(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 882 123 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
22.09.2021 Bulletin 2021/38

(51) Int Cl.:
***B63B 27/10** (2006.01)*

(21) Application number: **20164617.1**

(22) Date of filing: **20.03.2020**

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

(71) Applicant: **MacArtney A/S**
6710 Esbjerg V (DK)

(72) Inventors:
- **Rasmussen, Lasse**
  6000 Kolding (DK)
- **Hansen, Uffe Nørgaard**
  7500 Holstebro (DK)

(74) Representative: **Inspicos P/S**
Kogle Allé 2
2970 Hørsholm (DK)

(54) **A METHOD OF HARVESTING ENERGY FROM A LIFTING STRUCTURE**

(57) A vessel with a boom/mast/crane (14) with an elevated element, such as a wire block (18), configured to move relative to the boom/mast/crane. A load (50) is supported by the elevated element. Energy is harvested from the relative movement of the elevated element and the boom/mast/crane.

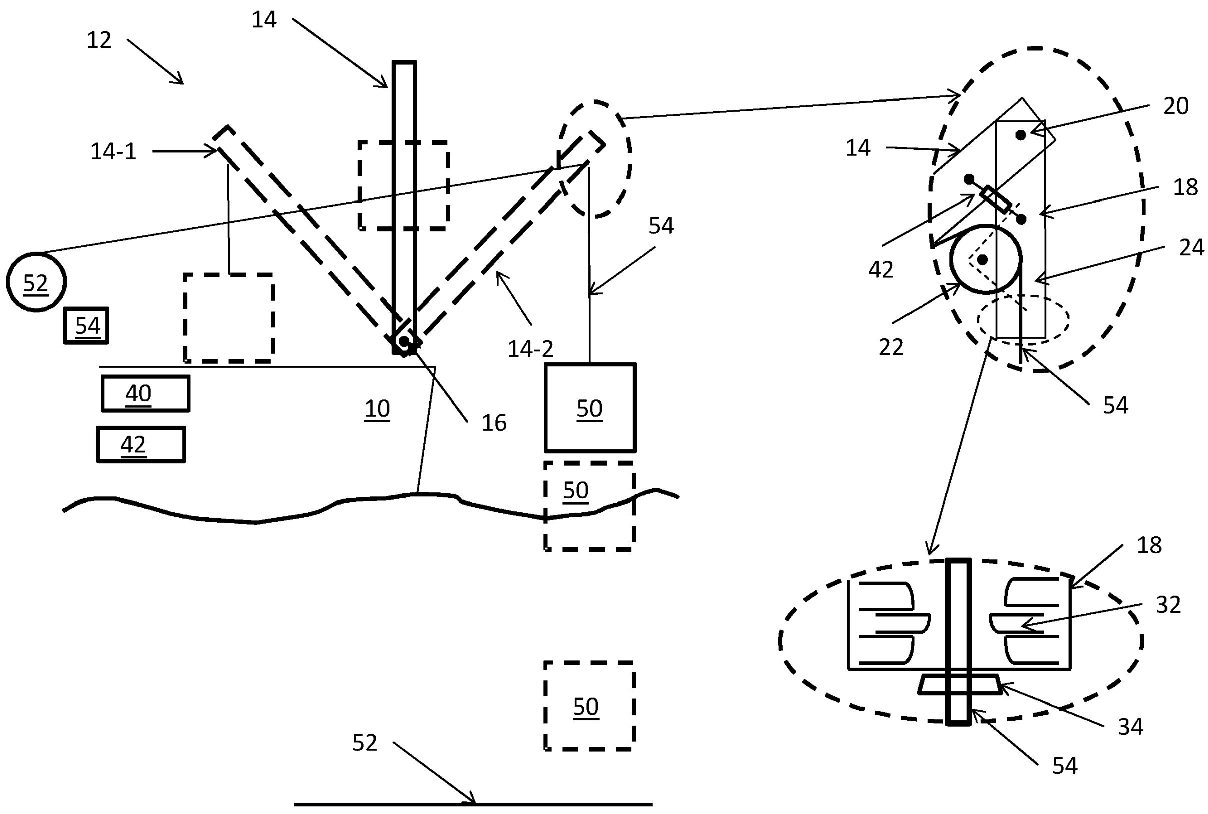

Figure 1

EP 3 882 123 A1

Description

[0001] The present invention relates to a method of harvesting energy from a lifting structure and in particular from a swinging or reciprocating portion of a lifting structure for vessels.

[0002] A first aspect of the invention relates to a vessel having an elevated element hanging from a portion from the vessel, the vessel further comprising means for harvesting energy from a movement of the elevated element relative to the portion.

[0003] In the present context, a vessel usually is a floating vessel, such as a ship, boat, or the like. The vessel may, however, be stationary in relation to the sea bed, such as an oil rig or other rig or structure standing on the sea bed.

[0004] A portion of the vessel may be a crane or other structure of the vessel. An especially interesting structure is a Launch And Recovery System (LARS) which is used for moving submersible tools from the deck to over the water. Often such portions or structures extend upwardly from the deck of the vessel. The portion/structure may, however, extend outwardly, such as horizontally or at least partly horizontally over the deck or from the deck and at least partly over the water/sea outside of the vessel.

[0005] An elevated element hangs from the portion. The element is elevated in the sense that it is not supported from below but is hanging below the portion or at least partly below the portion. This elevated element is able to move relative to the portion. This relative motion may be caused by waves causing the portion to alter its angle relative to vertical and/or to be translated at least partly in the horizontal plane. Another reason for the relative movement may be that the elevated element is attached to a load, the position of which shifts at least partly in the horizontal plane relative to the position of the portion. In a particularly interesting situation, the elevated element is attached to a load hanging from the elevated element or provided in the water below the elevated element so that movement of the vessel or the load relative to each other may cause relative movement between the portion and the elevated element.

[0006] The means for harvesting energy are provided to harvest energy from this relative movement.

[0007] The relative movement may be a translation but will usually be a rotation, such as around an axis. Then, the energy harvesting means may be configured or provided to harvest energy from movement along or around that axis. Naturally, the translation and/or rotation may be more complex, such as around multiple axes. In such situations, the energy harvesting means may be configured to harvest energy from translation/rotation along or around multiple axes or multiple energy harvesting means may be provided where each energy harvesting means may be configured to derive energy from relative movement around e.g. a single axis.

[0008] A large variety of means for harvesting energy exist. Almost all devices configured to generate a movement, such by generating a force or torque, may be used for converting such a relative movement into energy. Thus, hydraulic drives, electric drives, electric motors and the like may be used for harvesting energy.

[0009] In this context, harvesting energy may mean that the relative movement is converted into energy. Usually, this will mean that the relative movement is stopped or braked/decelerated to obtain energy to convert to energy. Usually, the energy derived from the energy harvesting is electric energy, but the harvested energy may as well be kinetic energy in the form of e.g. a rotating fly wheel, potential energy in the form of an elevated mass or load or hydraulic energy in the form of pressurized fluid.

[0010] In one situation, the elevated element comprises a wire block or the like rotatably connected to the portion. In this manner, a load may be lowered/lifted by or via the elevated element. The load may be connected to a wire, cable or the like extending between the load and a lifting means, such as a winch, via the elevated element. If the elevated element comprises a wire block the wire or cable may be allowed to run over the wire block and be redirected from the winch or another wire block or the like to the load.

[0011] Often such wire blocks may form part of a docking head of a LARS. A docking head often comprises, in addition to one or more wire blocks, also a locking arrangement for attaching a load to the docking head without requiring tensioning of any cable or wire.

[0012] Such docking heads thus may be capable of handling rather large loads and then often, as they are usually made of a metal, such as steel, are rather heavy. The relative movement of a heavy docking head or wire block thus may generate a lot of energy which may be ha rvested.

[0013] As mentioned, the harvesting means may comprise a hydraulic system provided between the elevated element and the portion. A hydraulic system is usually configured to generate a linear movement between a piston and a cylinder. This movement is generated by a flow of hydraulic fluid into or out of the cylinder. The fluid may be moved due to the operation of a motor, such as an electric motor.

[0014] Thus, reversing the operation, generating a relative translation between the piston and cylinder may cause the fluid to flow and thus a movement of the motor - which as a reaction will output electrical energy.

[0015] Yet another manner may be a purely mechanical conversion where the relative movement is fed to a flywheel, such as in the same manner as brake energy harvesting in vehicles.

[0016] In that or another situation, the harvesting means comprises an electric motor provided between the elevated element and the portion. In this manner, the relative movement may be directly translated by the motor to energy. If the relative motion is a rotation, the rotation may be fed directly to the rotor or the motor, for example.

[0017] However, it may be desired to provide additional elements to assist in the conversion of the energy. In one situation, the harvesting means further comprise a gear between the elevated element and the portion. This gear may be used for altering one rotation to a larger or smaller rotation, from one translation to a larger or smaller translation and/or from rotation to translation or vice versa.

