippers 4 are attached to the hull of serviced unit 1 above sea level. The intervention/service vessel 2, flowing perpendicularly from the serviced unit 1, releases the mooring ropes 7 using mooring winches 8 and places floating power supply buoys in the water 6.

[0024] Intervention/service vessel 2 with the use of its propulsion system, loosening and keeping the mooring ropes 7 under constant, safe tension through the mooring winches 8 located at the stern of this unit, approaches the side of the serviced unit 1 in the place closest to the stern of this unit. Another two electromagnetic grippers 4 are attached to the hull of the service unit 1. The inter-

vention/service vessel 2, while departing from the service unit 1, releases the mooring ropes 7 on the bow and, by using the integrated mooring winches 8 and the control panel of the Mobile Electromagnetic Mooring System 10, maintains constant tension on the winches. Floating power supply buoys 6 are placed in the water and both units are brought into contact with their sides by pneumatic spacer fenders 3. When all four electromagnetic grippers 4 are connected to the hull of the service unit 1 and connected via power supply buoys 6 by mooring ropes 7 to mooring winches 8 maintaining constant tension on these lines, the system is activated by the control panel 10, and the intervention/service unit 2 moves to its final position relative to the serviced unit 1 at any moment and at any time without the assistance of the serviced unit's crew, as indicated in Figures 1 and 3.

[0025] The un berthing is the reverse process of the mooring process shown in Fig. 4. Moreover, for safety reasons, in the event of any failure or the need for immediate unberthing, each of the four electromagnetic grippers 4 is equipped with an emergency electromagnetic release 9, which is activated in the control panel 10 of the intervention/service unit.

[0026] In another embodiment of the invention shown in Fig. 5, the Mobile Electromagnetic Mooring System is equipped with a set of two electromagnetic grippers 4, powered by two floating power supply buoys 6, connected by mooring ropes to a set of two mooring winches 8 located on the bow and stern of the watercraft, respectively. Figure 5 shows a Mobile Electromagnetic Mooring System according to the invention, where on the side of an intervention/service vessel 2 equipped with a Mobile Electromagnetic Mooring System there are mobile pneumatic spacer fenders 3. In a third embodiment, the Mobile Electromagnetic Mooring System according to the invention comprises two electromagnetic grippers 4, two floating power supply buoys 6, and two mooring winches 8, where two electromagnetic grippers 4 are equipped with a system of electromagnets enabling mooring to steel elements. Each of the grippers is connected to a floating power supply buoy 6 through an insulated power cable and a mooring rope 5 and a power system supplied to the grippers directly from the intervention/service unit 2, where each of the grippers 4 is also equipped with an emergency electromagnetic release which is activated remotely from the deck of intervention/service unit 2. Floating power supply buoys 6 powering electromagnetic grippers 4 are equipped with batteries and photovoltaic panels that recharge the batteries inside the buoy, with each floating power supply buoy 6 connected with an insulated power cable and a mooring rope 5 to the electromagnetic gripper 4 and by a mooring rope 7 to the mooring winch 8 located on the intervention/service unit 2. Two mooring winches 8 are equipped with an integrated system for measuring and maintaining constant tension on the mooring lines 7 connected to floating power supply buoys 6, which ensures the mobility of the intervention/service unit 2 against the side of the serviced unit 1 through the control panel located together with the emergency electromagnetic release 9 in the wheelhouse 10 of the intervention/service unit 2. The process of unberthing the intervention/service unit in the second embodiment is also opposite to the mooring process.

List of the symbols in the drawing:

[0027]

1 - serviced vessel
2 - intervention/service vessel equipped with a Mobile Electromagnetic Mooring System
3 - mobile pneumatic spacer fenders on equipment of the intervention/service vessel 2
4 - electromagnetic gripper
5 - mooring rope with a power cable connecting the electromagnetic gripper 4 with a floating power supply buoy 6
6 - a floating power supply buoy, supplying the electromagnetic gripper 4, equipped with batteries to keep the electromagnet powered
7 - mooring rope, connecting the floating power supply buoy 6 with the mooring winch 8
8 - an integrated system of mooring winches mounted on the intervention/service vessel 2 equipped with a system for maintaining constant tension of the mooring ropes 7
9 - emergency release of electromagnetic grippers 4
10 - the central control panel of the intervention/service vessel 2
11 - the water level.

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[0028]

[1] Rutkowski G., Numerical Analysis of the Contact Forces Generated on a Hiload DP1 Prototype Attachment System at Calm Sea, Publikacja w Zeszytach Naukowych AM w Gdyni, ISSN 1644-1818, ZeszytNr 87/2014, Str. 22-32, Gdynia 2014.

