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(57) Summary: PORTABLE ELECTRIC PROPULSION SYSTEM FOR VESSELS. This invention patent describes a portable electric propulsion system (1) (Fig. 2) for vessels (8) in the field of waterway transport, consisting of retractable power trains equipped with electric motors (4), propellers (6) or turbines, which are fixed to transportable structures (1) that house rechargeable batteries or fuel cells or flow cells to power the said motors. These structures are loaded and unloaded in the same way as the payloads transported (12) (Fig. 4), eliminating the need for modifications to existing waterway transport systems. This Portable Electric Propulsion System for Vessels aims to promptly replace, with cost reduction and no operational impact, the pushers (39) (Fig. 15) that use fossil fuel engines that emit greenhouse gases with a socio-economic and ecologically sustainable solution. It also highlights the incidental advantage of fostering the economy of riverside communities that depend on diesel in power generators for production and housing. The electric energy stored in containers (2) can be taken to the communities or, henceforth, the plants for capturing and storing green electric energy will be more viable along the waterways due to the imminent replacement of the costly diesel energy in cargo transport, thus enhancing socio-economic activity.(...).

DESCRIPTIVE REPORT

'Portable Electric Propulsion System for Vessels'

Introduction

[001] This descriptive report refers to a patent for an invention called Portable Electric Propulsion System for Vessels belonging to the field of waterway transport in which a set of one or more motors electric equipped with azimuthal propellers is added to a set of rechargeable batteries and/or fuel cells as one of the possible means of providing electrical energy. Both sets are part of the transportable load and can be loaded or unloaded freely when necessary. This patent was developed to provide environmental advantages and socioeconomic advantages when compared to conventional propulsion systems used in vessels.

Problem

[002] The ferries (Fig. 15) play a fundamental role in providing transport services on waterways at a lower cost compared to rail, road, and air transport. However, these ferries depend on pushers or tugboats (39)(Fig. 15) with engines powered by fossil fuels, which results in environmental pollution and high costs operational, similar to conventional cargo ships.

[003] As an example, the transport of 60 containers of cargo on a barge on the Amazon River (Fig. 15) involving a pusher with a 755 hp Diesel Engine and an average consumption of 125 l/h on the Belém x Macapá x Belém, a trip that lasts on average 72 to 80 hours round trip, incurring a total average consumption of 9,500 liters of marine diesel. Considering the sum of 80 trips per year, results in an average annual consumption of 760 thousand liters of fuel which implies the emission of 2,000 tons of CO_2 and high cost in transportation.

[004] The transformation of current pushers, tugboats, and vessels (39) (Fig. 15). with traction based on fossil fuels, to electric traction requires downtime in shipyards and the consequent drop in profitability

in cargo transport operations. On the other hand, the replacement of diesel-powered tugs or pushers with new electric ones requires considerable investments.

Objectives

[005]The Portable Electric Propulsion System has the following objectives:

[006] I - Accelerate the implementation of sustainable propulsion systems in vessels,

[007] II - Improve energy efficiency, safety, maneuverability and performance in operations with ferries or cargo transport vessels, vehicles and passengers,

[008] III - Foster agricultural and fishing productivity of riverine populations through solutions for providing electric power with sustainable viability socioeconomic sustainability and, mainly,

[009] IV - Promptly replace traditional propulsion systems (38)(Fig. 15) that use thermal engines powered by fossil fuels, which release waste, pollutants, and greenhouse gases, with a propulsion system that is economically and ecologically sustainable.

Solution

[0010]The need for sustainable solutions for waterway transport and environmentally friendly and the demand for greater performance in operations logistics, stimulated the invention of a Portable Electric Propulsion System for Vessels (1)(Fig. 1), hereinafter referred to as SP2E2, equipped with electric motors (4) powered by secondary batteries (2) or flow batteries or fuel cells (11)(Fig. 3), all mounted and arranged in such a way as to be part of the loads (9, 10)(Fig. 2) transported by the vessels (8)(Fig. 2) (17)(Fig. 5) in order to provide rapid deployment and portability.

[0011]Secondary electrochemical batteries made of metals such as lithium or sodium have stood out as a promising technology due to their high energy density, longer lifespan, enhanced safety features, and environmentally friendly nature. They are rechargeable and operate with solid and/or liquid electrolytes.

[0012]Alternatively, flow batteries generate electrical energy by transforming the electrochemical energy stored in solutions that flow through ion exchange membranes and involve the electrodes. When depleted of chemical energy, these solutions are restored or replaced by those reused and re-energized at reprocessing stations supplied with green electrical energy.

[0013]In turn, fuel cells generate electrical energy through special catalysts and electrodes consuming renewable fuel liquids with a low carbon footprint such as ethanol or ammonia or green hydrogen.

[0014]In one of the modalities of this invention, two units of the SP2E2 (1)(Fig. 2), each with 10 MWh of electrical energy storage capacity in lithium iron phosphate batteries carry 60 cargo containers on a barge on the Amazon River on the Belém x Macapá stretch. The expected savings in spending on energy is at least 80% (R$ 1.25/kWh diesel versus R$ 0.25/kWh electric), which results in R$ 3 million/year (80%x760kl*R$5.00). The payback period for capital amortization is less than 6 years, considering R$ 1,000.00/kWh of investment cost in the SP2E2 (R$ 20 million), which has an estimated life of 20 years. In the amortization calculation, the reduction in costs was considered operational and the revenue of R$ 500 thousand/year in carbon credits for the CO2 that is no longer emitted. (all values estimated based on the year 2023)

[0015]The abundance of solar energy and area for its capture on the surface of rivers, lakes, and bays, such as in the Amazon region, favors the implementation of plants, floating or not, for the chemical storage of green electrical energy generated by solar panels or hydropower plants. Alternatively, wind generators or turbines collecting energy from river tides are also promising sources of low-cost green energy generation.

[0016]The chemical storage of green electrical energy can be done in the form of liquid hydrogen or ammonia to supply the tanks of the batteries of fuel cells of the mentioned vessels or, also, in ionic solutions used in the onboard flow batteries.

[0017]Green electrical energy can also, in a more traditional way, be stored electrochemically in rechargeable secondary batteries. The depleted batteries (16)(Fig. 4) of energy in the electric propulsion of their vessels may be replaced by the transshipment of other re-energized ones (12, 15).

[0018]It is also an option for rapid transfer, through electric cables, of energy from the batteries of the generation plants to the onboard batteries and depleted in waterway transport.

[0019]In the mode of using fuel cells or flow batteries, the storage of green electric energy can be achieved with the production of liquid hydrogen or ethanol or ammonia to supply the tanks (11)(Fig. 3)(Fig. 5) of the fuel cells of the mentioned vessels or for re-energizing of ionic solutions used in the tanks of the onboard flow batteries. These liquids loaded with chemical energy can be transferred to the containers onboard through supply hoses or transshipment of the tanks.

[0020] Another viable implementation is to board solar panels to cover the extensive area of the loads transported by the ferries, thus dispensing with the plants stationary supply stations. The solar panels provide during the day the energy needed for the electric traction motors and for recharging the batteries that will move the vessels during the night.

Advantages

[0021]Environmental Benefits: The invention provides for the elimination of emissions of greenhouse gases associated with the propulsion systems of the vessels traditional ones powered by thermal engines using fossil fuels, significantly reducing air and water pollution.

[0022]Extending the lifespan of lithium cells: Rechargeable lithium batteries, or other metals, used in hybrid or exclusively electric motor vehicles have reduced charge density with use, which reduces the range of the vehicles and requires their replacement. A second life for these is possible batteries before recycling as they can be reused in vessels with electric propulsion because the ratio of stored energy to weight is not a predominant factor.