[0018] Numerous types of gears exist, such as gears converting from rotation to rotation, such as gears comprising toothed wheels, such as are known from bicycles, cars or the like, or gears converting between rotation and translation, such as gears comprising a ball screw. Another type of gear is a type comprising an eccentric element. An eccentric element may convert between rotation and rotation or between rotation and translation. An eccentric element may alter the torque applied as a function of a position or rotation. One example of the use of an eccentric is that of compound bows where a larger torque is applied to the frame with the same force to the string.

[0019] In this connection, it is noted that "between the elevated element and the portion will mean that the energy harvesting means is configured to harvest energy from the relative movement of the elevated element and the portion. Usually, the energy harvesting means will have one part connected to, fastened to or fixed to, such as rotatably, the portion and another part connected to, fastened to or fixed to, such as rotatably, the elevated portion.

[0020] As mentioned, the energy harvesting means may have a gear which is then also provided between the portion and the elevated element. Then, the gear may have one part connected to one of the elevated element and the portion and another part connected to an energy harvesting element such as a motor, actuator or the like which then may have one part connected to the gear and another part connected to the other of the portion and the elevated element.

[0021] Then, a relative movement between the parts may be converted into energy. In some situations, the energy harvesting means is configured to be extended and/or compressed along a predetermined direction. In this manner, a translational relative movement between the elevated element and the portion may be harvested by attaching the energy harvesting element in that direction. One type of such energy harvesting means may comprise a linear actuator or a similar element. If the relative movement is a rotation, it may be desired that the first and second parts are rotatably connected to the elevated element and the portion, relatively.

[0022] In other situations, the energy harvesting element is configured to have one part rotated in relation to another part, such as is the situation for motors. Then, one part may be operatively connected to the rotor and the other part may be operatively connected to the remainder of the motor, for example. The operative connection may be a direct connection, a connection via a gear, for example, or a connection via one or more rigid elements and/or wires/chains configured to convey rotation to the motor. Then, if one of the elevated element and the portion is rotatable around an axis and relative to the other of the portion and the elevated element, the motor may be configured to have the rotor rotate around that axis so that the rotor may be attached to the elevated element and the remainder of the motor to the portion, or vice versa.

[0023] In one situation, the vessel further comprises means for blocking or locking relative motion between the elevated element and the portion. Situations exist where the relative movement between the elevated element and the portion is not desired, such as when this could result in contact between the elevated element and the portion - or a load connected to the elevated element.

[0024] In general, the load may be fixed or attached to the elevated element. In one situation, this has the advantage that when the load is attached/fixed to the elevated element, no other lifting element is required to maintain the load in position. This may be an advantage in that less power is required for holding the load in the correct position during rotation of the portion (see below). Naturally, the attachment/fixing may be automatic (such as a clicking action) in one direction, such as attachment and operatable, such as remotely operatable in the other direction, such as detachment.

[0025] If the locking/blocking is provided, the load may be fixed so that the locking/blocking of the relative movement will do the same to relative movement between the load and the portion. A too hard impact could damage the elevated element/load or the portion which clearly would not be desired,

[0026] Many types of means may be used for blocking or locking relative movement. Brakes of different types exist, such as brakes based on friction or a brake pawl. Other types of blocking/locking would be to block a motor, one part of which is connected to the portion and another connected to the elevated element. Blocking e.g. an electrical motor may be accomplished by operating the motor to counter any rotation thereof.

[0027] In one embodiment, the harvesting means is configured to generate energy by limiting a velocity of the relative movement to a velocity within a predetermined interval, such as a velocity below a predetermined maximum velocity. In fact, the harvesting means may be configured to allow a maximum velocity of the relative movement, where the maximum velocity may be made dependent of the relative position of the elevated element relative to the portion. Thus, the maximum allowable velocity may be higher at a central point of the relative movement than at extreme positions thereof.

[0028] In one embodiment, the harvesting means is configured to generate energy by providing a decelerating force to the elevated element to decelerate the relative movement. Deceleration may be obtained by applying an oppositely directed force. This may be achieved by braking the relative movement. When the velocity of the relative movement is reduced, energy is generated which may be harvested.

[0029] One manner of decelerating a movement is to brake it. Braking a movement and harvesting energy therefrom is a well-known technology seen in e.g. electrical cars.

[0030] In one situation, the harvesting means is configured to vary the deceleration force. A varying deceleration force has a number of advantages. If the elevated element may have different weights and/or different velocities, different deceleration forces are required to bring the relative movement to a standstill or to within a desired interval (position, distance and/or velocity). In one embodiment, a load may be attached to the elevated element whereby its weight will increase, sometimes dramatically. However, the root cause of the relative movement, i.e. usually the movement of the vessel due to waves, may not be affected by this, so that the force required to brake or control a higher weight needs to be higher.

[0031] In that or another situation, the harvesting means is configured to increase the deceleration force when the elevated means is closer to the portion. Alternatively, the force may be increased when a load connected to the elevated means is closer to the portion. Contact or impact of the load on the portion is not desired.

[0032] Naturally, the deceleration, position, velocity and the like may be along an axis or within a plane in which the harvesting means is configured to act. Clearly, if the harvesting means is configured to act in a predetermined plane, movement out of that plane may be desired braked or controlled, if at all, by other means.

[0033] Alternatively, the deceleration force may be defined and applied also as a function of a movement, position or angle of the vessel or a change thereof. It may be possible to foresee the relative movement between the portion and the elevated element from e.g. the vessels angle to horizontal and/or vertical. In some situations, the relative movement between the portion and the elevated element is dependent from but delayed in relation to the movement of the vessel, so that the relative movement between the portion and the elevated element may be predicted into the future. Then, the force applied may be applied based on that prediction.

[0034] In one situation, a load is supported by the elevated element. The load may be fixedly attached to the elevated element, or the load may be hanging from the elevated element. Especially in the first situation, it may be desired that the harvesting means is configured to increase the deceleration force for higher weights of the load. This deceleration force may be applied also to the load via the supporting of the load by the elevated element. In this connection, the fixed attachment of the load may be a stiff or rigid (not able to rotate around e.g. a horizontal axis relative to the elevated element) attachment so that a force, such as a horizontally directed force, applied to the elevated element may be at least partly transferred to the load.

[0035] In one situation, the harvesting means is configured to generate a first deceleration force when the load is submerged and a second, higher, deceleration force when the load hangs in the air.

[0036] In many scenarios, the relative movement is caused at least partly by the vessels movements caused by waves. Then, the relative movement may be upwardly directed but may mainly be sideways or more or less horizontally directed. When the load is submerged or at least partly submerged, movements thereof will be braked by the water,

[0037] In addition, the overall weight of the load will be lower when fully or partly submerged. Also for this reason may the required force be lower than if the load was fully above the water.

[0038] In addition, as explained above, if the load is connected to, such as fixed to, the elevated element, the overall weight which is to be braked will be larger, which may require a higher force.

[0039] In one situation, the portion is rotatable relative to the vessel between a first position where the elevated element is above a deck of the vessel and a second position where the elevated element is not above the deck of the vessel. Often, the portion is rotatable around a horizontal axis, which may be positioned at or close to an edge of the deck of the vessel. In this situation, the harvesting means is configured to provide a higher deceleration force in the first position than in the second position.

[0040] One reason for the higher deceleration force, or a maximum deviation from a predefined central position of the load, is that the load may be close to the portion or other elements on the deck of the vessel. Thus allowing a too large swinging or deviation of the load from a central position may cause impact and potentially damaging of the load and/or the portion or other elements on the deck.

[0041] The higher deceleration force may also be desired only in some directions or planes and perhaps not in other. For example, the portion may be a so-called A-frame, where the elevated element is carried by a top portion of the A-frame bridging the two more or less vertical legs. The load then is carried between the two legs when the frame is rotated from the second to the first position. Clearly, when the load is positioned between the legs, movement is desired restricted in the direction between the legs, so that the load is not allowed to touch and thus potentially damage a leg. Much larger movements may be allowed in the plane perpendicular to the plane defined by the two legs, at least until the load is close to the deck, where relative movement in the plane of the deck may be desired restricted to ensure that the load is landed on the deck without damage.

[0042] Thus, the relative movement may be controlled differently in perpendicular, vertical planes, especially when the portion is an A-frame or a frame having two upright legs and a bridging portion between these at the upper end. Then, when the portion is in the second position, less controlling may be needed, whereas when the portion is rotated, firstly movement is limited or braked out of the vertical first plane perpendicular to the plane defined by the legs. Then, when the portion approaches the first position, movement also in the first plane may be braked or limited so that relative movement between the load and the deck is limited when the load reaches the deck.