[2] E. B. (eds.), F. Vasco Costa (auth.), Advances in Berthing and Mooring of Ships and Offshore Structures. 1988.

[3] UK P & I CLUB, "Understanding Mooring Incidents." Available on. https://www.ukpandi.com/-/media/files/imports/13108/bulletins/2937-understandingmooringincidents.pdf

Claims

1. The Mobile Electromagnetic Mooring System mounted above water and located above the waterline of an intervention vessel with small hull dimensions, equipped on the approach side with mobile

pneumatic distance fenders and an electromagnetic module with an electric power supply system, is **characterised by** two integrated mooring winches (8) located at a minimum of two ends of the intervention/service vessel (2), equipped with a system of constant tension mooring lines (7), the ends of which are attached to the floating power supply buoys (6) via insulated power cables with mooring lines (5) positioned horizontally in the electromagnetic grippers (4), and controlled from the central control panel (10) of the intervention/service vessel (2).

2. The Mobile Electromagnetic Mooring System according to claim 1 is **characterised by** the fact that each set of at least two electromagnetic grippers (4) is equipped with an electromagnet powered by at least two floating power supply buoys (6), whereas all single electromagnetic grippers (4) are supplied by a single floating power supply buoy (6) using an insulated power cable with a mooring rope (5).

3. The Mobile Electromagnetic Mooring System according to claim 1 is **characterised by** the fact that each of the electromagnetic grippers (4) is equipped with an emergency electromagnetic release (9) for activation in the central control panel (10) of the intervention/service vessel (2).

4. The Mobile Electromagnetic Mooring System according to claim 1 is **characterised by** the fact that each of the mooring winches (8) is equipped with an integrated system for measuring and maintaining constant tension on each mooring line (7) connected to the floating power supply buoy (6) via a common control panel located together with the emergency electromagnetic release (9) in the central control panel (10) of the intervention/service vessel (2).

5. The Mobile Electromagnetic Mooring System according to claim 1 is **characterised by** the fact that each floating buoy is equipped with a photovoltaic panel-assisted power supply which allows the electromagnet to operate for at least 10 hours.

6. The Mobile Electromagnetic Mooring System according to claim 5 is **characterised by** the fact that its power supply is a battery or a power source supplied by an intervention/service vessel (2) or a serviced unit (1).

7. The Mobile Electromagnetic Mooring System according to claims 1 to 6 is **characterised by** the fact that it is intended to equip a small watercraft (up to 24 m in length) which moors to the side of larger serviced vessels to carry out servicing, repairs, or the transfer of cargo or people.

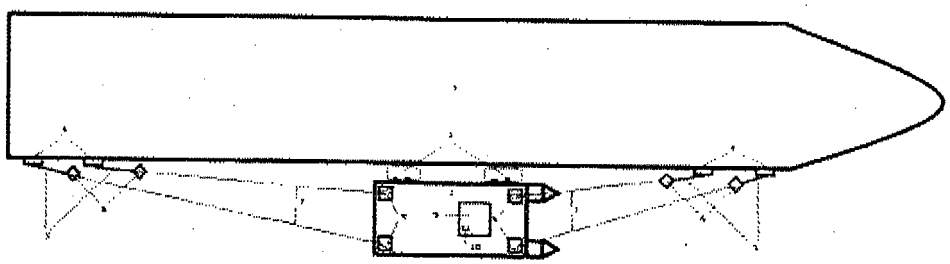


Fig. 1.

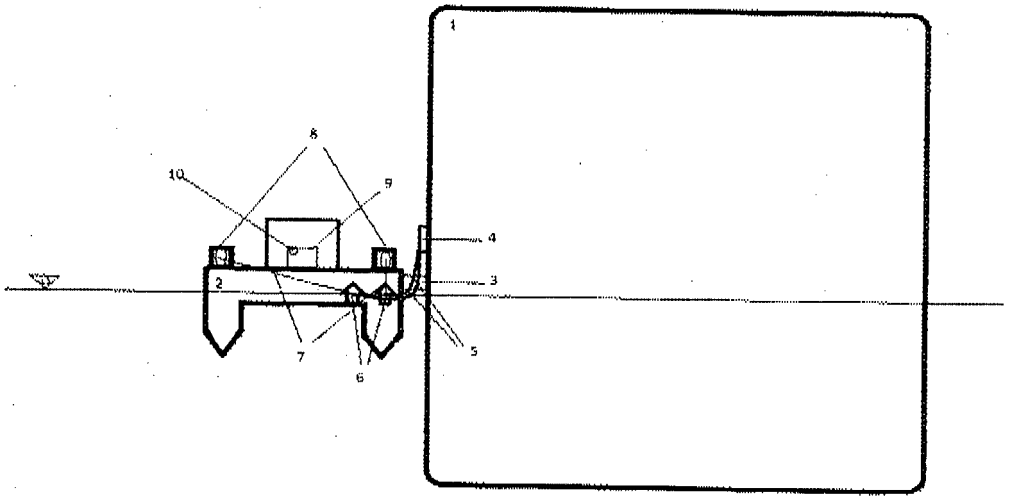


Fig. 2.