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[0023]Energy Efficiency: The portable electric propulsion system offers a much higher energy efficiency and operational cost compared to conventional thermal engines due to reduced financial expenditure on energy and mitigation of downtime during preventive and corrective maintenance.

[0024]Better Performance: The azimuthal propulsion at the stern and/or aft of the ferries provides superior maneuverability, allowing for faster and more precise maneuvers, improving the overall performance of vessels in ports considering the reduction of docking time and greater operational safety.

[0025]Lower operational and maintenance costs: Rechargeable batteries, or flow or fuel cells, as well as electric motors, have a longer lifespan, are more reliable, and require less frequent maintenance, resulting in less downtime and interruptions operational due to failures compared to conventional propulsion systems with diesel engines.

[0026]Evolution of the inland waterway transport industry: The portable azimuthal electric propulsion system can be easily applied to various types of vessels, including passenger ferries, vehicle ferries, and cargo ferries. cargo. The invention has significant commercialization potential, offering a sustainable, economical, and highly profitable solution for the inland water transport sector.

[0027]Enhancement of socioeconomic activity: Service ferries (13) (Fig. 4) or transport ferries for energy storage units (15) could, literally bring electricity to riverside populations. The deployments of energy capture and storage plants will also be more viable, floating or not, along the waterways because there will be a demand for energy electricity on a larger scale from the new vessels with electric propulsion. The economic activity will be intensified because the low cost of clean energy, the ease of distribution and/or speed in the deployment of power plants, have the potential to foster the extractive and sustainable industry of the communities riverside communities that depend on diesel in their electric power generators for productive activities and housing.

[0028]Indeed, the portable azimuthal electric propulsion system meets the objectives listed a priori. It uses green energy to power the motors in the ferries and vessels through the storage of clean electrical energy in the form of chemical energy and subsequent conversion back to electrical, and vice versa. It reduces emissions of pollutants and greenhouse gases. It increases economic profitability by using cheaper energy. It improves the operational performance of transport inland waterway transport in general, including greater maneuvering speed at anchorage.

of barges and vessels in ports. And it offers an innovative approach, ecologically correct, sustainable, and readily available to meet and revolutionize the inland waterway transport industry.

Description of the figures

[0029]For better didactics of the present invention, Figures 1 to 12 present, in perspective, details of the invention not meaning that it deals with the only forms of implementation.

[0030]Fig. 1 presents a version of the Portable Electric Propulsion System for Vessels or SP2E2 (1) composed of a storage unit of energy (2), a powertrain composed of an electric motor (4) and a propelling element propeller (6) housed in a tilting structure (3) that pivots on a tilting guide axis (7) and can be immobilized at fixed points (5) both in the horizontal and retracted position, as well as in the vertical and extended position to submerge the propelling element (6) in the aquatic medium of the waterway.

[0031]Fig. 2 presents two units of the SP2E2 (1) onboard a barge (8) loaded with trailers (12) of cargo containers (9, 10) and also with containers of additional energy storage units (2). The powertrain (4, 6) is fixed on a rail (3) immobilized in the vertical position for the service of propulsion of the barge.

[0032]Fig. 3 presents an alternative to that shown in Fig. 2 where the SP2E2 (1) uses a tank with ionic solution or green fuel (11) for the storage of energy. The powertrain (4, 20) is fixed in a structure telescopic (18) extended with its azimuthal propelling unit (20) submerged in the aquatic medium of the waterway.

[0033]Fig. 4 presents a service and transshipment barge (13) that serves as a floating dock for the transit of trailers (12) in order to replace the containers with discharged batteries (16) onboard the transport barge (8) with those containing charged batteries (15) on the service barge (13).

[0034]Fig. 5 presents two SP2E2 (1) onboard a pusher (17) of barges (8) whose powertrains are powered by stored green hydrogen in tanks (11) that drive shrouded azimuthal propellers without shaft (20).

[0035]Fig. 6 shows different arrangements of power trains with engines (4) and propellers (19, 20, 21) positioned on rails (3) or telescopic structures (18). The propellers (20) mechanically driven at the perimeter through the fairing are the best because they do not have the shaft in the central part and minimize the interference of foreign objects in propulsion (20)(Fig. 16).

[0036]Fig. 7 shows the detail of the tilting guide (23) when the tilting rail of the power train (3, 22) is in the vertical position and immobilized in such a way ready to perform the propulsion service.

[0037]Fig. 8 presents the positioning of the power train when emerged from the waterway (24).

[0038]Fig. 9 details the pivoting of the tilting rail of the power train (25) over the axis of the tilting guide (26) like a seesaw. The position of balance of moments of force in relation to this axis provides less effort mechanical in the transition of the power train from the service position (22)(Fig. 12) to the retracted (28) in order to facilitate the transshipment of the SP2E2 (12)(Fig. 4).

[0039]Fig. 10 shows the tilting rail of the power train in retraction (27) in order to allow the imminent transshipment of the SP2E2 (12)(Fig. 4).

[0040]Fig. 11 presents the detail of the tilting guide (29) in the position horizontal and the tilting rail of the power train (3) in the retracted position (28) for transshipment or transport of the SP2E2 (1).

[0041]Fig. 12 details the movement by the positioning mechanism of the power train (4) of the tension cables (32, 33) around the pulleys (30, 31) fixed to the tilting rail (28) so that the sequence (28, 27, 25, 24, 22) of immersion of the propulsion unit in the aquatic medium of the waterway (22) or the reverse, of retraction (28) for boarding or disembarking of the SP2E2 (1).

[0042]Fig. 13 presents another mode of implementation of the service of transport by forming a convoy (36) of 4 barges to transport a set (10) of more than 200 containers through the motor power of 6 SP2E2 (1) at the bow and another 2 at the stern (1). The motor power of this set of propellers is greater than 3,000 hp and autonomy of 4 hours.

[0043]Fig. 14 is a photomontage (37) of a waterway transport barge that embarks two SP2E2 (1) for its propulsion dispensing with the diesel tug (39).

[0044]Fig. 15 shows a photo (38) of the state of the art in cargo transport on in waterways with a diesel pushboat (39).

[0045]Fig. 16 presents the photograph (40) of the technical state of a unit of electric energy storage (BESS – battery energy storage system) portable of 1.6 MWh inside a container transported by a trailer and its mechanical horse. A powertrain with engine and propeller is also presented cabinless azimuthal propeller (20) and another, with a propeller azimuthal cabin (21).

[0046]Fig. 17 shows the state of the art of a diesel propulsion unit semi-portable (41).

[0047]Fig. 18 presents the state of the art of a barge (8) pushed by two fixed electric motors (42).