[0043] In one embodiment, where the portion may be an A-frame or the like, the portion may be rotatable so that the load moves in a vertical plane which is along the longitudinal direction of the vessel. In this situation, the harvesting means may further be configured to harvest energy from a movement of the elevated element, relative to the portion, in a vertical plane perpendicular to a longitudinal axis of the vessel.

[0044] In one embodiment, such as that described above, the vessel may further comprise means for blocking movement of the elevated element, relative to the portion, in a vertical plane perpendicular to a longitudinal axis of the vessel.

[0045] In that embodiment, for example, the harvesting means may be configured to harvest energy from a movement of the elevated element, relative to the portion, in a vertical plane parallel to a longitudinal axis of the vessel. Thus, by allowing movement in a plane, the integrity of the vessel including the load may be ensured while energy may be harvested. As described above, also the movement in this plane may be limited in some positions, such as some positions of the portion relative to the deck.

[0046] One embodiment of the first aspect of the invention further comprises an energy storage configured to receive energy from the harvesting means. This energy storage may be adapted to receive the type of energy produced by the harvesting means. Thus, the energy storage may be a battery or capacitor when the harvesting means is configured to output electrical energy. Alternatively, the energy storage may be a pressure tank for holding pressurized fluid, an elevated tank for receiving fluid pumped to an elevated position or e.g. a flywheel. An interesting type of energy storage is a Hydrogen tank. Especially on vessels, generation of Hydrogen is simple, as the energy harvested may be electric energy which may be fed to a converter also receiving water, such as sea water, and outputs Hydrogen which is captured and stored. Hydrogen may again be converted to electric energy, such as in a fuel cell as used in e.g. vehicles.

[0047] Clearly, a combination of energy storages may be used if desired. Also, multiple energy storages may be provided if desired. A battery, for example, may be suitable for longer term energy storage where a capacitor or a fly wheel may be more suited for short term energy storage. Also, one energy storage may be provided close to the elevated element or the harvesting means where another energy storage may be positioned more remotely therefrom.

[0048] The energy storage may receive energy also from other energy harvesting means of the vessel or even from e.g. a generator or an engine of the vessel.

[0049] Naturally, the energy generated by the harvesting means may be converted to be of a type suitable for the energy storage. Thus, if the energy generated is electrical, a fly wheel may be accelerated using an electrical motor connected to the fly wheel. Also, mechanical energy may be converted into electrical energy for feeding to a battery or a capacitor.

[0050] The energy storage may deliver energy to one or more energy consumers on the vessel. One such energy consumer may be a lifting element configured to lift a payload supported by the elevated element. Alternatively or additionally, the energy storage may power an element configured to rotate the portion in relation to the deck of the vessel. The rotation may be around a vertical axis but preferably around an axis parallel to horizontal or the deck of the vessel.

[0051] In general, the energy consumers and energy harvesting means may be based on electric energy. In that situation, a frequency converter or variable frequency drive may be used for receiving and forwarding the electric energy. Such circuits may have three or more portions including an AC portion connected to each energy consumer/provider (harvesting means) and a common DC portion via which the energy from harvesting means to consumers takes place. A battery may be seen as both a consumer and an energy provider. In this manner, only the power not immediately consumed is fed to the battery. if not enough power is generated, power is withdrawn from the battery. This has the advantage that only the power not immediately consumed is stored in the battery for later retrieval. Storage and retrieval of power from a battery brings about loss of energy and may thus be reduced.

[0052] In one situation, the vessel further comprises a controller configured to control a lifting element configured to lift a payload using energy from the energy storage. In many situations, the elevated element is configured to re-direct a wire or cable from a lifting element, such as a drum rotated by a motor, and to a load, such as a payload, attached to the wire/cable and which may hang from the elevated element and be lowered into the water by the drum.

[0053] In this situation, the controller may be configured to control the lifting element to only lift the payload above a predetermined depth, if the energy in the energy storage exceeds a first threshold limit. This is especially interesting if the lifting element is only powered by the energy storage. The predetermined depth may be a depth below the surface of the waters in which the vessel floats. The depth may be so shallow that a portion of the payload is no longer submerged. The predetermined depth may also be a height above the surface of the water.

[0054] When the vessel moves due to the waves, there is a risk that the payload will start swinging and thereby potentially hit the vessel, which clearly is not desired. If there is not sufficient power to lift the payload sufficiently, it may be desired to keep the payload or a part thereof submerged, as the water will dampen the movement thereof relative to the vessel. Actually, the depth may be a depth larger than the draft of the vessel so that it is prevented that it is prevented that the vessel hits the payload even if it floats over it.

[0055] During this situation, the harvesting means may still operate and feed energy to the energy storage which eventually may have sufficient energy to lift the payload.

[0056] The energy required may be the energy required to lift the payload all the way to the elevated element. In one embodiment, as is also described further above, the payload may be attached to the elevated element so that the lifting means need no longer carry the weight of the payload. The energy required may be the energy required to lift the payload to a height where it may be attached to the elevated element - added the power required to activate or operate any locking element of the elevated element configured to engage the payload and support its weight.

[0057] In one situation, the portion is rotatable and the controller is configured to control the portion to not rotate to a position where the payload is above the vessel, until the energy in the energy storage exceeds a second threshold limit. As described above, the portion may be rotatable to bring the load from a position in which the load is over the deck to a position in which the load is over the water. In some positions of the portion, the harvesting means may be able to harvest energy whereas this may be more difficult in other positions.

[0058] For example, in some positions, it may be desired to restrict relative movement between the load and/or elevated element and the portion, whereas a more free relative movement, and thus energy harvesting, may be allowed in other positions.

[0059] Thus, if there is not sufficient energy in the energy storage to rotate the portion to the final position, where the payload is above the vessel, such as above a predetermined area of the deck, it may be desired to not rotate the portion to maintain the payload in a position over the water where relative movement may be less restricted or less risky for the portion and payload and where the harvesting means may be operable to generate energy and feed this energy to the energy storage.

[0060] In e.g. the situation where the portion is an A-beam, such as a LARS, the rotation of the portion will bring the payload between the two legs, where restriction of the sideways movement of the payload may be desired. Further rotation to the position where the payload is close to the deck may require additional restriction of the movement of the payload relative to the deck, so that energy harvesting may be difficult.

[0061] It is noted that in general, the relative movement need not be between two portion of a crane or mast of the vessel. One of the elements may be a portion of the vessel and the other portion may be a payload hanging from a lifting element or the portion.

[0062] A second aspect of the invention relates to a method of harvesting energy, the method comprising harvesting energy from a movement of an elevated element of a vessel relative to a portion of the vessel, where the elevated element hangs from the portion.

[0063] Naturally, all aspects, embodiments, situations or the like may be combined with each other in any desirable manner.

[0064] A third aspect of the invention relates to a method of harvesting energy from an elevated element hanging from a portion, such as a LARS, of a vessel, the method comprising converting kinetic energy of the swinging elevated element into electrical or hydraulic energy.

[0065] In one embodiment, the step of harvesting the energy comprises harvesting energy from relative movement between the portion and a wire block or the like rotatably connected to the portion. A wire block may be a heavy element which is rotatable in order to allow it to maintain a direction of a cable or wire extending from the wire block and to a submerged payload. When the vessel moves due to the waves, the angle between vertical and the portion will change. This variation could be transferred to the wire/cable, if the elevated element or wire block was not allowed to rotate in relation to the vessel and/or portion.

[0066] This relative motion may, due to the forces involved, have a rather large torque, whereby a fair amount of energy may be harvested over time.

[0067] In one situation, the harvesting step comprises the step of proving the relative motion to a hydraulic system outputting energy. The energy may be output as hydraulic energy which may increase the pressure of a fluid in a tank, or to elevate a liquid to a higher position. Alternatively, the hydraulic energy may be converted to electrical energy.

[0068] In another situation, the harvesting step comprises providing the relative motion to an electric motor outputting energy. In this manner, electrical energy may be output which is simple to transfer, store, retrieve and use.

[0069] Clearly, the harvesting step may further comprise providing the relative movement to a gear, such as a gear comprising toothed wheels or a ball screw, or even an eccentric element, to convert the relative movement to a larger movement, a rotation, a translation or the like, depending on the type of harvesting means used.

[0070] In one embodiment, the method further comprises the step of blocking or locking relative motion between the elevated element and the portion. As described above, this may be employed if there is a risk that the elevated element or a load attached thereto or hanging therefrom will impact on the portion, the vessel or the like.

[0071] In one embodiment, the harvesting step comprises generating energy by providing a decelerating force to the elevated element to decelerate the movement. The decelerating force may be generated by braking the relative movement. This braking may be achieved in the same manner as is seen in e.g. vehicles where an electrical motor is configured to convert kinetic energy to electric energy. In other systems, a vehicle may be braked by converting the kinetic energy of the vehicle into kinetic energy in a fly wheel.

