Claims

1. A mobile active heave compensator provided with a first attachment device for suspending the compensator from a load bearing device and a second attachment device for carrying a payload, the mobile active heave compensator comprising a passive heave compensation part and an active heave compensation part, and being associated with a sensor arrangement producing input signals for a control unit and a power source, wherein the compensator incorporates a hydraulic fluid pump and/or a motor device, affecting the active heave compensation part, producing output signal(s) to the hydraulic fluid pump and/or the motor device, based on input signals received from the sensor arrangement.

2. The mobile active heave compensator according to claim 1, wherein the power source and/or the control unit form an integral part of the compensator.

3. The mobile active heave compensator according to claim 1 or 2, wherein the mobile active heave compensator is self supported without any external electric or fluid connection to a surface vessel or a connection to an externally arranged high pressure unit.

4. The mobile active heave compensator according to any one of claims 1 to 3, wherein the compensator comprises at least a first actuator and a first gas accumulator and wherein the hydraulic fluid pump directly or indirectly affects pressures appearing in the first actuator and/or the first gas accumulator.

5. The mobile active heave compensator according to any one of claims 1 to 4, further comprising a conduit system including a by-pass line, enabling by-passing the pump and/or the motor device operating in a passive modus.

6. The mobile active heave compensator according to any one of claims 1 to 5, wherein:

the passive heave compensation part is adapted for linear reciprocating motion;

the sensor arrangement is adapted for giving an output signal to an active element, based on payload motion and/or crane hook motion and/or vessel motion and/or crane tip motion; and

the active element is adapted for manipulating the linear reciprocating motion in such a way that the motion of the payload relative to the seabed is minimized when desired;

wherein the mobile active heave compensator is connected between the crane hook and the payload.

7. The mobile active heave compensator, according to claim 6, comprising elements selected from the group of elements consisting of:

the first actuator, consisting of a first cylinder having an upper end and a lower end, a connection device mounted at the upper end of the first cylinder, a first piston located within the first cylinder and adapted for reciprocation with respect thereto, a first piston rod connected to the first piston and extending downwardly therefrom through the lower end of the first cylinder, a connector device located at the lower end of the first cylinder, a first volume located between the first piston and the lower end of the first cylinder, a second volume located between the first piston and the upper end of the first cylinder;

a depth compensator, consisting of a sixth cylinder, a fourth piston rod exposed to external pressure and a fourth piston, forming a ninth volume between one end of the sixth cylinder and the fourth piston, a tenth volume between the other end of the sixth cylinder and the fourth piston;

a second gas accumulator, consisting of an eighth cylinder and a sixth piston forming a thirteenth volume between one end of the eighth cylinder and the sixth piston, a fourteenth volume between the other end of the eighth cylinder and the sixth piston;

a double acting pressure intensifier, consisting of a twelfth cylinder mounted concentric between a thirteenth cylinder at the upper end of the twelfth cylinder and a fourteenth cylinder at the lower end of the twelfth cylinder, a seventh piston, a fifth piston rod connected to the lower end of the seventh piston and a sixth piston rod connected to the upper end of the seventh piston, forming a twenty-first volume between one end of the fourteenth cylinder and the lower end of the twelfth cylinder displaced by the fifth piston rod, a twenty-second volume between the lower end of the twelfth cylinder, the lower end of the seventh piston and the outer diameter of the fifth piston rod, a twenty-third volume between the upper end of the twelfth cylinder, the upper end of the seventh piston and the outer diameter of the sixth piston rod, a twenty-fourth volume between one end of the thirteenth cylinder and the upper end of the twelfth cylinder displaced by the sixth piston rod; and

any functional combinations thereof.

8. The mobile active heave compensator according to claim 6, comprising:

the first actuator, consisting of a first cylinder having an upper end and a lower end, a connection device mounted at the upper end of the first cylinder, a first piston located within the first cylinder and adapted for reciprocation with respect thereto, a first piston rod connected to the first piston and extending downwardly therefrom through the lower end of the first cylinder, a connector device located at the lower end of the first cylinder, a first volume located between the first piston and the lower end of the first cylinder, a second volume located between the first piston and the upper end of the first cylinder, where the first volume is filled with oil and the second volume is filled with gas or is under vacuum;

at least one second gas accumulator, consisting of an eighth cylinder and a sixth piston forming a thirteenth volume between one end of the eighth cylinder and the sixth piston, a fourteenth volume between the other end of the eighth cylinder and the sixth piston, where the thirteenth volume is filled with oil and the fourteenth volume is filled with gas;