[0048]Legend of the components of the figures

(1)Portable Electric Propulsion System for Vessels SP2E2

(2)Container with secondary batteries (BESS)

(3)Tilting rail of the powertrain

(4)Electric propulsion motor and positioning servomotors of the rail

(5)Tilting rail immobilization point

(6)Propeller

(7)Tilting guide

(8)Cargo transport barge

(9)Cargo container

(10)Set of cargo containers

(11)Ionic solution tank / green fuel

(12)Trailer

(13)Service and transshipment barge

(14)Control and accommodation cabin

(15)Container with charged secondary batteries

(16)Container with discharged secondary batteries

(17)Electric tug / pushboat

(18)Telescopic structure for the powertrain

(19)Azimuthal propeller

(20)Cowl-less azimuthal propeller without shaft

(21)Cowl azimuthal propeller

(22)Tilting rail of the immobilized power train for propulsion service

(23)Tilting rail guide in the vertical position

(24)Tilting rail of the power train with the emerged propeller

(25)Tilting rail of the power train in tilting equilibrium

(26)Tilting rail guide inclined in pivotal movement

(27)Tilting rail of the power train in retraction

(28)Tilting rail of the power train retracted for SP2E2 transshipment

(29)Tilting rail guide in the horizontal position

(30)Pulley I

(31)Pulley II

(32)Tension cable I

(33)Tension cable II

(34)Anchor point I of tension cable I in the container

(35)Anchor point II of tension cable II in the container

(36)Convoy of 4 barges and 2 portable azimuthal propulsion systems at the bow and 6 at the stern

(37)Photomontage of the Portable Electric Propulsion System for Vessels

(38)Convoy of 2 barges with diesel pusher and 60 containers

(39)Diesel pusher

(40)Mechanical horse, trailer, and energy storage container (BESS)

(41)Fixed azimuthal propulsion unit with diesel engine

(42)Fixed azimuthal propulsion unit with electric motor.

Detailed description of the invention

[0049]The Portable Electric Propulsion System for Vessels (1)(Fig. 1) or SP2E2 comprises the inventive and innovative integration of one or more of the following components available in the state of the art:

[0050]Bank of secondary batteries: High-capacity rechargeable devices for storing a significant amount of electrical energy for propulsion, such as the BESS housed in a container that can be transported on a trailer (40)(Fig. 16).

[0051]Fuel cells: Devices that consume ethanol or hydrogen liquid or ammonia and convert it into electrical energy to power the electric motors in propulsion.

[0052]Flow Cells: Devices that generate electrical energy through the transformation of stored chemical energy in ionic solutions.

[0053]Azimuthal Electric Propulsion Motors: Powertrain or set of devices that convert electrical energy into mechanical energy to drive propellers (4, 19)(Fig. 6) or aquatic propulsion turbines (20, 21) (Fig. 16). The set of these devices is fixed to positioning mechanisms attached to the container. Alternatively to azimuthal deflection, rudders may be used to provide the maneuverability of the vessel.

[0054]Powertrain positioning mechanisms: Devices telescopic (18) (Fig. 6) or retractable moved by pneumatic systems, hydraulic or screw-driven. Or also, a lower-cost, inventive solution and innovative as presented in the sequence of figure 12. The mechanisms of powertrain positioning aim to provide the direction and sense of the vessel in transport movement and also to dive or remove the propellers (19, 20, 21)(Fig. 6) from the water or to completely retrieve the entire set to provide the portability of the SP2E2 (1, 12)(Fig. 4).

[0055]Energy Management and Control System: A system for AC-DC conversion, monitoring and control that manages the flow of energy between the onboard battery banks and the green energy generation plants and also from the onboard batteries or fuel cells for the electric propulsion motors, optimizing performance and energy efficiency.

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[0056]Charging Infrastructure: A stationary infrastructure or on board a service barge (13)(Fig. 4) to recharge or swap the onboard secondary batteries (15, 16) on the transport barge (8) using energy from the electric grid or renewable energy sources such as solar, wind, tidal, and hydropower.

[0057]The consolidation of all these components into a portable structure (1)(Fig. 1) as configured in one of the modalities of the invention presented in figure 1 replaces with various advantages the diesel pushers and towboats traditional (38) (Fig. 15) or the recent alternatives fixed diesel power trains on the barges (41)(Fig. 17), or by the electric/hydraulic (42)(Fig. 18), also fixed.

Description of a type of power train positioning mechanism

[0058]To enable the portability of the Portable Electric Propulsion System for Vessels, and without prejudice to the concept of inventive unit, will be detailed in followed by the operation of a lower-cost type of mechanism for positioning of a portable power train as well.

[0059]It consists of a tilting and portable structure with a rail (3)(Fig. 9) that pivots like a seesaw on a tilting guide axis (26) and that can be immobilized and secured at fixed points (5)(Fig.1) both in the horizontal position and retracted (28)(Fig. 12), as well as in the vertical and extended (22) in order to submerge the propulsive element (19) in the aquatic environment of the waterway.

[0060]The tilting guide axis (23)(Fig. 7), (26)(Fig. 9) rotates in bearings rotating fixed at the upper edge aligned with the width of the container. The guide of tilting is, in turn, a sliding bearing for the rail (3) that moves the power train according to the sequence of figure 12.

[0061] The tension cables (32, 33)(Fig. 12) are pulled by servomotors and positioning mechanisms housed next to the electric traction motor (4). A control system keeps the cables permanently taut from the anchor points I and II in the container (34, 35) and around the pulleys (30, 31) secured on the tilting rail (28). The control system and the mechanism of positioning of the power train (4) performs the sequence (28, 27, 25, 24, 22) of submersion of the propulsive unit in the aquatic environment (22), or conversely, its retraction (28).

[0062]As detailed on the right side of figure 12, the rail tilting is slid from the retracted position (28)(Fig. 12) to just beyond the seesaw balance point (25). The cable (32) is then further released by the its respective servomotor and the weight of the power train initiates the rotation of tilting. The release and retraction of the cables (32, 33) coordinated by the servomotors provides the positioning of the tilting train (22) for the appropriate submersion of the propeller (19) according to the weight of the transported load and the draft of the waterway.

[0063]Both the bearings of the tilting guide shaft (23)(Fig. 7), (26)(Fig. 9) as well as the anchoring points I and II (34, 35)(Fig. 12) can be removed and installed in a new container or in another structure of the vessel.

[0064]As an additional advantage, the removal or installation of the power train attached to the tilting rail can be done without the use of cranes. The tension cables I and II (32, 33)(Fig. 12) properly secured can be pulled through the manual control of the servomotors of the positioning mechanism (4) and provide the lifting of the entire structure. Thus, the set acts as a service electric hoist.

CLAIMS

1. "Portable Propulsion System for Vessels" (1) characterized by using energy production units (2) and/or engines (4) that can be disembarked or embarked freely (Fig. 4) from a vessel or from a consolidated set of vessels (36) that perform the self-propulsion of the said vessel (37) or consolidated set of vessels (36).

2. "Portable Propulsion System for Vessels", according to claim 1, characterized by using engines (4) for self-propulsion that are attached to the energy storage units (2).

3. "Portable Propulsion System for Vessels", according to claim 1, characterized by fixing propulsion units with one or more propellers (19) and/or turbines (20) in a retractable structure (3, 18) that has the function of immersing them in the waterway so that they can perform the said self-propulsion or retrieve them in order to allow the said free (Fig. 4) boarding or disembarking of the "Portable Propulsion System for Vessels" (1).

4. "Portable Propulsion System for Vessels", according to claim 1, characterized by fixing the self-propulsion units with one or more propellers (19) and/or turbines (20) in a tilting structure (25) of positioning that executes a pivotal movement around the axis of a tilting guide (26) with the function of immersing the said propellers and/or turbines in the waterway so that they can perform the said self-propulsion or retrieve them in order to allow the said free boarding or disembarking of the "Portable Propulsion System for Vessels" (1).

5. "Portable Propulsion System for Vessels", according to claim 4, characterized by the capacity in which the tilting structure (28) performs, in addition to the said pivotal movement, a linear translational movement through the tilting guide (29) through coordinated pulls executed by a positioning system with servomotors (4) so that the sequence of movements (28, 27, 25, 24, 22) from the retraction position for transporting the "Portable Propulsion System for Vessels" (1) to the propulsion service position with the immersion of the propelling unit in the waterway or the sequence of

reverse movements, from the propulsion service position (22) to the position of retraction of the tilting structure (28) for boarding or disembarking and land transport of the "Portable Propulsion System for Vessels" (1).