[0072] In one embodiment, the harvesting step comprises varying the deceleration force. A varying force may, as is described above, be desired for increasing the deceleration or braking when the relative movement or relative position reaches or approaches a threshold position or a certain distance, angle or the like from a central position or angle.

[0073] For example, the harvesting step may comprise increasing the deceleration force when the elevated means is closer to the portion. In this manner, the deceleration or braking may increase so as to prevent impact or contact between the portion and the elevated element or a load connected thereto or hanging therefrom.

[0074] In one situation, a load is supported by the elevated element. This supporting may be the load hanging from the elevated element. Alternatively, as is also described further above, the load may be attached to, such as fixed to or rigidly attached to, the elevated element.

[0075] Then, the harvesting step may comprise increasing the deceleration force for higher weights of the load. When a higher load is supported, a higher force may be required if the relative movement is to be controlled, decelerated or braked. Thus, the deceleration force may be altered as a function of the weight of the load or the combined weight of the payload and elevated element. In addition thereto, the force may also be adapted to the position as described above.

[0076] In one embodiment, the harvesting step comprises generating a first deceleration force when the load is submerged and a second, higher, deceleration force when the load hangs in the air. When the load, or at least a part thereof, is submerged, the water may assist in braking the movements thereof, so that a relatively small force may be required to brake the relative movement of the elevated element. The elevated element and the load may be interconnected, but usually the interconnection, such as via a cable or wire, is sufficiently flexible to not transfer all forces from the load to the elevated element.

[0077] When the load is lifted to above the water, however, all forces of the load may be transferred to the elevated element, whereby the forces required may be higher.

[0078] Especially in the situation where the load is connected to, such as fixed to, the elevated element, large forces may act on the elevated element and thus the harvesting means, during the relative movement. Then, it may be desired to be able to act on the elevated element - or the load - with equally large forces if required, to be able to brake the movement.

[0079] Thus, the deceleration force may be varied for a number of reasons.

[0080] Varying the deceleration force may be obtained using e.g. a gear converting the relative movement to a movement fed to an actuator or generator. When a larger force is required, a higher gear may be selected to convert the same relative movement into more movement of the actuator/generator.

[0081] Alternatively, if the harvesting means is based on an electrical motor, the torque applied by the motor to rotation thereof may be controlled. This is standard in variable frequency drives today.

[0082] It is noted that electric motors often have therein position encoders and torque feed back. Thus, from the encoder, it may be possible to determine the position and/or angle of the elevated element vis-à-vis the portion. Thus, the torque applied by the motor as a response to the relative movement may be controlled based on the encoder output, so that the braking force may be tailored as desired.

[0083] In one embodiment, the portion is rotatable relative to the vessel between a first position where the elevated element is above a deck of the vessel and a second position where the elevated element is not above the deck of the vessel, such as over the water. In this situation, the harvesting step preferably comprises providing a higher deceleration force in the first position than in the second position. As described above, it may be desired to provide a higher deceleration force to limit the relative movement between the elevated element and the portion. In some positions, a large relative movement or displacement is not desired. This may be prevented by increasing the braking force. Alternatively, relative movement may be prevented in these situations. As described above, relative movement may be allowed in one plane but prevented or braked in another plane.

[0084] In one embodiment, the harvesting step comprises harvesting energy from a movement of the elevated element, relative to the portion, in a vertical plane perpendicular to a longitudinal axis of the vessel. If the portion is an A-frame, such as a LARS, this plane may be parallel to a plane comprising the two legs when vertical. This movement may be caused by the rolling of the vessel.

[0085] In that or another embodiment, the method further comprises the step of blocking movement of the elevated element, relative to the portion, in a vertical plane perpendicular to a longitudinal axis of the vessel. This plane may be that described above. This has the advantage that when the A-frame is rotated from the outlier position to the position over the deck, the load is transported between the A-frame legs. This blocking of the movement acts to prevent the load from impacting on the legs when positioned between the legs.

[0086] In one embodiment, the harvesting step comprises harvesting energy from a movement of the elevated element, relative to the portion, in a vertical plane parallel to a longitudinal axis of the vessel. Thus, a swinging along the longitudinal axis of the vessel may be allowed even when rotating the A-frame, as long as the swinging is along that direction. Thus, energy harvesting may be possible even during rotation of the portion.

[0087] This movement prevention or braking thus may be different in different planes.

[0088] In one embodiment, the method further comprises feeding harvested energy to an energy storage.

As described above, the energy storage may be of different types, and the energy may be converted between the harvesting and the storage if required.

[0089] Multiple energy storages may be provided. One energy storage may be provided close to the harvesting means, such as if the harvesting means or an energy consumer close thereto requires energy. In that manner, the set-up is not dependent on power lines from the harvesting means to a more remote energy storage and back again. This provides a more fail-safe set-up where the energy consumer close to the harvesting means may operate independently of a more remote energy storage.

[0090] The elevated element may have additional power consumers such as a brake for locking relative movement, at least in one plane or direction, between the elevated element and the portion. Another power consumer could be means for rotating the load relative to the elevated element. This rotation may be desired in order to have the payload have a desired direction before e.g. rotating the portion to bring the payload on to the deck. If the payload has, in a horizontal plane, a longer and a shorter dimension, it may be desired to align the shorter dimension along an axis between the legs of e.g. an A-frame in order to have maximum space between the payload and the legs during rotation.

[0091] In fact, it may be desired to provide a separate frequency converter or variable frequency drive in the elevated element to transport the harvested energy to the energy consumers without firstly feeding it to a battery.

[0092] In one situation, the method comprises the step of controlling a lifting element lifting a payload using energy from the energy storage. In that situation, especially when the lifting element is powered only by the energy storage, the controlling step may comprise controlling the lifting element to only lift the payload above a predetermined depth, if the energy in the energy storage exceeds a first threshold limit. As described above, this threshold limit may be defined to allow the payload to be lifted to the elevated element and optionally be attached thereto. Clearly, this threshold limit may be determined based on e.g. the weight of the payload.

[0093] In one example, the method further comprises the step of rotating the portion, wherein the rotation step comprises not rotating the portion to a position where the payload is above the vessel, until the energy in the energy storage exceeds a second threshold limit. In that manner, it may be ensured that the portion is not rotated until there is sufficient energy to achieve the full rotation. The second threshold limit may then define sufficient energy to allow the portion to rotate to the desired position. Optionally, the second threshold limit may also define sufficient energy to ensure that the payload is lowered to the deck.

[0094] In one situation, the swinging elevated element is a payload hanging from a lifting element. Thus, the lifting device may be the portion which needs have no swinging or rotating portions. The energy then may be harvested directly from a relative movement between the portion and the payload.

[0095] Another aspect of the invention relates to a method of harvesting energy on a vessel comprising a winch and a wire block (or the like) as well as a payload attached to one end of a wire running over the wire block and attached to the winch, the method comprising altering between:

- a first mode where the winch is controlled to maintain the payload at at least approximately the same height over the seabed and
- a second mode in which movement of the winch is converted into electrical or hydraulic energy.

[0096] In this context, the method may be as described above. In this situation, however, the portion and the elevated may not be needed or may not need the functionality described above. The portion may be a standard boom, mast or crane and need not e.g. be rotatable. The elevated element needs no harvesting means.

[0097] The wire may be any type of wire, cable, rope or the like suitable for attachment to a load to be submerged from a vessel. Often, the wire/cable is made of a polymer and/or metal. The wire/cable may merely be suited for supporting the weight of the load. Other types of wire/cable are additionally configured to transport power, signals, information, liquid or the like to/from the load.

[0098] Preferably, the wire/cable is bendable so as to be suitable for winding on to a drum or standard winch.

[0099] A winch in this connection is an element which is capable of storing a length of the wire, cable or the like. Often, a winch has a drum for storing the wire/cable when not in use. Also, the winch normally has one or more motors for rotating or driving the winch to output or draw in wire. Other structures exist where the cable is driven by e.g. a number of rollers and stored in a storage space in which it is not e.g. rolled on a drum.

[0100] The wire block may be any type of element capable of guiding a wire or cable. A rotatable wire block is often used, as it generates no wear on the cable. A stationary portion of e.g. a crane or boom would also be useful. The wire block has the advantage that it may redirect the wire or cable from a direction toward the winch or another wire block or the like guiding the wire/cable from the winch toward the wire block, and toward the load when elevated/submerged.

[0101] As described above, the wire block may be rotatable or allowed to have a relative movement relative to the boom/crane/portion. This may reduce stress to the cable/wire when the load is submerged. Additionally, energy may be harvested from that movement.

[0102] Naturally, as described above, the load may be attachable to the wire block or boom/crane if desired.

[0103] According to the invention, the method comprises altering between:

- a first mode where the winch is controlled to maintain the payload at at least approximately the same height over the seabed and

- a second mode in which movement of the winch is converted into electrical or hydraulic energy.