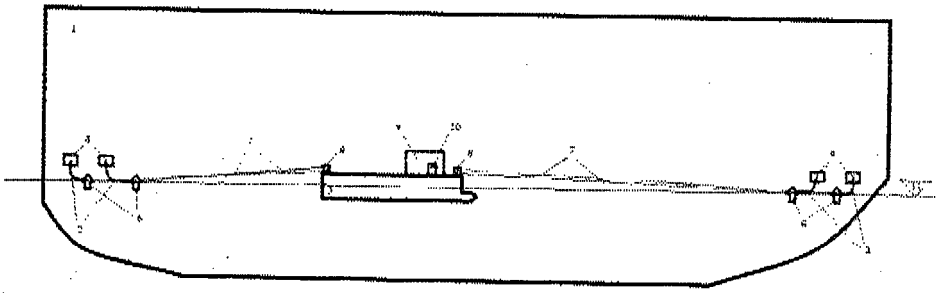
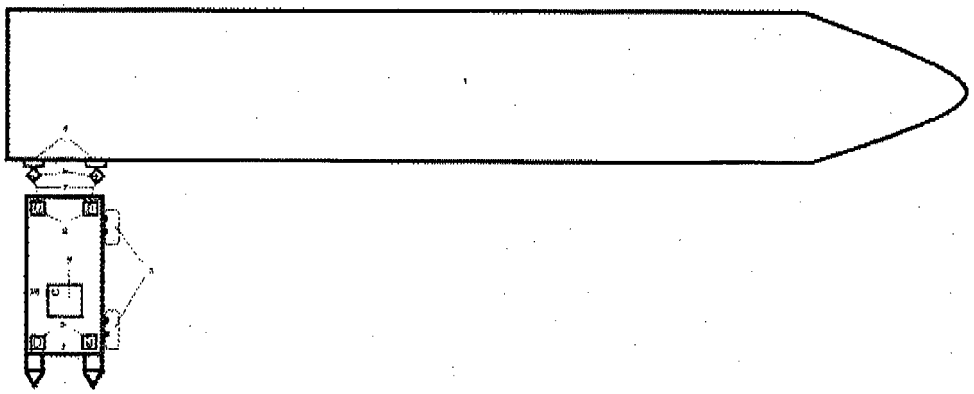
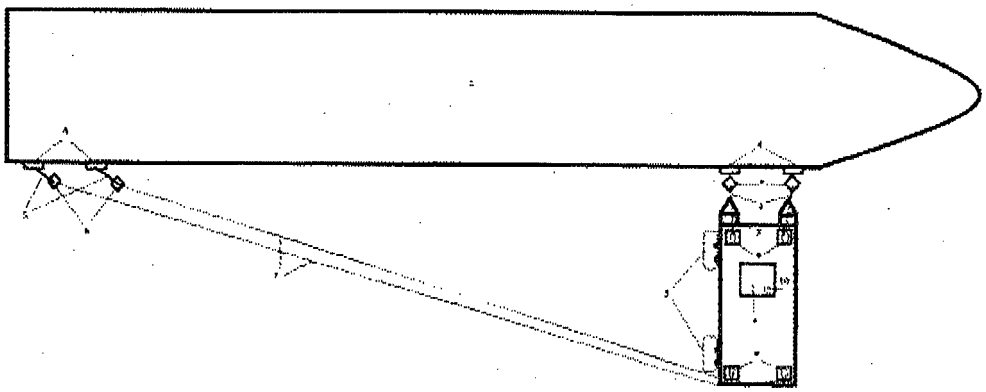


Fig. 3.

a)



b)



c)

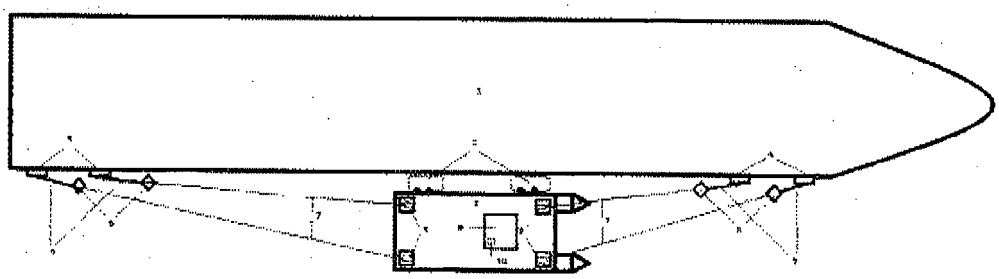


Fig. 4.