6. "Portable Propulsion System for Vessels", according to claim 5, characterized by grouping the said positioning system of the structure tilting and the propeller (6) and/or traction turbine (20) and fixing them to the structure tilting (3), forming a unique and portable set that can be installed or uninstalled practically on the fixed structure of the vessel or in the units of energy production (2) onboard.

7. "Portable Propulsion System for Vessels", according to claim 1, characterized by using rechargeable secondary batteries as units of electric power production responsible for powering the electric motors of self-propulsion.

8. "Portable Propulsion System for Vessels", according to claim 1, characterized by using fuel cell batteries as production units of electric power responsible for powering the electric motors of self-propulsion.

9. "Portable Propulsion System for Vessels", according to claim 1, characterized by using rechargeable flow batteries of ionic solutions as units of electric power production responsible for powering the motors electric self-propulsion.

10. "Portable Propulsion System for Vessels", according to claim 1, characterized by using nuclear energy as units of energy production thermal responsible for powering the self-propulsion engines.

11. "Portable Propulsion System for Vessels" according to any of the preceding claims characterized by using the method of boarding or disembarking the energy units and/or the self-propulsion units of the same way as the method of boarding or disembarking cargo in water transport vessels.

Fig 1

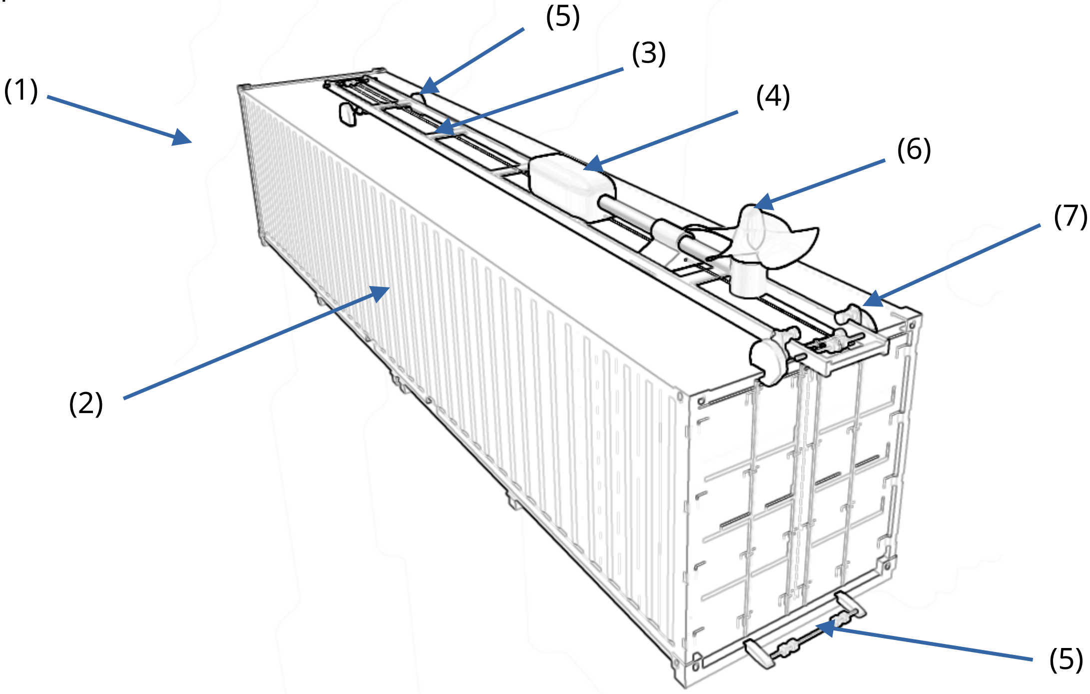

Fig 2

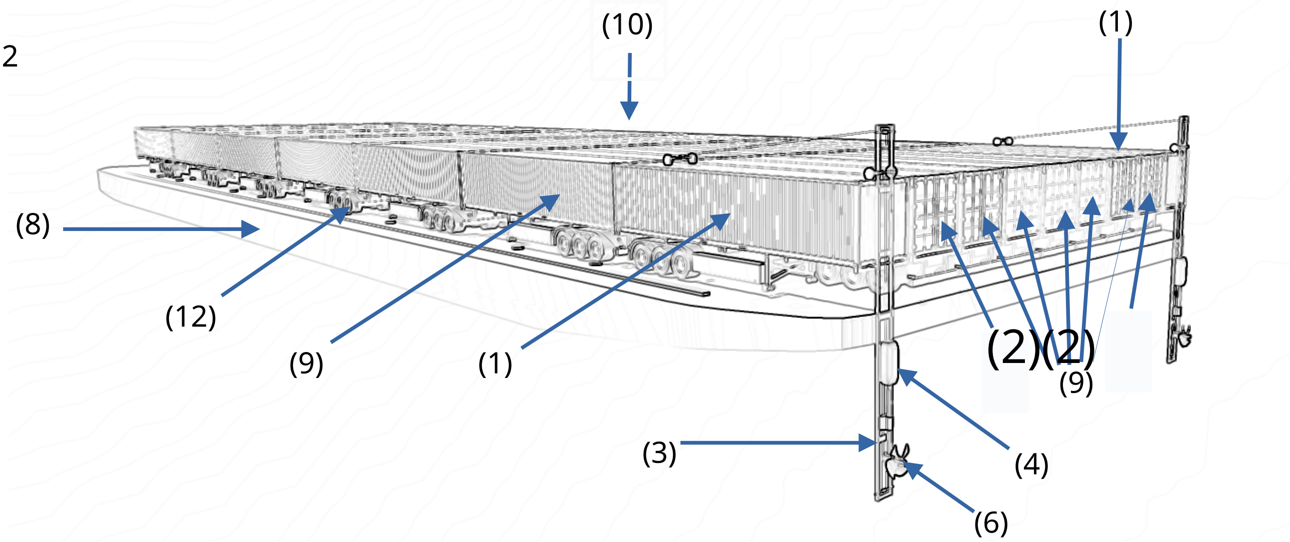

