CLAIMS

1. Transportable inline heave compensator (100) provided with connection devices (19) for suspending the compensator (100) from a load bearing device and a connection device (19) for a carrying a payload (101), **~~characterized in that~~** wherein the compensator (100)~~, comprising~~ comprises a passive heave compensator part and ~~possibly~~ an active heave compensator part, and being provided with a sensor arrangement, where the compensator (100) further comprises at least ~~-~~one actuator (10)~~,~~ that is horizontally oriented in operation and comprises an actuator piston rod (13) with a horizontally stroke indirectly connected to a rope means (18), where the rope means (18) at an end, via a connection device (19)~~, such as a padeye,~~ is connected to at least one ~~of;~~of: a vessel (102) at the sea surface or a payload (101), incorporating a device with a curved surface where the rope means is suspended to for converting the vertical movements of the vessel (102) or the payload (101), to horizontal movements of the actuator piston rod (13) compensating the load (101).

2. Transportable inline heave compensator (100) according to claim 1, wherein the compensator comprises an active part which is self supported and not connected to the vessel (102).

3. Transportable inline heave compensator (100) according to claim 2, wherein elements incorporated in the compensator are in fixed position and relation to each other as elements are directly or indirectly fixed to a framework (80).

4. Transportable inline heave compensator (100) according to claim 3, wherein rope means (18) preferably comprises steel wire rope, fiber rope, chain belt or similar.

5. Transportable inline heave compensator (100) according to claim 4, wherein the compensator comprises at least one gas accumulator (30), comprising a cylinder (31), a piston (32) separating oil/hydraulic fluid from gas, fluidly

connected to the actuator (10) at either rod side or piston side of the actuator (10*)*.

6. Transportable inline heave compensator (100) according to claim 5, wherein the actuator (10) comprises a horizontally oriented actuator cylinder and an actuator piston (12) located inside the cylinder and adapted for reciprocation with respect thereto and a piston rod (13) connected to the actuator piston (12) and extending outwardly and through one end of the actuator cylinder (11).

7. Transportable inline heave compensator (100) according to claim 6, wherein the compensator (100) further comprises a valve means used to block or partially block flow of oil/hydraulic fluid between actuator and accumulator.

8. Transportable inline heave compensator (100) according to claim 7, wherein the compensator further comprises minimum one gas tank (T1, T2,…, TN) connected to gas side of gas accumulator via conduit means, adapted with control valves (CVA1, CVA2, …, CVAN, CVB0, CVB1, …, CVBN, CV4) for adjustment of the gas volume in accumulator (100).

9. Transportable inline heave compensator (100) according to claim 8, wherein the actuator comprises minimum two horizontally mounted actuator cylinders (11), where each actuator cylinder comprises an actuator rod (13) connected to an actuator piston (12).

10. Transportable inline heave compensator (100) according to claim 9, wherein the incorporated curved device/device with a curved surface is minimum one actuator sheave (25), where actuator sheaves (25) are connected at the end of the actuator piston rods (13).

11. Transportable inline heave compensator (100) according to claim 10, wherein the two horizontally mounted actuator cylinders (11) comprises a passive actuator cylinder (11) and an active actuator cylinder (20).

12. Transportable inline heave compensator (100) according to claim 11,

wherein the first actuator cylinder (11) which is a passive actuator cylinder (11), where piston (12) divides cylinder into two volumes, designated V1 and V2, where V1 is on the piston side and V2 is on the rod side, the volumes are filled differently, depending on if the passive actuator cylinder (11) is working in tension or compression mode, where V1 is filled with hydraulic fluid and is connected to the gas accumulator (30) via conduit means and V2 is either filled with oil or filled with low pressure gas, (including vacuum), when working in compression mode and where V2 is filled with hydraulic fluid and is connected to the gas accumulator (30) via conduit means and V1 is either filled with oil or filled with low pressure gas, (including vacuum), when working in tension mode;

wherein the second actuator cylinder (20) which is an active actuator cylinder (20), including a piston rod (21), and the passive actuator cylinder (11) have collinear longitudinal axes that are horizontal, where the respective piston rods (13, 21) are fixed together in a stiff connection with actuator sheaves (25, 26) at the connection point;

further comprising a position measurement means (90) to register the position of the piston (12);