[0104] The first mode may be a mode often called "active heave compensation" where the payload is maintained at more or less the same height over the seabed or in the same position in the body of water in which it is provided. The payload may then be a platform or dock for a swimmer, ROV or the like. When the platform does not move to any substantial degree relative to the body of water, it may more easily exit or detach from the platform and enter or attach to the platform again. Naturally, a relative movement may be seen relative to the seabed or the body of water. It is noted that currents will make the water move in relation to the seabed so that some relative movement may be expected and accepted. A relative movement between the platform and the seabed may be below a 10m/s, such as below 5m/s, such as below 2m/s, such as below 1m/s.

[0105] The relative movement is primarily or only in the vertical direction. This relative position is controlled by the winch which will output wire/cable when the vessel moves upwardly due to waves and will draw in wire/cable when the vessel moves downwardly. This may be controlled by a load/torque of the winch or using GPS/accelerometers/inclination sensors or the like on the vessel.

[0106] The second mode is a mode in which relative movement is allowed between the seabed and the payload. Thus, the heaving of the vessel may pull the payload upwardly, which will create an increased torque on the wire/cable. This torque or pull may be converted to energy by allowing the winch to rotate or otherwise output wire/cable. From this movement, energy may be harvested in much the same manner as described above.

[0107] Energy harvesting may be obtained using the same motor(s) or actuator(s) provided for controlling or facilitating the outputting and retrieval of cable/wire. For example, an electrical motor may generate energy by braking a rotation of its rotatable part relative to its other part.

[0108] The overall direction of movement of the payload thus is downwardly, as each upward movement may comprise the outputting of more wire/cable. Naturally, the payload needs to be elevated again.

[0109] When the vessel descents from the top of a wave, the winch may be controlled to draw in a length of the wire/cable. In this situation, the drawing in requires less force and thus energy, as the downward movement of the vessel aids to slack the wire/cable or at least reduce the force required to elevate the payload, such as to the same relative distance to the sea bed.

[0110] Thus, energy is generated and may be fed to an energy storage or used for e.g. powering the winch when the payload is desired retrieved back to the vessel.

[0111] As said, the second mode may comprise the steps of:

- when the vessel elevates, the winch outputting wire and energy,

- when the vessel moves downwardly, the winch receiving wire.

[0112] The amount of wire output and that received may be the same or not.

[0113] Another aspect of the invention then relates to a vessel comprising a winch and a wire block, or the like, as well as a payload attached to one end of a wire running over the wire block and attached to the winch, the vessel further comprising a controller configured to control the winch to alter between:

- a first mode where the winch is controlled to maintain the payload at at least approximately the same height over the seabed and
- a second mode in which movement of the winch is converted into electrical or hydraulic energy.

[0114] Then, as described, the controller may operate the winch so that the second mode comprises the steps of:

- when the vessel elevates, the winch outputting wire and energy,

- when the vessel moves downwardly, the winch receiving wire.

[0115] Yet another aspect of the invention relates to a method of generating energy on a vessel comprising a winch and a wire block as well as a payload attached to one end of a wire running over the wire block and attached to the winch, the method comprising lowering the payload into a body of water, such as the water, ocean, lake, river or the like, in which the vessel floats, while generating energy from the winch outputting wire/cable.

[0116] This energy may be fed to an energy storage and fed back to the winch when the payload is again desired elevated.

[0117] In the following, preferred embodiments of the invention will be described with reference to the drawings, wherein:

Figure 1 illustrates the operation of a Launch And Recovery System,

In figure 1, a vessel 10 comprises a lifting device 12 comprising an elevated element, such as a crane, boom or rod 14 rotatable around an axis 16. In many applications, the boom 14 actually is an A frame, such as a Launch And Recovery System (LARS) having two uprights rotatable around the same axis 16 and usually both driven by a separate drives, such as hydraulic or electric drives.

[0118] A winch 52 is provided for elevating or lowering a load 50 toward or from a wire block 18 attached to the boom 14 using a wire 54 attached to the winch and the load.

[0119] The boom 14 may be rotated, around an axis 16 and in relation to the vessel 10 from a first position, 14-1 at which the load may be positioned on or above the deck of the vessel and a second position 14-2 at which the load may be lowered into the water outside of the deck of the vessel.

[0120] The load 50 may be a submarine, ROV or robot for inspecting vessels, platforms or the like and a launch platform for holding the robot during lowering and elevation thereof.

[0121] Often, the robot, ROV or submarine is connected to an operator on the vessel via a cable, which runs via the platform of the load 50, so that the platform is not retrieved during operation of the submarine/robot.

[0122] Thus, during operation of the submarine/robot, which operation may take many hours, the platform 50 is provided in the water and thus will pull the cable 54 downwardly due to gravity but also to the side due to the relative movement of the vessel relative to the platform due to the waves, current and the like.

[0123] This pulling will cause a force to be exerted on to the winch but also to the wire block 18 which, when movable in relation to the boom 14 will be moved due to the pulling of the wire 54.

[0124] This relative movement between the boom 14 and the wire block 18 may be converted into energy by providing an energy harvesting element 42 between the boom 14 and the wire block 18. Relative movement between the boom 14 and the wire block 18 will then act on the harvesting element which may then output energy.

[0125] To the right in figure 1, an expanded view is provided of the top of the boom 14 comprising the wire block 18. The wire block 18 comprises a block element 22 over which the cable or wire 54 runs from the winch to the load. The block element 22 is rotatably connected to an arm 24 which is connected to the boom 14 to be rotatable around an axis 20. Naturally, the axis may be directed in any desired manner. In one situation, the main movement is in a plane perpendicular to a longitudinal axis of the vessel. This may be the situation where the vessel is elongated and the boom 14 extends from the rear of the vessel which will mostly roll. Rolling is around a horizontal axis along the longitudinal axis of the ship. Usually, the wire will be mostly downwardly directed, so that when the wire block 18 more or less follows the direction of the wire, the relative movement between the boom 14 and the wire block will be a rotation around a, often horizontal, axis parallel to the longitudinal axis of the vessel.

[0126] Naturally, the vessel may also pitch (rotation around a horizontal axis perpendicular to the longitudinal axis of the vessel) or yaw (rotation around a vertical axis).

[0127] Pitching may cause the above effect if the boom 14 extends not from the rear of the vessel but from a side thereof.

[0128] Thus, the relative movement may be converted into energy.

[0129] Naturally, the manner in which the wire block 18 is connected to the boom 14 may be tailored to the expected relative movement between the boom and the wire block. If the movement is primarily expected in one plane, the wire block may be made rotatable in that plane such as by being rotatable around an axis perpendicular to the plane.

[0130] If a more complex movement is desired allowed or captured, the wire block may be rotatable around multiple axes relative to the boom.

[0131] The harvesting element may be tailored to the expected relative movement between the wire block and the boom and/or to the possible relative movement between the wire block and the boom. If the relative movement is a rotation around one axis, the harvesting element may capture that rotation.

[0132] The harvesting element may be an element configured to convert an extension or compression thereof into energy. Alternatively, the harvesting element may be configured to convert rotation into energy.

[0133] Naturally, a converter may be provided converting a rotation into a translation if desired, so that any type of harvesting element may be used to capture energy from any relative movement.

[0134] Linear actuators may be embodied in a large number of manners including ball screws, spindles, hydraulics and even telescoping actuators.

[0135] A rotational converter may be a rotational motor, such as an electrical motor. Rotation of the rotor relative to the stator, for example, will make the motor output energy.

[0136] A compression/extension may be captured by a linear actuator. Linear actuators may be based on hydraulics or e.g. spindles. Often, such linear actuators are driven by - or in this example drive- rotational actuators such as motors. The linear actuators thus act to convert the longitudinal movement into a rotational movement.

[0137] A linear actuator may be configured to convert a compression/extension of 2 cm to a rotation exceeding 40 degrees, such as exceeding 50 degrees, such as exceeding 90 degrees, such as a rotation exceeding 120 degrees, such as exceeding 150 degrees, such as exceeding 180 degrees, such as a rotation exceeding 200 degrees, such as exceeding 270 degrees, such as exceeding 360 degrees.

[0138] An actuator may be configured to output energy from both directions of a cyclic movement or may be biased in one direction (such as a telescopic chain based actuator) in one direction and output energy in the other.

[0139] Other types of movement conversion are gears. A gear may convert one movement/rotation into another, larger or smaller, rotation. Gears may also be used for converting between linear and rotational movement.

[0140] Gears may then be used for converting a small rotation, such as a rotation below 10 degrees, into a larger rotation, such as a rotation exceeding 40 degrees, such as exceeding 50 degrees, such as exceeding 90 degrees, such as a rotation exceeding 120 degrees, such as exceeding 150 degrees, such as exceeding 180 degrees, such as a rotation exceeding 200 degrees, such as exceeding 270 degrees, such as exceeding 360 degrees.