a double acting pressure intensifier, consisting of a twelfth cylinder mounted concentric between a thirteenth cylinder at the upper end of the twelfth cylinder and a fourteenth cylinder at the lower end of the twelfth cylinder, a seventh piston, a fifth piston rod connected to the lower end of the seventh piston and a sixth piston rod connected to the upper end of the seventh piston, forming a twenty-first volume between one end of the fourteenth cylinder and the lower end of the twelfth cylinder displaced by the fifth piston rod, a twenty-second volume between the lower end of the twelfth cylinder, the lower end of the seventh piston and the outer diameter of the fifth piston rod, a twenty-third volume between the upper end of the twelfth cylinder, the upper end of the seventh piston and the outer diameter of the sixth piston rod, a twenty-fourth volume between one end of the thirteenth cylinder and the upper end of the twelfth cylinder displaced by the sixth piston rod, where the twenty-fourth volume is filled with oil, the twenty-third volume is filled with gas, the twenty-second volume is filled with oil and the twenty-first volume is filled with oil;

a first conduit device connecting the twenty-second volume to the first volume;

a second conduit device connecting the twenty-fourth volume to at least one of the oil filled volumes of the at least one second gas accumulator(s);

a third conduit device connecting the twenty-first volume to at least one of the oil filled volumes of the at least one second gas accumulator(s); and

a fourth conduit device connecting the twenty-first volume and the twenty-fourth volume via a device for hydraulic fluid transportation.

9. The mobile active heave compensator according to claim 6, comprising:

the first actuator, consisting of a first cylinder having an upper end and a lower end, a connection device mounted at the upper end of the first cylinder, a first piston located within the first cylinder and adapted for reciprocation with respect thereto, a first piston rod connected to the first piston and extending downwardly therefrom through the lower end of the first cylinder, a connector device located at the lower end of the first cylinder, a first volume located between the first piston and the lower end of the first cylinder, a second volume located between the first piston and the upper end of the first cylinder, where the first volume is filled with a first fill substance and the second volume is filled with a second fill substance;

a depth compensator, consisting of a sixth cylinder, a fourth piston rod exposed to external pressure and a fourth piston, forming a ninth volume between one end of the sixth cylinder and the fourth piston, a tenth volume between the other end of the sixth cylinder and the fourth piston, where the tenth volume is filled with a third fill substance, and the ninth volume is filled with a fourth fill substance;

at least one second gas accumulator, consisting of an eighth cylinder and a sixth piston forming a thirteenth volume between one end of the eighth cylinder and the sixth piston, a fourteenth volume between the other end of the eighth cylinder and the sixth piston, where the thirteenth volume is filled with a fifth fill substance and the fourteenth volume is filled with a sixth fill substance;

a double acting pressure intensifier, consisting of a twelfth cylinder mounted concentric between a thirteenth cylinder at the upper end of the twelfth cylinder and a fourteenth cylinder at the lower end of the twelfth cylinder, a seventh piston, a fifth piston rod connected to the lower end of the seventh piston and a sixth piston rod connected to the upper end of the seventh piston, forming a twenty-first volume between one end of the fourteenth cylinder and the lower end of the twelfth cylinder displaced by the fifth piston rod, a twenty-second volume between the lower end of the twelfth cylinder, the lower end of the seventh piston and the outer diameter of the fifth piston rod, a twenty-third volume between the upper end of the twelfth cylinder, the upper end of the seventh piston and the outer diameter of the sixth piston rod, a twenty-fourth volume between one end of the thirteenth cylinder and the upper end of the twelfth cylinder displaced by the sixth piston rod, where the twenty-fourth volume is filled with a seventh fill substance, the

twenty-third volume is filled with an eighth fill substance, the twenty-second volume is filled with a ninth fill substance and the twenty-first volume is filled with a tenth fill substance;

a first conduit device connecting the second volume to the tenth volume;

a second conduit device connecting the twenty-second volume to the first volume;

a third conduit device connecting the twenty-fourth volume to at least one of the volumes of the at least one second gas accumulator, wherein the at least one of the volumes of the at least one second gas accumulator is filled with oil;

a fourth conduit device connecting the twenty-first volume to at least one of the volumes of the at least one second gas accumulator, wherein the at least one of the volumes of the at least one second gas accumulator is filled with oil; and

a fifth conduit device connecting the twenty-first volume and the twenty-fourth volume via a device for hydraulic fluid transportation; wherein the first, second, third, fourth, fifth, sixth, seventh, eighth, ninth, and tenth fill substances are selected from the group of fill substances consisting of any fluid, oil, gas, vacuum, and combinations thereof.