where the gas accumulator (30), featuring the piston (32) that separates two volumes designated V6 and V7, where V6 is connected to V1 in the passive actuator cylinder (11) if operating in compression mode and to V2 in the passive actuator cylinder (11) if operating in tension mode, via conduit means adapted with a control valve (CV1), filled with hydraulic fluid and where V7 is filled with gas;

the actuator (10) comprising a framework (80) joining the elements together in a stiff connection, where the framework (80) may partly consist of tanks and accumulators to reduce weight, the framework (80) is further fitted with connection device (19) used to connect the compensator (100) to a crane, or similar, located on a vessel (102), where the connection device (19) may be located in the centre of gravity of the compensator (100) or at other locations, the framework (80) further supports three secondary sheaves (27, 28, 29), used to support rope means (18), such as steel wire

rope, fiber rope, belt, chain or similar, connecting the actuator sheaves (25, 26) to the lower connection device (19), which in turn is connected to the payload (101), the rope means (18) are reeved over the actuator sheaves (25, 26) and the secondary sheaves (27, 28, 29), with one end connected to a fixed point, such as the framework (80) and the other end connected to the payload (101) via a lower connection device (19), lowering of the payload (101) relative to the compensator (100) causes the actuator sheaves (25, 26) to move horizontally, the direction (i.e., towards or away from the active actuator cylinder (11)) depending on if the compensator (100) is compression- or tension based;

further comprising an accelerometer integrated into the compensator (100), adapted for measuring vertical motion;

further comprising communication means, such as wireless communication while in air and acoustic communication while submerged, adapted for transmitting data from the vessel (102), such as commands and winch spooling speed, to the compensator (100);

further comprising a hydraulic motor (P), which is reversible, adapted to actuate the active actuator cylinder (20), based on measurement data from the position sensor (90), the accelerometer and the measurement data from the vessel (102), such as winch spooling speed.

13. Transportable inline heave compensator (1) according to claim 12,

where the active actuator cylinder (20) comprises a first hollow piston rod (21), connected to a first piston (23), a second hollow piston rod (24) connected to a second piston (22), where the second hollow piston rod (24) and the second piston (22) are mounted concentrically inside the first hollow piston rod (21) and fixed to one end of the active actuator cylinder (20), the active actuator cylinder (20) has three separate volumes, designated V3, V4 and V5; V3 is located between: the inside of the first hollow piston rod (21), the inside of the second piston rod (24), the top of the second piston (22) as well as the end of the actuator cylinder (20) and is filled with hydraulic fluid; V4 is located between; the inside of the first hollow piston rod (21), the

outside of the second piston rod (24), the bottom of the second piston (22) and the first piston (23) as well as the end and inside diameter of the actuator cylinder (20) and is filled with a low pressure gas, (including vacuum); V5 is located between; the outside of the first hollow piston rod (21), the top of the first piston (23) as well as the end and inside diameter of the actuator cylinder (20) and is filled with a hydraulic fluid;

further comprising conduit means between V3 and V5 adapted with a hydraulic pump (P) adapted to transport oil under pressure between the respective volumes in any direction, adapted with control valves (CV2, CV3) and a gas accumulator (190) suitable for handling pump leakage and providing low flow restriction when the compensator (100) is used in passive mode;

further comprising a number of tanks (T1, T2, …, TN) suitable for gas storage;

further comprising conduit means between V7 and the tank volumes (T1, T2, ..., TN) adapted with control valves (CVA1, CVA2, ..., CVAN) for adjustment of the volume size connected to V7;

further comprising conduit means between all gas volumes (V7, T1, T2, …, TN), the gas booster (160) as well as the surroundings, adapted with control valves (CV4, CV5, CV6, CVB1, CVB2, …, CVBN), suited for pressure adjustment, both up and down, in all volumes as well as filling from the surroundings or release of pressure to the surroundings.

14. Transportable inline heave compensator (100) according to claim 13, further comprising a first MRU (105) placed in a crane tip; and/or a second MRU (104) placed in the vicinity of the payload (101), adapted for transmitting wireless signals to the compensator (100), to improve control over the active actuator cylinder (20).

15. Transportable inline heave compensator (100) according to claim 10, wherein mounting direction of actuator sheaves may be horizontal or vertical.