[0141] Gears may be embodied in a number of manners including toothed wheels.

[0142] Naturally, multiple energy harvesting elements may be used. In one situation, different harvesting elements act in different planes or around different axes, such as planes/axes with a non-zero angle between them. In that manner, relative movement not in a single plane may be converted into energy.

[0143] The energy harvested naturally may be fed to a battery 40 or other energy storage of the vessel. A controller for controlling the operation of the boom, winch or the like may also be provided on the vessel. Other types of energy storage are pressurized tanks, flywheels or the like.

[0144] The energy clearly may be used for driving the winch and/or any rotation of the boom as described above.

[0145] In that situation, it may be possible to make the present system a stand-alone system in which no power from the outside is provided to the energy storage. In that situation, it may be desired to ensure that sufficient energy is available, before certain operations are commenced.

[0146] For example, due to the potential swinging of the load, due to the waves, when elevated above the water, it may be desired to only elevate the load to a height close to the surface or above the water, when sufficient energy is available to lift the load to a predetermined distance from the wire block - or preferably into a locking position in which the load is attached to the boom or wire block. In figure 1, two other positions of the load, a partly submerged and a fully submerged, is illustrated.

[0147] In the lower right illustration of figure 1, the lower part of the wire block is seen in which the cable 54 extends through a movable or expandable lock 32. The lock 32 may expand the opening therein in which the cable 54 runs so that a stopper 34 fixed to the cable or to the load, may pass there through. When the lock 32 is open, the stopper may pass downwardly so that the load may be submerged. Elevating the load may be performed to the step where the stopper 34 passes through the lock 32 which is then narrowed to prevent downward movement of the cable and the load. Thus, the load may be attached to the wire block so that the winch does not have to provide the force overcoming the weight of the load.

[0148] Thus, it may be desired to not elevate the load from the water, until sufficient energy is available to bring the stopper in engagement with the lock.

[0149] When the boom is rotatable as described above, it may be desired to not lift the load from the water, until sufficient energy is available to both lift the load and rotate the boom, so that the load may be positioned on the vessel deck. Clearly, lowering the load on to the deck may again be the source of energy harvested from the winch (see below).

[0150] Alternatively, it is noted that the load, when elevated, may also swing due to the movement of the vessel caused by the waves. This swinging may be a swinging of the wire block in relation to the boom so that the harvesting element 42 may be used. Thus, energy may be harvested during this phase. This may be in the situation where the energy storage does not have sufficient energy to rotate the boom. The load may be left swinging until sufficient energy is available.

[0151] In this situation, it is noted that the force transferred to the harvesting element may be much higher than when the load was submerged. Thus, more energy may be harvested.

[0152] Then, it may be desirable to provide a harvesting element 42 which is capable of varying the braking or deceleration of the movement (linear, rotational or combinations thereof).

[0153] In one situation, this breaking/deceleration is a function of the displacement/rotational angle thereof. It is desirable to be able to brake the relative movement between, in this embodiment, the wire block and the boom. An extreme position, or multiple extreme positions, may be determined and the braking/deceleration may be increased when the relative position between the wire block and the boom approaches an extreme position, such as a collision position. This may harvest optimal energy while possibly preventing that the extreme position is reached or acting to, if the extreme position is reached, this is with a sufficiently low relative velocity to prevent damage to the boom, wire block and load.

[0154] This varying of the deceleration/braking may be a uniform variation determined as a function of the relative position. The closer to an extreme position, the higher force. Alternatively, a step function may be determined so that the deceleration/braking is increased from a lower to a higher value when a threshold position is overstepped in the direction of an extreme position.

[0155] In another situation, the breaking/deceleration may be varied depending on the forces generated causing the relative movement. In one example, the relative movement is created by a varying angle from the boom to the wire extending from the block to the submerged load. In another example, the relative movement is that between the elevated load and the angle of the boom. Clearly, much larger forces will be generated in the latter situation.

[0156] Electronically, the two positions may be determined from the actual weight of the load, which clearly is lower when it is submerged. This weight may be determined from the torque delivered by the winch. This torque may be read out from motor(s) driving the winch.

[0157] Also, an elevated load may be determined from operation of the lock 32. If this is closed and the stopper 34 is above it, the load is elevated.

[0158] Then, it may be desired to be able to provide a much higher braking or deceleration of the relative movement in the elevated situation. Then, much more energy may be harvested per unit of time.

[0159] Also, it may be desired to prevent excessive relative movement causing the load to impact on the boom, for example. Thus, for this situation, one or more extreme positions may be defined, as described above, so that the two above situations may be combined, so that not only is the mean braking/deceleration larger, the braking/deceleration is still varied as a function of the relative position.

[0160] Different manners exist of varying the braking/deceleration of an energy harvesting means. A simple manner is a gear between the relative movement and a motor or other energy harvesting means. Thus, if a higher braking/deceleration is desired, a higher gear ratio may be selected so that e.g. an electrical motor generating a predetermined energy output per rotation may be used. Increasing the gear ration makes the motor perform more rotations for the same relative movement change between the boom and the wire block.

[0161] A gear may also make a linear actuator displace a larger (or smaller) distance for the same relative movement between the boom and the wire block again creating a resulting variation in the deceleration/braking and a variation in the energy harvesting.

[0162] Optionally, the circuit controlling the motor and thus receiving power from the motor may be adapted to adapt so that the resistance or torque provided by the motor against the rotation thereof may be adapted. If the energy harvesting means is based on a hydraulic technology, the force applied may be controlled by controlling the allowable flow into or out of the hydraulic cylinder or a motor controlling/generating the flow of the hydraulic fluid.

[0163] If the energy harvesting means comprises an electric motor, the motor may be controlled to give a larger or lower resistance to rotation of the rotor.

[0164] Generally, the motor or harvesting means may have therein e.g. a position or rotation encoder outputting information as to a rotation or rotational position thereof. This information may be used by the controller to estimate a position and/or a rotational position of the docking head and/or the payload. This may again be used for adapting the countering force to the position, so that the force may be increased when the docking head/load approaches a maximum or extreme position.

[0165] The docking head may have yet a functionality. It may be configured to rotate the load to a desired rotational direction before rotating the boom 14. The load may, in the horizontal plane, be longer than its width so that the load may be rotated to have its width direction along the direction between the legs of e.g. an A frame.

[0166] Another aspect of the invention relates to harvesting energy when lowering the load into the water.

[0167] As the loads usually have a mean density higher than that of water, gravity will pull them toward the seabed 52 even when fully submerged. Thus, in order to prevent a free fall of the load, the winch may be controlled to brake this movement by braking or controlling the output of wire/cable to the block during the descent of the load to the desired depth or height above the seabed.

[0168] This braking or controlling may be converted into energy by driving e.g. a motor of the winch to harvest energy from the pull provided by the load.

[0169] In addition, once the load is at the desired depth/height, different modes of operating the winch may be selected. In some situations, it is desired that the load or at least a part thereof presently attached to the cable is maintained at a desired height above the seabed. This mode may be called "Active Heave Compensation" where any heave (the vessel is lifted/lowered due to the surface waves of the water) is compensated for by the winch so that the load is maintained preferably fixed in relation to the seabed. This mode is especially relevant when part of the load is a ROV or the like and another part is a ROV platform for delivering the ROV to the water and for receiving it again for retrieval. In this situation, it is desired that the platform is more or less stable in the body of water in which the ROV moves. This heave compensation however is energy consuming, as it requires the winch to constantly overcome the weight of the load and of the cable and to constantly receive or output wire.

[0170] Another mode may be to allow the load to have a varying height above the seabed, such as when the ROV is supported by the platform or when the ROV has left the platform and is working.

[0171] In that situation, the pulling of the wire experienced when the vessel is elevated, relative to the seabed, by the waves, may be converted into energy. This pulling will be created not only by the weight of the submerged load (or part thereof) but also due to the friction between the load and the water resisting the upward movement of the load relative to the body of water in which the load is provided. When the vessel returns downwardly, the load may be allowed to also be lowered, whereby gravity merely pulls the load downwardly, overcoming the friction created between the load and the water.

[0172] Naturally, the puling created by the upward movement of the vessel may result in an outputting of a length wire by the winch. The opposite movement may then comprise the winch receiving a corresponding length of wire. This withdrawing of wire will not require as much energy as was generated by the pulling, as the vessel may move faster downwardly than the load (the movement of which is braked by the water), so that this withdrawing of wire may require only lifting the weight of the wire (most of it is in the water) and not overcoming any friction between the load and the water to provide the desired displacement between the load and the vessel.

[0173] The winch then may be controlled to alter between the heave compensation mode and the mode wherein the load or a portion thereof may be allowed to vary its distance to the sea bed and wherein puling of the wire is converted into energy.