10. The mobile active heave compensator according to claim 9, wherein:

the first fill substance comprises oil;

the second fill substance comprises oil;

the third fill substance comprises oil;

the fourth fill substance comprises gas or vacuum;

the fifth fill substance comprises oil;

the sixth fill substance comprises gas;

the seventh fill substance comprises oil

the eighth fill substance comprises gas;

the ninth fill substance comprises oil; and

the tenth fill substance comprises oil.

11. The mobile active heave compensator according to claim 10, wherein the effective size of any of the numbered volumes is expanded by connecting tanks or other devices to

any of the numbered volumes.

12. The mobile active heave compensator according to claim 11, wherein the device for hydraulic fluid transportation is controlled based on measurements from at least one position sensor and/or one motion sensor.

13. The mobile active heave compensator according to claim 7, further comprising at least two devices for hydraulic fluid transportation.

14. The mobile active heave compensator according to claim 13, wherein any two of the numbered volumes that are adjacent in the pressure intensifier are connected together.

15. The mobile active heave compensator according to claim 14, wherein a device for gas transportation is used to transport gas between at least one of the numbered volumes and another of the numbered volumes and/or to the surroundings.

16. The mobile active heave compensator according to claim 15, wherein the sensor arrangement adapted to directly or indirectly measure the position of the first piston is further adapted for measuring the equilibrium position of the first piston and/or the first piston rod relative to the ends of the first cylinder.

17. The mobile active heave compensator according to claim 16, wherein the first gas accumulator and the second gas accumulator are replaced by a third gas accumulator comprising two volumes filled with oil and one volume filled with gas.

18. The mobile active heave compensator according to claim 5, further comprising:
a hydraulic actuator, comprising a first cylinder having an upper end and a lower end, a first piston rod connected to a first piston and extending downwardly therefrom through the lower end of the first cylinder, adapted for reciprocation with respect thereto, a connection device mounted at the upper and lower end of the hydraulic actuator adapted for connecting the active heave compensator to a floating object, and a payload;

a first volume, filled with hydraulic fluid, located between the first piston and the lower end of the first cylinder;

a second volume, filled with gas at any pressure including zero, located between the first piston and the upper end of the first cylinder;

a double acting gas accumulator, comprising a fourth cylinder, a ring shaped piston mounted concentrically within the fourth cylinder and adapted for reciprocation with respect thereto, where the lower end of the ring shaped piston is on the same side as the lower end of the fourth cylinder when the ring shaped piston is at zero stroke, a third inner cylinder mounted concentrically within the fourth cylinder and fixed to the upper end of the fourth cylinder with a leak tight connection, a fourth inner cylinder mounted concentrically inside the fourth cylinder and connected to the upper end of the ring shaped piston with a leak tight connection, a cylinder end mounted concentrically with the fourth cylinder at the upper end of the fourth inner cylinder with a leak tight connection, a fifth inner cylinder mounted concentrically with the fourth cylinder at the lower end of the fourth cylinder in a leak tight manner, where the assembly consisting of the ring shaped piston, the fourth inner cylinder and the cylinder end is adapted to reciprocate inside the fourth cylinder, inside the third inner cylinder and outside the fifth inner cylinder in a leak tight manner;

a sixth volume, filled with hydraulic fluid, located between the cylinder end, the inside of the fourth inner cylinder, the fifth inner cylinder and the lower end of the first cylinder;

a seventh volume, filled with hydraulic fluid, located between cylinder end, the outside of the fourth inner cylinder, the inside of the third inner cylinder and the upper end of the first cylinder;

an eighth volume, filled with hydraulic fluid, located between the ring shaped piston, the outside of the fifth inner cylinder and the lower end of the first cylinder;

a ninth volume, filled with gas at any pressure, located between the inside the fourth cylinder, the upper end of the fourth cylinder, the outside of the third inner cylinder, the outside of the fourth inner cylinder and the upper end of the ring shaped piston;

a second gas accumulator, consisting of a seventh cylinder and a fifth piston, adapted for reciprocation with respect thereto;

a seventeenth volume, filled with hydraulic fluid, located between the upper end of the seventh cylinder and the upper end of the fifth piston;

an eighteenth volume, filled with gas at any pressure, located between the lower end of the seventh cylinder and the lower end of the fifth piston;

a first conduit device between the first volume and the eighth volume;

a second conduit device between the sixth volume and the seventh volume, the second conduit device having a first hydraulic pump adapted to transport oil under pressure between the sixth and seventh volumes;

a third conduit device between the seventeenth volume and the seventh volume, the third conduit device having a third device control valve;

a fourth conduit device between the seventeenth volume and the sixth volume, the fourth conduit device having a second control valve;

a first sensing device adapted for measuring the position of the first piston;

a second sensing device adapted for measuring the motion of the active heave compensator;

one or more third sensing devices adapted for measuring the pressure in one or more of the numbered volumes;

a computer adapted for controlling the first hydraulic pump and the control valves based on input from the sensing devices.