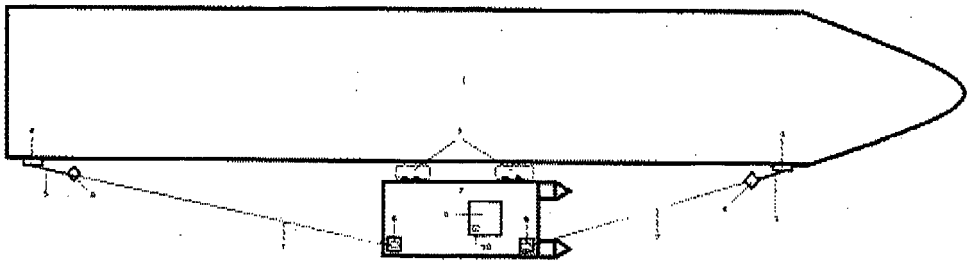


Fig. 5.

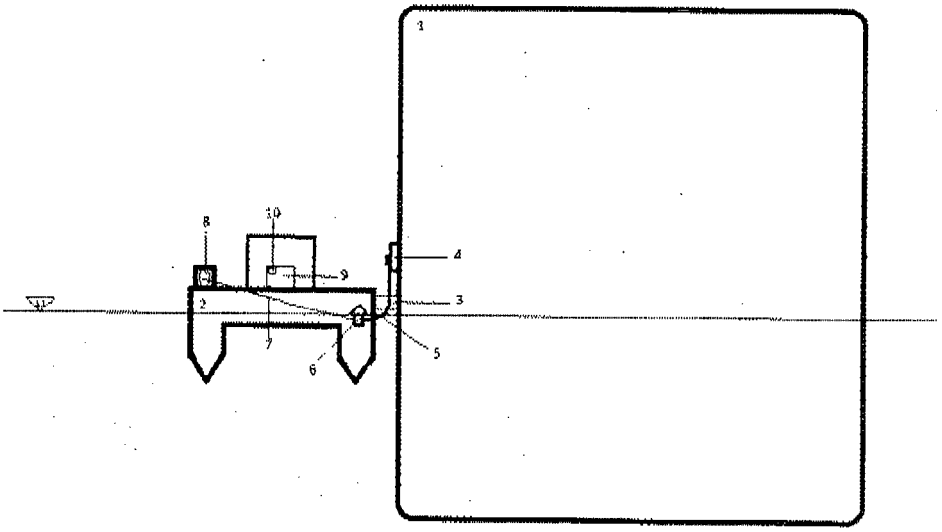


Fig. 6.

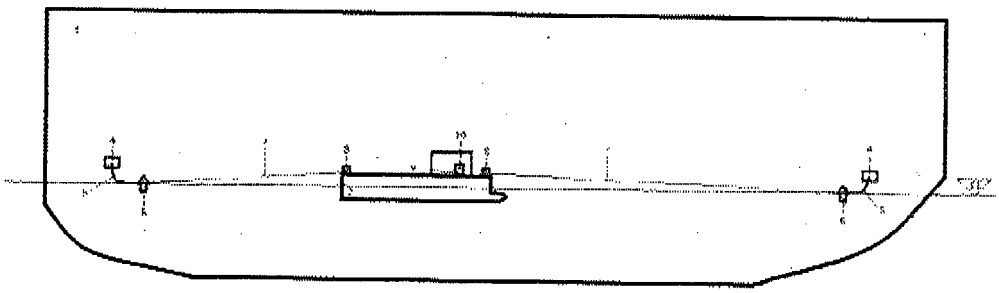


Fig. 7.

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EUROPEAN SEARCH REPORT

Application Number
EP 22 00 0102

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	EP 3 494 040 A1 (ROLLS ROYCE MARINE AS [NO]) 12 June 2019 (2019-06-12) * figures 1C,5B *	1-7	INV. B63B21/02 B63B21/16
A	CN 203 318 659 U (UNIV DALIAN TECH) 4 December 2013 (2013-12-04) * figures 1-8 *	1-7	
A	US 3 974 794 A (KAKITANI SHIGEYUKI ET AL) 17 August 1976 (1976-08-17) * figure 5 *	1-7	
			TECHNICAL FIELDS SEARCHED (IPC)
			B63B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	23 September 2022	Cerva-Pédrin, Sonia

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