16. Transportable inline heave compensator (100) according to claim 15, where the gas accumulator is a double acting gas accumulator

17. Transportable inline heave compensator (100) according to claim 16,

wherein the actuator sheaves are adapted for applying force to rope means (18), where the rope means is connected to a payload (101) via connection device (19)~~, such as a padeye,~~ and minimum one secondary sheave (26), where the actuator sheave (25) and the number of rope means (18) is minimum one with no upper limit;

where the framework (80) may be used as anchoring points for connection device (19)~~, like padeyes,~~ to connect the compensator (100) to a crane, or similar machine;

further comprising a first actuator volume (V+), located between the actuator piston (12) and piston side of the actuator cylinder (11), filled with oil for compression based designs and filled with gas, ~~(~~at any pressure, including vacuum~~)~~ , on tension based designs, a second actuator volume (V-), located between the actuator piston (12) and rod side of the actuator cylinder (11), filled with oil on tension based designs and filled with gas, ~~(~~at any pressure, including vacuum~~)~~ , on compression based designs;

further comprising a position measurement means (90), such as a laser position sensor, a linear position sensor or an ultrasonic position sensor, to register the position of the actuator piston (12);

where ~~(~~the gas accumulator is a~~)~~ double acting gas accumulator (70), comprising of a first cylinder (71), a ring shaped piston (72) mounted concentrically within the first cylinder (71) and adapted for reciprocation with respect thereto, where the lower end of the ring shaped piston (72) is on the same side as the lower end of the first cylinder (71) when the ring shaped piston (72) is at zero stroke, a first inner cylinder (73) mounted concentrically with and fixed to the upper end of the ring shaped piston (72), a second inner cylinder (74) mounted concentrically within the first cylinder (71) and fixed to the lower end of the first cylinder (71) with a leak tight connection against the lower end of the first cylinder (71) as well as a leak tight seal

against the ring shaped piston (72), an inner piston (78) mounted concentrically within the second inner cylinder (74) with a leak tight seal against the first inner cylinder (74) where the lower end of the inner piston (78) is at the same level as the lower end of the ring piston (72), a third inner cylinder (75) mounted concentrically within the first cylinder (71) and fixed to the upper end of the inner piston (78) and to a cylinder connector (76) that joins the third inner cylinder (75) with the first inner cylinder (73) in a stiff connection, a stuffing box (77) is mounted on top of the second inner cylinder (74) to form a leak tight connection with the first inner cylinder (73), the cylinder connector (76) has openings that allow free flow of fluids to either side of the cylinder connector (76), the second inner tube (74) is equipped with means for transporting fluid, such as gun drilling the tube walls, from outside the double acting gas accumulator (70) to the volume (V3) between the first inner tube (73) and the second inner tube (74);

further comprising a first volume (V8), located between the lower end of the ring piston (72), the lower end of the first cylinder (71) and the outside of the first inner cylinder (74);

further comprising a second volume (V9), located between the lower end of the inner piston (78), the lower end of the first cylinder (71) and the inside of the second inner cylinder (74);

further comprising a third volume (V10), located between the upper end of the ring piston (72), the outside of the first second cylinder (74), the inside of the first inner cylinder (74) and the lower end of the stuffing box;

further comprising a fourth volume (V11), contains the remaining volume of the double acting accumulator (70) not occupied by any parts or any other volumes;

further comprising a number of tanks (T1, T2, …, TN) suitable for gas storage;

further comprising conduit means between the first actuator volume (V+) and the first volume (V1) for compression based designs and conduit means between the second actuator volume (V-) and the first volume (V8) for tension based designs;

further comprising a sensing means adapted for measuring the vertical motion of the compensator (100);

further comprising one or more sensing means adapted for measuring the pressure in one or more volume;

further comprising a computer adapted for controlling the pump (P) and the control valves (CV) based on input from the sensing means;

further comprising a communication means~~, such as acoustic communication while subsea and wirelessly while in air,~~ adapted to transfer winch spooling data and other signals between the vessel (102) and the compensator (100);

further comprising either a battery pack or an umbilical for energy supply.