Fig 3

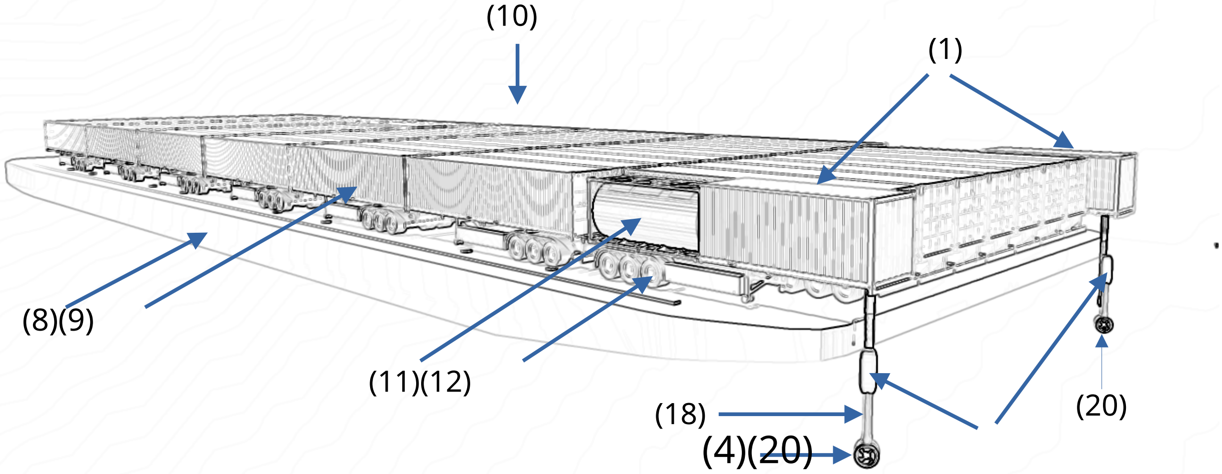

Fig 4

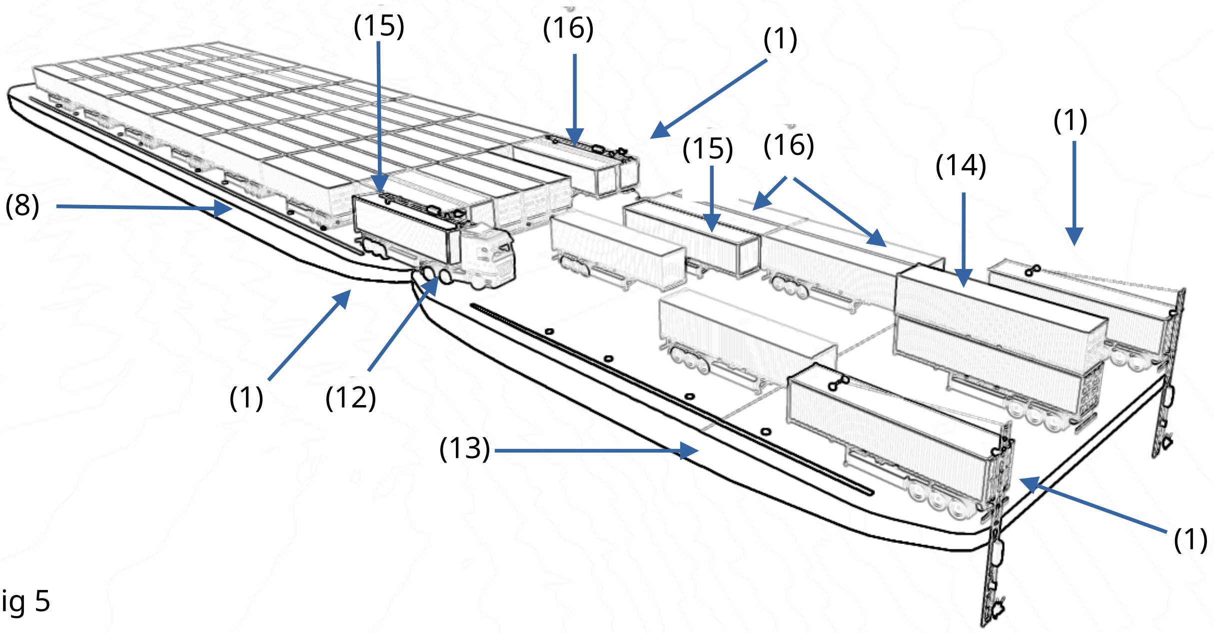

Fig 5

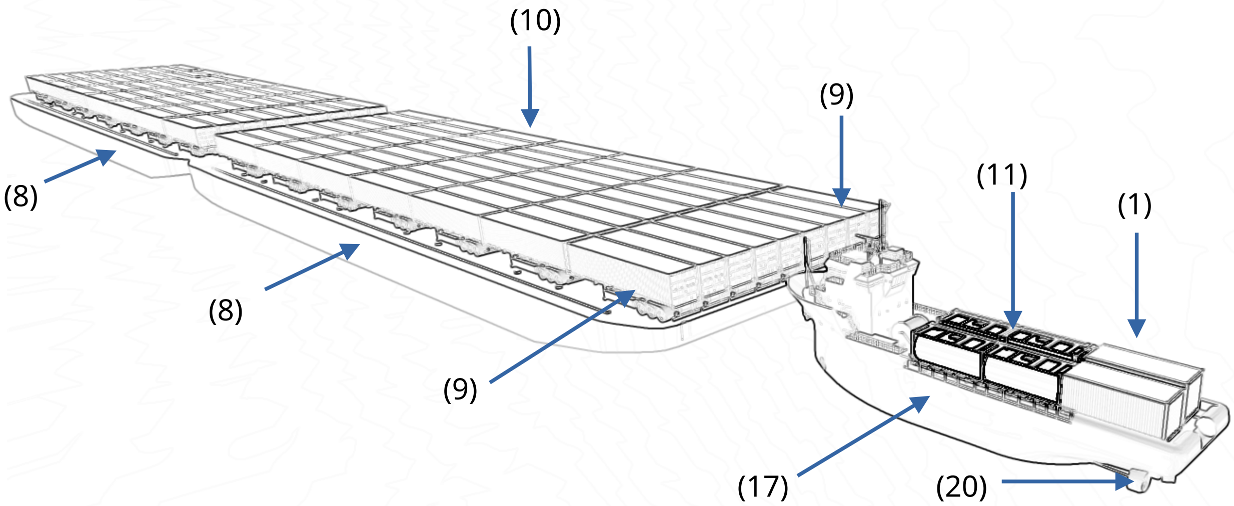

Fig 6

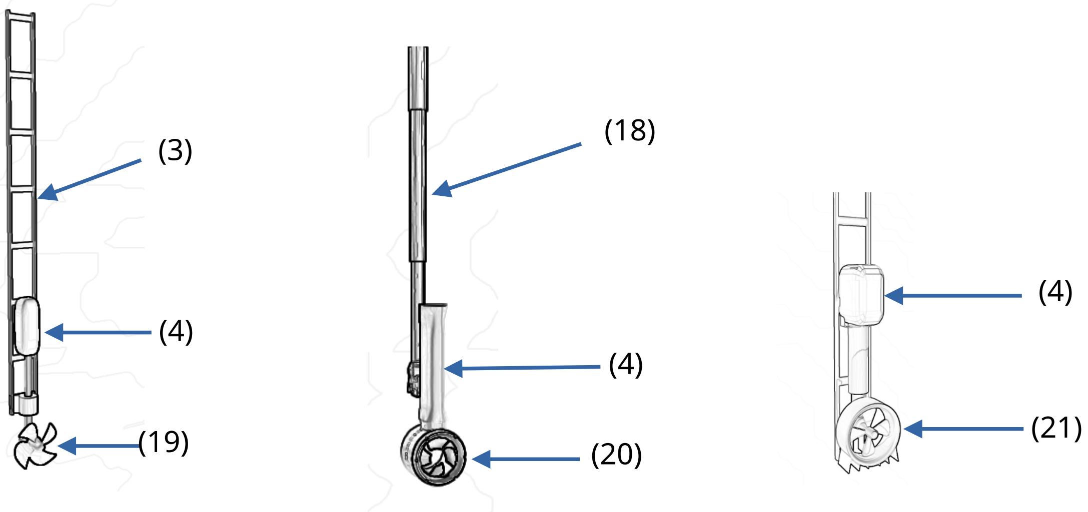

Fig 7

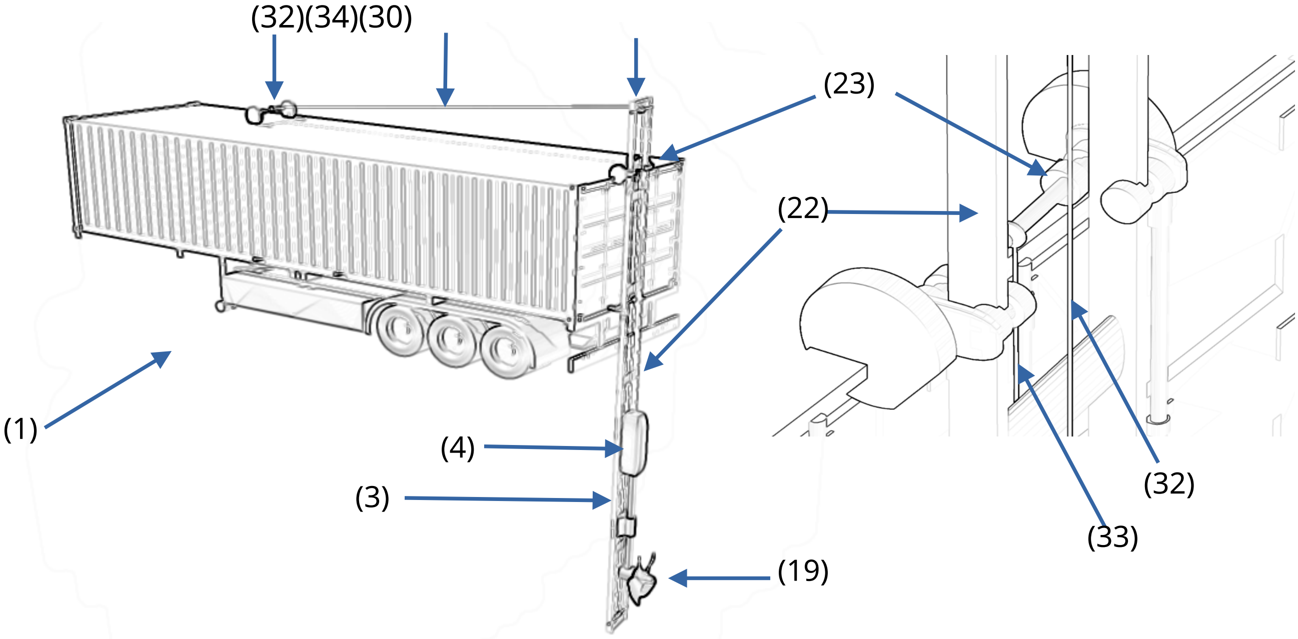

Fig 8

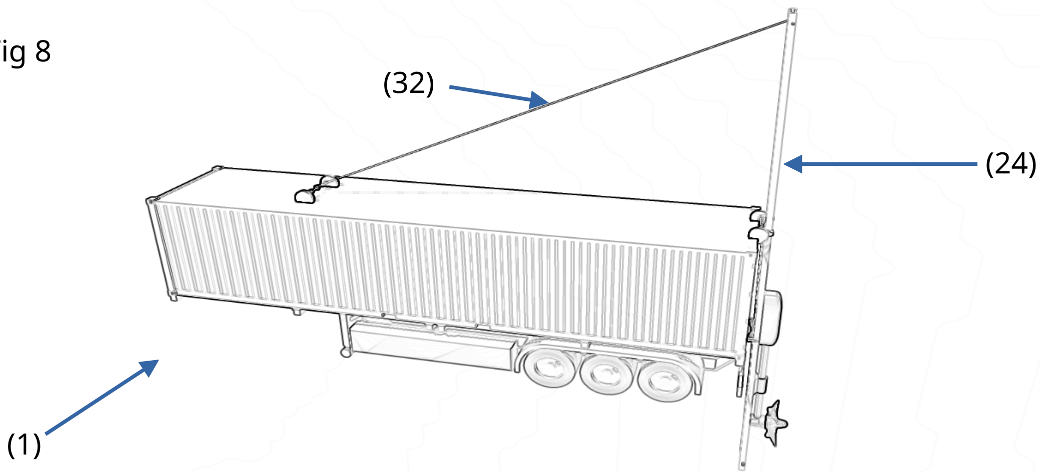

Fig 9

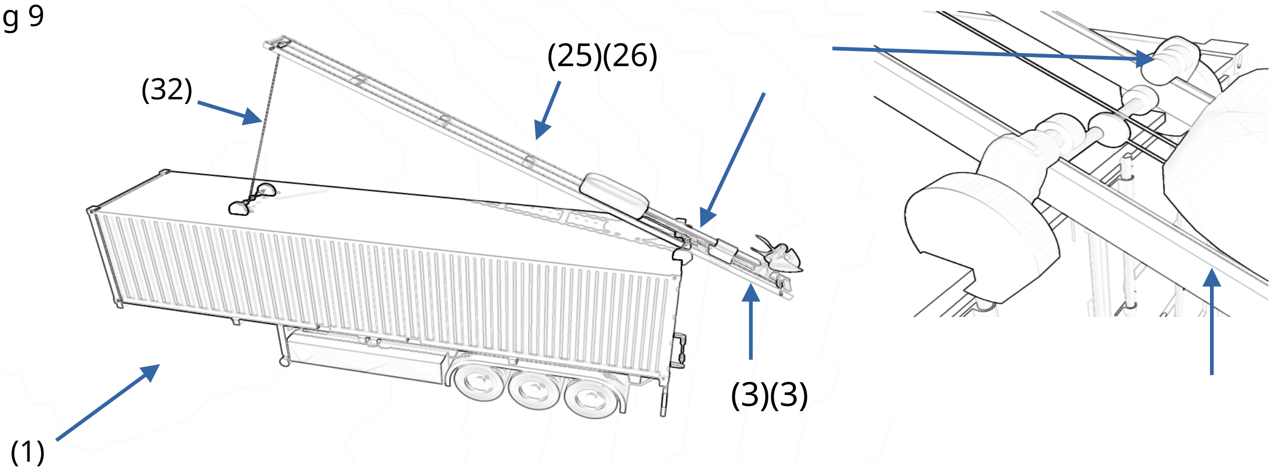

Fig 10

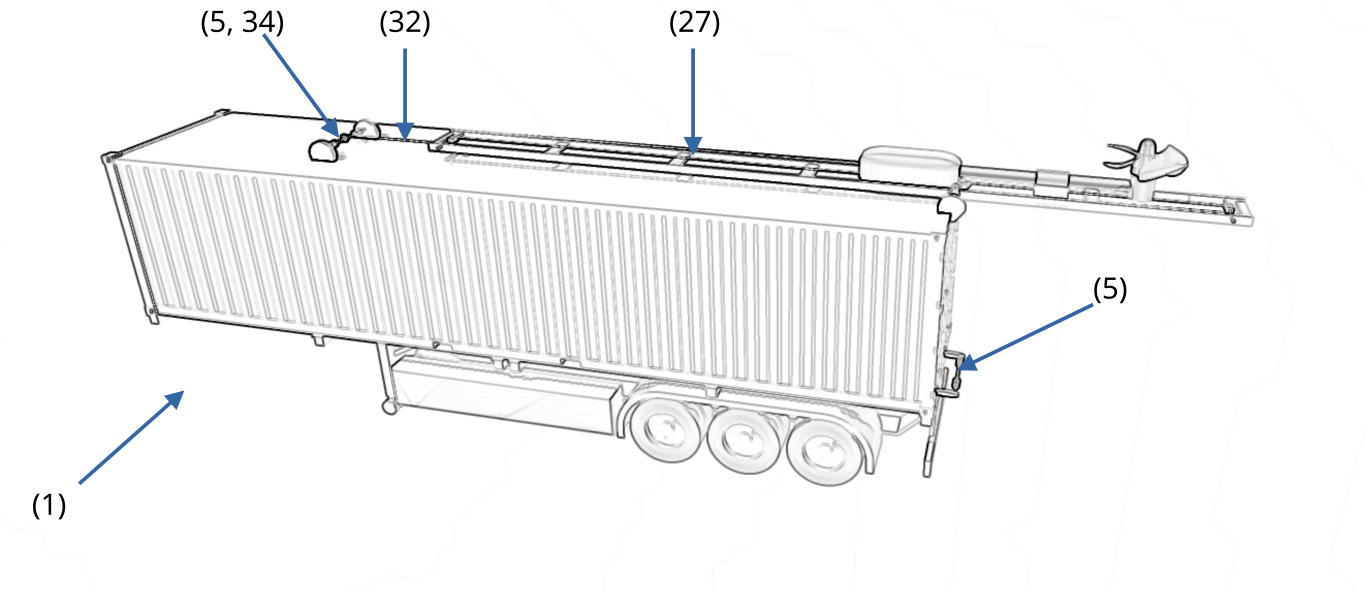

Fig 11

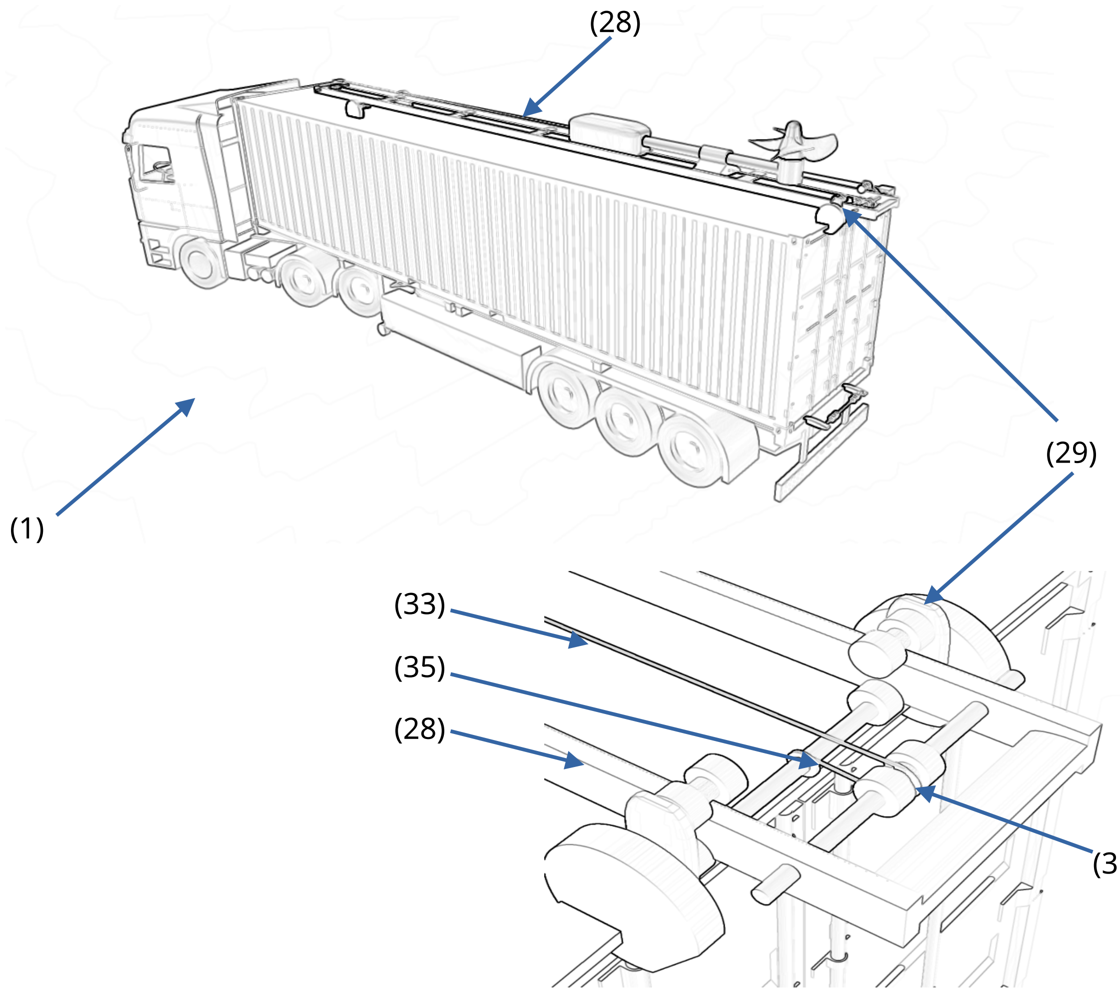

Fig 12

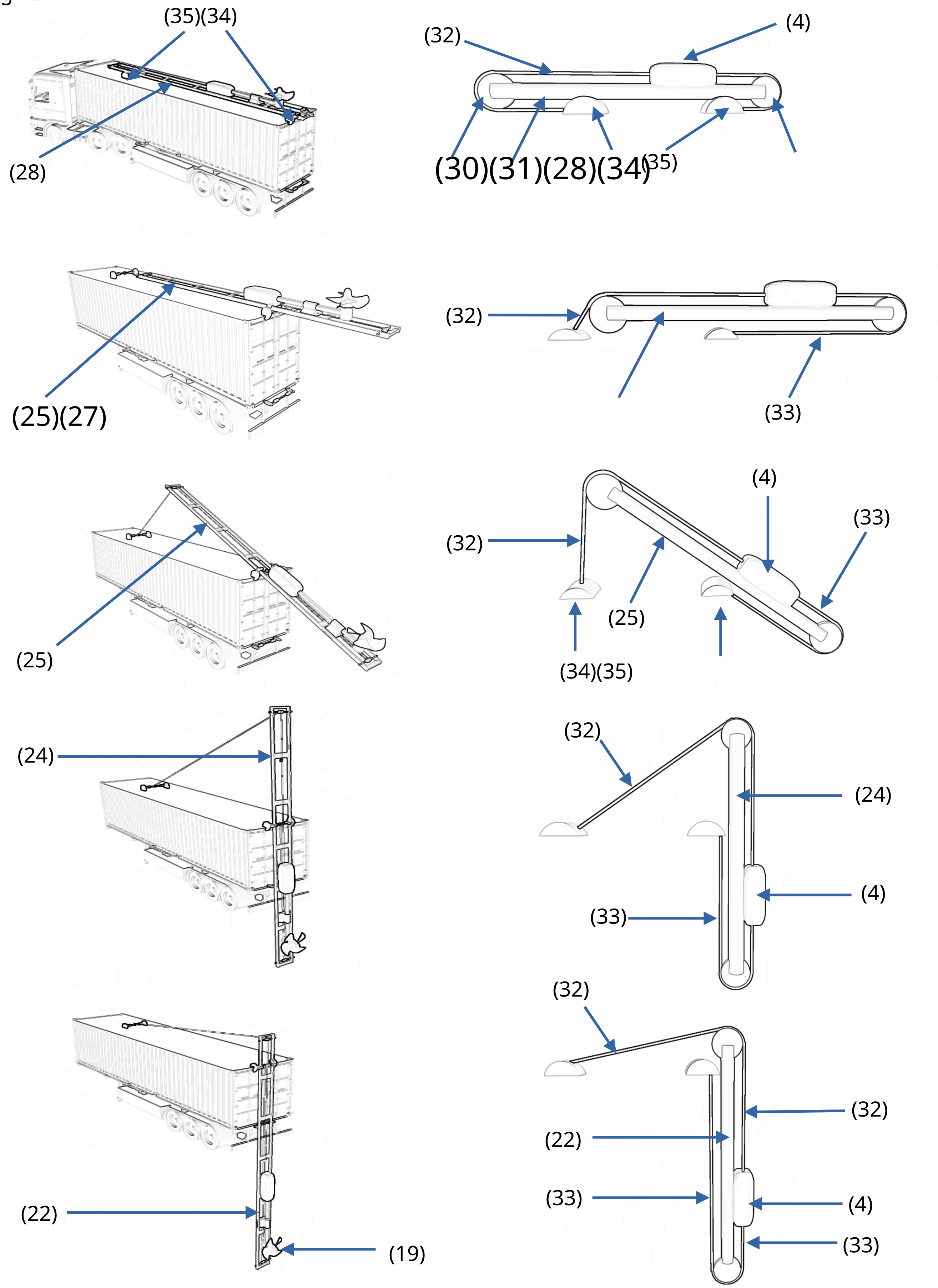
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Fig 13