EMBODIMENTS

[0174]

1. A vessel having an elevated element hanging from a portion from the vessel, the vessel further comprising means for harvesting energy from a movement of the elevated element relative to the portion.

2. A vessel according to embodiment 1, wherein the elevated element comprises a wire block rotatably connected to the portion.

3. A vessel according to embodiment 1 or 2, wherein the harvesting means comprises a hydraulic system provided between the elevated element and the portion.

4. A vessel according to any of embodiments 1-3, wherein the harvesting means comprises an electric motor provided between the elevated element and the portion.

5. A vessel according to any of the preceding embodiments, wherein the harvesting means further comprise a gear between the elevated element and the portion.

6. A vessel according to embodiment 5, wherein the gear comprises toothed wheels.

7. A vessel according to embodiment 5, wherein the gear comprises a ball screw.

8. A vessel according to embodiment 5, wherein the gear comprises an eccentric element.

9. A vessel according to any of the preceding embodiments, further comprising means for blocking or locking relative motion between the elevated element and the portion.

10. A vessel according to any of the preceding embodiments, wherein the harvesting means is configured to generate energy by providing a decelerating force to the elevated element to decelerate the movement.

11. A vessel according to embodiment 10, wherein the harvesting means is configured to vary the deceleration force.

12. A vessel according to embodiment 11, wherein the harvesting means is configured to increase the deceleration force when the elevated means is closer to the portion.

13. A vessel according to embodiment 11 or 12, wherein a load is supported by the elevated element and wherein the harvesting means is configured to increase the deceleration force for higher weights of the load.

14. A vessel according to embodiment 13, wherein the harvesting means is configured to generate a first deceleration force when the load is submerged and a second, higher, deceleration force when the load hangs in the air.

15. A vessel according to any of embodiments 11-14, wherein the portion is rotatable relative to the vessel between a first position where the elevated element is above a deck of the vessel and a second position where the elevated element is not above the deck of the vessel, and wherein the harvesting means is configured to provide a higher deceleration force in the first position than in the second position.

16. A vessel according to any of the preceding embodiments, wherein the harvesting means is configured to harvest energy from a movement of the elevated element, relative to the portion, in a vertical plane perpendicular to a longitudinal axis of the vessel.

17. A vessel according to any of the preceding embodiments, further comprising means for blocking movement of the elevated element, relative to the portion, in a vertical plane perpendicular to a longitudinal axis of the vessel.

18. A vessel according to any of the preceding embodiments, wherein the harvesting means is configured to harvest energy from a movement of the elevated element, relative to the portion, in a vertical plane parallel to a longitudinal axis of the vessel.

19. A vessel according to any of the preceding embodiments, further comprising an energy storage configured to receive energy from the harvesting means.

20. A vessel according to embodiment 19, further comprising a controller configured to control a lifting element configured to lift a payload using energy from the energy storage, where the controller controls the lifting element to only lift the payload above a predetermined depth, if the energy in the energy storage exceeds a first threshold limit.

21. A vessel according to embodiment 20, wherein the portion is rotatable and the controller is configured to control the portion to not rotate to a position where the payload is above the vessel, until the energy in the energy storage exceeds a second threshold limit.

22. A vessel according to any of the preceding embodiments, wherein the swinging elevated element is a payload hanging from a lifting element.

23. A method of harvesting energy, the method comprising harvesting energy from a movement of an elevated element of a vessel relative to a portion of the vessel, where the elevated element hangs from the portion.

24. A method of harvesting energy from an elevated element hanging from a portion of a vessel, the method comprising converting kinetic energy of the swinging elevated element into electrical or hydraulic energy.

25. A method according to embodiment 23 or 24, wherein the step of harvesting the energy comprises harvesting energy from relative movement between the portion and a wire block rotatably connected to the portion.

26. A method according to any of embodiments 23-25, wherein the harvesting step comprises the step of proving the relative motion to a hydraulic system outputting energy.

27. A method according to any of embodiments 23-26, wherein the harvesting step comprises providing the relative motion to an electric motor outputting energy.

28. A method according to any of embodiments 23-27, wherein the harvesting step further comprises providing the relative movement to a gear.

29. A method according to embodiment 28, wherein the gear comprises toothed wheels or a ball screw.

30. A method according to embodiment 28, wherein the gear comprises an eccentric element.

31. A method according to any of embodiments 23-29, further comprising the step of blocking or locking relative motion between the elevated element and the portion.

32. A method according to any of embodiments 23-31, wherein the harvesting step comprises generating energy by providing a decelerating force to the elevated element to decelerate the movement.

33. A method according to embodiment 32, wherein the harvesting step comprises varying the deceleration force.

34. A method according to embodiment 33, wherein the harvesting step comprises increasing the deceleration force when the elevated means is closer to the portion.

35. A method according to embodiment 33 or 34, wherein a load is supported by the elevated element and wherein the harvesting step comprises increasing the deceleration force for higher weights of the load.

36. A method according to embodiment 36, wherein the harvesting step comprises generating a first deceleration force when the load is submerged and a second, higher, deceleration force when the load hangs in the air.

37. A method according to any of embodiments 34-36, wherein the portion is rotatable relative to the vessel between a first position where the elevated element is above a deck of the vessel and a second position where the elevated element is not above the deck of the vessel, and wherein the harvesting step comprises providing a higher deceleration force in the first position than in the second position.

38. A method according to any of embodiments 23-38, wherein the harvesting step comprises harvesting energy from a movement of the elevated element, relative to the portion, in a vertical plane perpendicular to a longitudinal axis of the vessel.

39. A method according to any of embodiments 23-38, further comprising the step of blocking movement of the elevated element, relative to the portion, in a vertical plane perpendicular to a longitudinal axis of the vessel.

40. A method according to any of embodiments 23-39, wherein the harvesting step comprises harvesting energy from a movement of the elevated element, relative to the portion, in a vertical plane parallel to a longitudinal axis of the vessel.

41. A method according to any of embodiments 23-40, further comprising feeding harvested energy to an energy storage.

42. A method according to embodiment 41, further comprising the step of controlling a lifting element lifting a payload using energy from the energy storage, where the controlling step comprises controlling the lifting element to only lift the payload above a predetermined depth, if the energy in the energy storage exceeds a first threshold limit.

43. A method according to embodiment 42, further comprising the step of rotating the portion, wherein the rotation step comprises not rotating the portion to a position where the payload is above the vessel,

until the energy in the energy storage exceeds a second threshold limit.

44. A method according to any of embodiments 23-3, wherein the swinging elevated element is a payload hanging from a lifting element.

45. A method of harvesting energy on a vessel comprising a winch and a wire block as well as a payload attached to one end of a wire running over the wire block and attached to the winch, the method comprising altering between:

- a first mode where the winch is controlled to maintain the payload at at least approximately the same height over the seabed and
- a second mode in which movement of the winch is converted into electrical or hydraulic energy.

46. A method according to embodiment 45, wherein the second mode comprises the steps of:

- when the vessel elevates, the winch outputting wire and energy,

- when the vessel moves downwardly, the winch receiving wire.

47. A vessel comprising a winch and a wire block, or the like, as well as a payload attached to one end of a wire running over the wire block and attached to the winch, the vessel further comprising a controller configured to control the winch to alter between:

- a first mode where the winch is controlled to maintain the payload at at least approximately the same height over the seabed and
- a second mode in which movement of the winch is converted into electrical or hydraulic energy.

48. A vessel according to embodiment 47, wherein the controller operates the winch so that the second mode comprises the steps of:

- when the vessel elevates, the winch outputting wire and energy,

- when the vessel moves downwardly, the winch receiving wire.

49. A method of generating energy on a vessel comprising a winch and a wire block as well as a payload attached to one end of a wire running over the wire block and attached to the winch, the method comprising lowering the payload into a body of water while generating power from the winch outputting wire/cable.

50. A method according to embodiment 49, further comprising the step of feeding the energy to an energy storage.

51. A method according to embodiment 50, further comprising the step of feeding energy from the energy storage to the winch during elevation of the payload.

52. A vessel comprising a winch* and a wire block as well as a payload attached to one end of a wire running over the wire block and attached to the winch, the vessel further comprising a controller controlling the winch to generate power when outputting cable/wire during lowering the payload into a body of water.

53. A vessel according to embodiment 52, further comprising an energy storage configured to receive energy from the winch.

54. A vessel according to embodiment 53, wherein the controller is configured to feed energy from the energy storage to the winch during elevation of the payload.

Claims

1. A vessel having an elevated element hanging from a portion from the vessel, the vessel further comprising means for harvesting energy from a movement of the elevated element relative to the portion.

2. A vessel according to claim 1, wherein the harvesting means is configured to generate energy by providing a decelerating force to the elevated element to decelerate the movement.

3. A vessel according to claim 2, wherein the harvesting means is configured to vary the deceleration force.

4. A vessel according to claim 3, wherein the harvesting means is configured to increase the deceleration force when the elevated means is closer to the portion.