18. Transportable inline heave compensator (100) according to claim 17, further comprising:

a gas booster (160), which can be of either single acting or double acting type, with or without area difference between gas and drive side, including means to drive it, which could be either hydraulic or gas based;

further comprising conduit means between the first actuator volume (V+), for tension based designs, and between the second actuator volume (V-), for compression based designs, and any number of tank volumes (T1, T2, ..., TN), adapted with control valves (CVC1, CVC2, ..., CVCN) for adjustment of the volume size connected to the actuator;

further comprising conduit means between all gas volumes (V11, V+ for tension based designs, V- for compression based designs, T1, T2, …, TN), the gas booster (160) as well as the surroundings, adapted with control valves (CV4, CV5, CV6, CVB0, CVB1, CVB2, …, CVBN), suited for pressure adjustment, both up and down, in all volumes as well as filling from the surroundings or release of pressure to the surroundings.

19. Transportable inline heave compensator (100) according to claim 18, further comprising a first MRU (105) placed in a crane tip~~;~~ and/or a second MRU (104) placed in the vicinity of the payload (101).

20. Transportable inline heave compensator (1) according to claim 18, further comprising tailrods (84) mounted to the actuator pistons (12), exposed to external pressure, with same diameter as the actuator rods (13).

21. Transportable inline heave compensator (100) according to claim 8,
wherein the incorporated curved device/device with a curved surface is minimum one drum (16) interacting with a pinion and a rack;
where the rack (14) is integrated in the piston rod (13) and interacting with the pinion (15), converting the rotational motion of the drum (16) and pinion (15) to linear motion of the rack (14) and the actuator piston (12);
comprising bearing means (17), fixed to framework (80), for the drum (16) allowing rotation of the drum (16).

22. Transportable inline heave compensator (100) according to claim 21,
comprising a connection device (19) in the other end, adapted for securing the rope means (18) to at least one of: a vessel (102) at the sea surface and a payload (101);
further comprising minimum one second connection device (19, 82) attached to either of; a rope means (18) or a fixed point on the compensator (100), adapted for securing the rope means (18) or the compensator (100) to at least one of: a vessel (102) at the sea surface and a payload (101).

23. Transportable inline heave compensator (100) according to claim 22,
wherein the compensator (100) further comprises minimum a second tank (T2) for high pressure gas;
further comprising a means for gas transportation (140) consisting of a pressure intensifier (141), connected to a pump (142), connected to a motor (143), connected- to an energy source (144), to transport gas between the first accumulator (30), the first tank (T1), the second tank (T2) and the surroundings;
further comprising a drum angle sensor(s) (91), which may be located in one or both the actuators (10,40), the first accumulator (30) or on the drum (16).

24. Transportable inline heave compensator (100) according to claim 22 or 23, where compensator further comprises minimum one second actuator (40), consisting of a cylinder (41) and a piston (42), where the piston (42) is connected to the rack (14), and adapted for reciprocation with respect thereto.

25. Transportable inline heave compensator (100) according to any one ~~or more~~ of the claims 22-24, further ~~comprises~~ comprising conduit means connecting the second actuator (40) to the first actuator (10).

26. Transportable inline heave compensator (100) according to any one ~~or more~~ of the claims 22-25, where the compensator further comprises minimum one accelerometer (92).

27. Transportable inline heave compensator (100) according to any one ~~or more~~ of the claims 22-26, where the compensator further comprises minimum one pressure sensor for seawater pressure (100).

28. Transportable inline heave compensator (100) according to any one ~~or more~~ of the claims 22-27, further comprising a second accumulator (60), consisting of a cylinder (61) and a piston (62), connected to the means for gas transportation (140) via conduit means.

29. Transportable inline heave compensator (100) according to any one ~~or more~~ of the claims 22-28, further ~~comprises~~ comprising valve means (CV6, CV5, CVB2, CV7) to control gas flow in and out of the means for gas transportation (140).

30. Transportable inline heave compensator (100) according to any one ~~or more~~ of the claims 22-29, further comprising~~:~~ communication means (145).

31. Transportable inline heave compensator (100) according to any one ~~or more~~ of the claims 22-30, further comprising

minimum one pressure intensifier (170) connected to the second actuator (40) via conduit means and to the second accumulator (60) via conduit

means, consisting of two cylinders (173, 174), a piston (172) and a rod (171),

minimum one hydraulic transportation means (180), connected to the pressure intensifier (170) and the second accumulator (60) via conduit means.

32. Transportable inline heave compensator (100) according to any one ~~or more~~ of the claims 22-31, wherein the drum (16) has a variable diameter with angle.