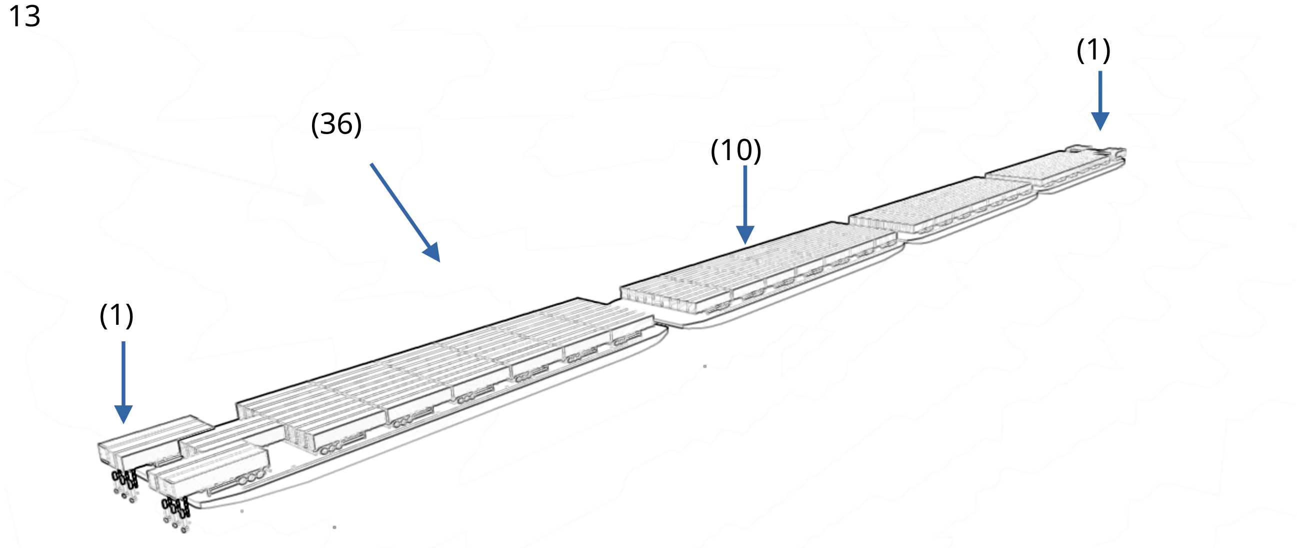

Fig 14

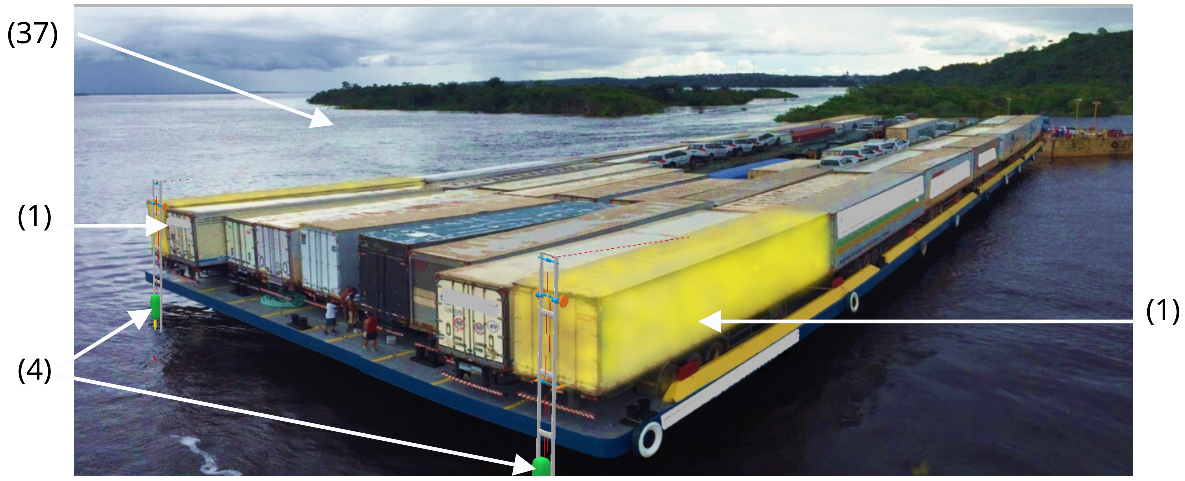

Fig 15

Fig 16

Fig 17

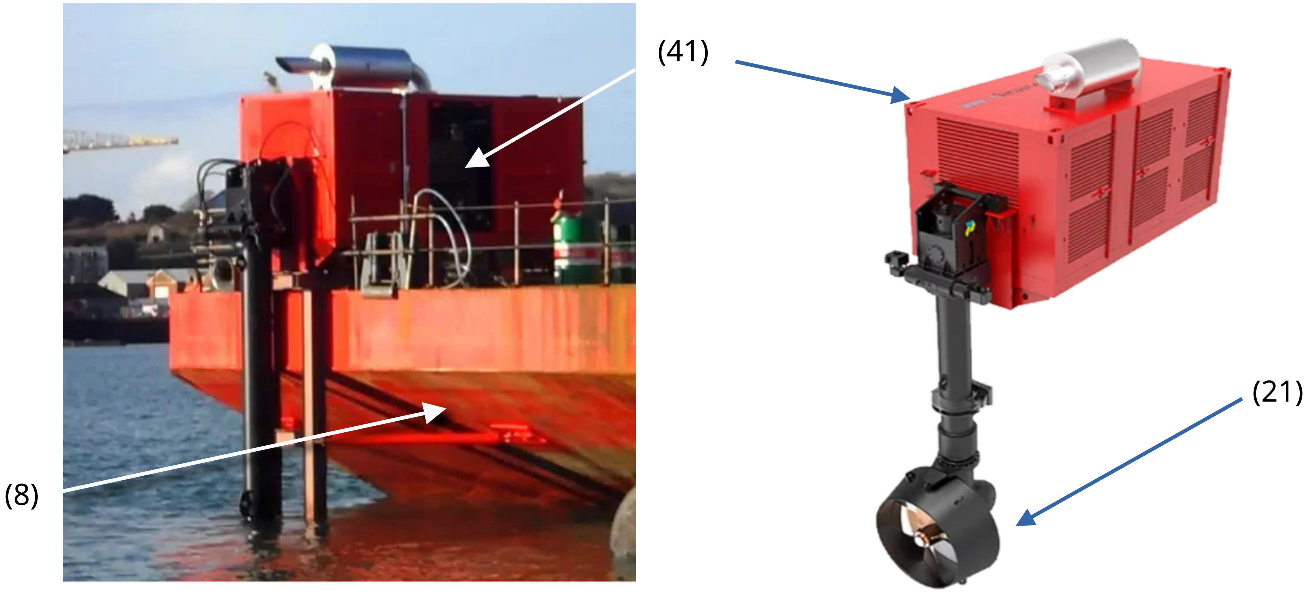

Fig 18