19. The mobile active heave compensator according to claim 18, further comprising:

one or more tanks adapted for gas storage;

one or more fifth conduit devices between each of the one or more tanks and the ninth volume, wherein each of the one or more fifth conduit devices includes a fourth control valve device, wherein each of the one or more fifth conduit devices is adapted for connecting each of the one or more tanks individually to the ninth volume.

20. The mobile active heave compensator according to claim 19, further comprising:

a gas booster, consisting of a fifth cylinder and third piston, adapted for reciprocation with respect thereto;

a third gas accumulator, consisting of a sixth cylinder and fourth piston, adapted for reciprocation with respect thereto;

a tenth volume, filled with gas under any pressure, located between the upper end of the fifth cylinder and the upper end of the third piston;

an eleventh volume, filled with hydraulic fluid, located between the lower end of the fifth cylinder and the lower end of the third piston;

a twelfth volume, filled with hydraulic fluid, located between the lower end of the sixth cylinder and the lower end of the fourth piston;

a thirteenth volume, filled with hydraulic fluid, located between the upper end of the sixth cylinder and the upper end of the fourth piston;

a sixth conduit device between the eleventh volume and the twelfth volume adapted with a second hydraulic pump adapted for transporting hydraulic fluid under pressure between the eleventh and twelfth volumes.

21. The mobile active heave compensator according to claim 20, further comprising:

a fifth control valve device in the first conduit device between the first volume and the eighth volume, the fifth control valve device adapted for manipulating the flow area from zero to free flow.

22. The mobile active heave compensator according to claim 21, further comprising:
the one or more fifth conduit devices between each of the one or more tanks and the ninth volume further disposed between each of the one or more tanks and the surroundings, the fourth control valve device disposed in each of the one or more fifth conduit devices and adapted for individually adjusting the pressure in the numbered volumes excluding the second volume, the thirteenth volume and the fifteenth volume.

23. The mobile active heave compensator according to claim 22, further comprising:
one or more sixth conduit devices between each of the one or more tanks and the second volume, one or more fifth control valve devices disposed in each of the one or more sixth conduit devices and adapted for individually connecting any of the one or more tanks to the second volume;
the one or more fifth conduit devices between each of the one or more tanks, the ninth volume and the surroundings, the fourth control valve device disposed in each of the one or more fifth conduit devices and adapted for individually adjusting the pressure in the numbered volumes, excluding the thirteenth volume and the fifteenth volume.

24. The mobile active heave compensator according to claim 23, wherein

a first inner cylinder is mounted concentrically inside the first cylinder and connected with a leak tight connection to the upper end of the first cylinder;

the first piston rod is hollow and has a sealing surface facing the first inner cylinder;

a third volume is formed, filled with hydraulic fluid, located inside the first piston rod, the first inner cylinder and the upper end of the first cylinder;

wherein the mobile active heave compensator further comprises:

a depth compensator consisting of a second cylinder, a second inner cylinder mounted concentrically with the second cylinder, connected to the upper end of the second cylinder in a leak tight fashion, a second piston located inside the second inner

cylinder, a second piston rod connected to the second piston and adapted for reciprocation within the second inner cylinder, a third cylinder mounted concentrically within the second cylinder and connected to the second piston rod via a cylinder-rod connector;

a fourth volume, filled with hydraulic fluid, located between the upper end of the second piston, the inside of the second inner cylinder and the upper end of the second cylinder; and

a fifth volume, filled with gas under any pressure, located between the inside of the first cylinder, the inside of the third cylinder, the inside of the second inner cylinder, the lower side of the second piston and the rod-cylinder connector;

wherein the rod-cylinder connector and the third cylinder are exposed to external pressure which will generate a higher pressure in the fourth volume.

25. The mobile active heave compensator according to claim 18, further comprising:

a communication device adapted to transfer signals between the vessel and the mobile active heave compensator, wherein the communication device utilizes acoustic communication.

26. The mobile active heave compensator according to claim 18, further comprising:

at least one wireless MRU adapted for transferring motion data to the active heave compensator.

27. The mobile active heave compensator according to claim 18, wherein the mobile active heave compensator is powered by a battery pack or by power delivered through an umbilical.