5. A vessel according to claim 3 or 4, wherein a load is supported by the elevated element and wherein the harvesting means is configured to increase the deceleration force for higher weights of the load.

6. A vessel according to claim 5, wherein the harvesting means is configured to generate a first deceleration force when the load is submerged and a second, higher, deceleration force when the load hangs in the air.

7. A vessel according to any of the preceding embodiments, further comprising an energy storage configured to receive energy from the harvesting means.

8. A method of harvesting energy, the method comprising harvesting energy from a movement of an elevated element of a vessel relative to a portion of the vessel, where the elevated element hangs from the portion.

9. A method of harvesting energy from an elevated element hanging from a portion of a vessel, the method comprising converting kinetic energy of the swinging elevated element into electrical or hydraulic energy.

10. A method according to any of claims 8 or 9, wherein the harvesting step comprises generating energy by providing a decelerating force to the elevated element to decelerate the movement.

11. A method according to any of claims 7-9, further comprising feeding harvested energy to an energy storage.

12. A method of harvesting energy on a vessel comprising a winch and a wire block as well as a payload attached to one end of a wire running over the wire block and attached to the winch, the method comprising altering between:

- a first mode where the winch is controlled to maintain the payload at at least approximately the same height over the seabed and
- a second mode in which movement of the winch is converted into electrical or hydraulic energy.

13. A method according to claim 12, wherein the second mode comprises the steps of:

- when the vessel elevates, the winch outputting wire and energy,
- when the vessel moves downwardly, the winch receiving wire.

14. A vessel comprising a winch and a wire block, or the like, as well as a payload attached to one end of a wire running over the wire block and attached to the winch, the vessel further comprising a controller configured to control the winch to alter between:

- a first mode where the winch is controlled to maintain the payload at at least approximately the same height over the seabed and
- a second mode in which movement of the winch is converted into electrical or hydraulic energy.

15. A vessel according to claim 14, wherein the controller operates the winch so that the second mode comprises the steps of:

- when the vessel elevates, the winch outputting wire and energy,
- when the vessel moves downwardly, the winch receiving wire.49. A method of generating energy on a vessel comprising a winch and a wire block as well as a payload attached to one end of a wire running over the wire block and attached to the winch, the method comprising lowering the payload into a body of water while generating power from the winch outputting wire/cable.

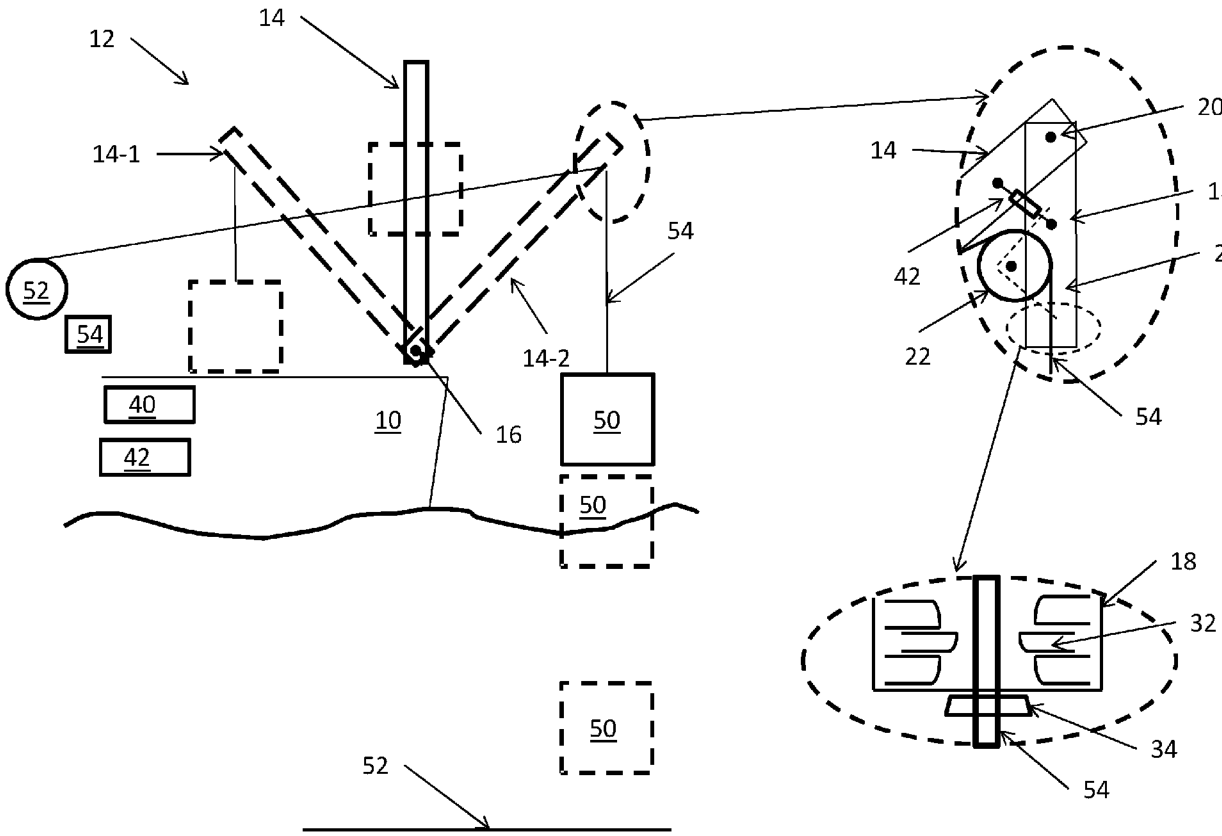
12
14
14-1
52
54
40
42
10
16
14-2
54
50
50
50
52
14
20
18
42
24
22
54
18
32
34
54

Figure 1

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 20 16 4617

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	WO 2013/015684 A1 (HEEREMA MARINE CONTRACTORS NL [NL]; MESKERS GERARDUS PETRUS [NL]) 31 January 2013 (2013-01-31)	1-3,5-15	INV. B63B27/10
Y	* page 2, line 27 - line 34; figure 3a *	4	
Y	GB 1 353 110 A (VICKERS LTD) 15 May 1974 (1974-05-15) * figure 1 *	4	
A	CN 107 444 575 A (UNIV HUNAN) 8 December 2017 (2017-12-08) * claim 1; figures *	4	
X	AU 2016 293 984 B2 (MHWIRTH AS [NO]) 6 February 2020 (2020-02-06) * page 13, line 6 - line 13 * * page 9, line 21 - line 26 *	12-15	

TECHNICAL FIELDS SEARCHED (IPC)

B63B
B63J
B66C
B66D

The present search report has been drawn up for all claims

2

Place of search	Date of completion of the search	Examiner
The Hague	7 December 2020	Balzer, Ralf

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

Europäisches Patentamt
European Patent Office
Office européen des brevets

Application Number
EP 20 16 4617

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☒ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☐ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).

Europäisches Patentamt
European Patent Office
Office européen des brevets

LACK OF UNITY OF INVENTION SHEET B

Application Number
EP 20 16 4617

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-11

The subject matter of claim 1 is known from document D1: WO2013/015684.This document shows a vessel having an elevated element hanging from a portion from the vessel,the vessel further comprising means for harvesting energy from a movement of the elevated element relative to the portion. The additional features of claims 2 and 3 are also known from document D1.
The special technical feature of the first group of inventions are therefore the features of claim 4, that the harvesting means is configured to increase the deceleration force when the elevated means is closer to the portion. With this special technical feature,the problem of harvesting energy from the movement of the elevated element during its swinging in both directions is solved.

---

2. claims: 12-15

The special technical features of the second group of inventions are the features, that the method comprises altering between a first mode where the winch is controlled to maintain the payload at at least approximately the same height over the seabed, and a second mode in which movement of the winch is converted into electrical of hydraulic energy.
With these technical features, the problem of being able to water another boat from the vessel is solved.

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 20 16 4617

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

07-12-2020

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
WO 2013015684	A1	31-01-2013	AU	2012287576	A1	06-03-2014
			BR	112014000562	A2	11-09-2018
			GB	2506811	A	09-04-2014
			MX	344752	B	05-01-2017
			NL	2007165	C2	24-01-2013
			US	2014238948	A1	28-08-2014
			WO	2013015684	A1	31-01-2013
GB 1353110	A	15-05-1974	NONE			
CN 107444575	A	08-12-2017	NONE			
AU 2016293984	B2	06-02-2020	AU	2016293984	A1	22-02-2018
			BR	112018000770	A2	04-09-2018
			GB	2556769	A	06-06-2018
			GB	2561665	A	24-10-2018
			NO	343495	B1	25-03-2019
			US	2019077641	A1	14-03-2019
			WO	2017010890	A2	19-01-2017

EPO FORM P0459

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