Claims

1. A hydraulic Ddepth compensated actuator (0), suitable to form a part, for example, of a transportable inline depth compensated heave compensator for subsea lifting or loading operations, the hydraulic depth compensated actuator comprising:

an actuator, (1 ,10)the actuator comprising

a first cylinder shaped body (11), and

a second cylinder mounted concentric with the first cylinder, and connected to the first cylinder at an upper end of the first cylinder,

a ring piston (12)configured to slide on the outer diameter of the second cylinder,

with a hollow piston rod (3,13), able connected to the ring piston and configured to reciprocate inside the first cylinder shaped body (11), wherein the hollow piston rod comprises a tail surface configured to be exposed to external water pressure,

a first connection means and second connection means (14) associated with the actuator (1,10) such that first connection means is positioned at an axial end of the actuator and second connection means is positioned at an opposing axial end of the actuator, and

a plurality of the actuator (1,10) also comprises volumes intended configured to contain a gas or a liquid, the plurality of actuator volumes including

and where tail surface associated with the piston rod (3,13) is intended to be exposed to external water pressure; a depth compensator (20) comprising a cylinder , a piston and a piston rod extending out through an end closure of the depth compensator (20), the end of which being exposed to a surrounding water; and conduit means (17) between at least one a first volume in the actuator (1,10) and one volume in the depth compensator (20), characterized by a combination either of:

- an actuator (10) with a hollow piston rod (13) configuration and a depth compensator (20) chosen from the group of: depth compensator (20) with aformed by an outer diameter surface of the hollow piston rod (22),; compensator with a ring shaped piston (32) and piston rod (33); or a compensator with a lower end surface of the first cylinder (21), an inner diameter surface of the first cylinder, and a lower end surface of the ring piston (22), wherein the first volume is configured to be filled with oil or gas, and piston rod (23), a free end of which being exposed to external water pressure; or

a second volume formed by an outer diameter surface of the second cylinder, an upper end surface of the first cylinder, the inner diameter surface of the first cylinder, and an upper end surface of the ring piston, wherein the second volume is configured to be filled with oil or gas or under vacuum, and

a third volume formed by an inner diameter surface of the second cylinder, the upper end surface of the first cylinder, an inner diameter surface of the hollow piston rod, and a lower end surface of the hollow piston rod, wherein the third volume is configured to be filled with oil or gas or under vacuum;

~~- an actuator (1) comprising a cylinder; piston (12); and piston rod (3); the free end of which being exposed to surrounding sea water,~~ and

a depth compensator ~~in with a ring-shaped piston (32) and piston rod (33),~~ the depth compensator comprising

a third cylinder,

a second piston,

a second piston rod extending out through an end closure of the depth compensator, wherein an end of the second piston rod is configured to be exposed to a surrounding water, and

a plurality of depth compensator volumes, the plurality of depth compensator volumes including

a fifth volume formed by a lower end surface of the third cylinder, an inner diameter surface of the third cylinder, a lower end surface of the second piston, and an outer diameter surface of the second piston rod, wherein the fifth volume is configured to be filled with gas or under vacuum, and

a sixth volume formed by an upper end surface of the third cylinder, the inner diameter surface of the third cylinder, and an upper end surface of the second piston, wherein the sixth volume is configured to be filled with oil; and

a conduit configured to connect the second volume in the actuator and the sixth volume in the depth compensator.

~~2. Depth compensated actuator according to claim 1, wherein the conduit means (17) connect a volume (V3) in the hollow actuator piston rod (13) and a volume (V5) in the hollow depth compensator piston rod (22).~~

~~3. Depth compensated actuator according to claim 1, wherein the conduit means (17) connects the volume at the closed end of the actuator and the closed volume of the piston in the compensator, both opposite side of the piston rod.~~

~~4. Depth compensated actuator (100) for use in subsea conditions according to one of the claims 1 or 2, wherein the actuator is a high pressure depth compensated actuator and comprises is a hollow rod actuator (100) and where the depth compensating is:~~

a hollow rod actuator (10), consisting of a first cylinder (11), a first piston (12), a first hollow rod (13), connection means (16) at each axial end of the hollow rod actuator (10), a second cylinder (14) mounted concentric with the first cylinder (11) and fastened to the upper end of the first cylinder (11) and a second piston (15) mounted at the lower end of the second cylinder (14);

a first volume (V1) is formed by the outer diameter of the hollow rod (13), the lower end of the first cylinder (11), the inner diameter of the first cylinder (11) and the lower end of the first piston (12), and may be filled with oil, gas or be under vacuum;

a second volume (V2) is formed by the outer diameter of the second cylinder (14), the upper end of the first cylinder (11), the inner diameter of the first cylinder (11), the upper end of the first piston (12), the inner diameter of the first hollow rod
(13) and the upper end of the second piston (15) and may be filled with oil, gas or be under vacuum;

a third volume (V3) is formed by the inner diameter of the second cylinder (14), the upper end of the first cylinder (11), the inner diameter of the hollow rod (13), the lower end of the second piston (15) and the lower end of the hollow rod (13), and may be filled with oil, gas or be under vacuum;

a depth compensator (20), consisting of a third cylinder (21), a second hollow rod (22), a fourth cylinder (23) mounted concentric with the third cylinder (21) and fastened to the upper end of the third cylinder (21), a third piston (24) mounted at the lower end of the fourth cylinder and a mechanical stroke limiter (25) mounted at the upper end of the second hollow rod (22), preventing the second hollow rod (22) from stroking excessively;

a fourth volume (V4) volume is formed between the lower end of the third cylinder (21), the inner diameter of the third cylinder (21), the outer diameter of the fourth cylinder (23), upper end of the third piston (24) and displaced by the second hollow rod (22) as well as the mechanical stroke limiter (25), which may be filled with gas or be under vacuum;

a fifth volume (V5) is formed between the lower end of the second hollow rod (22), the inner diameter of the fourth cylinder (23), the lower end of the second hollow rod (22), the upper end of the third cylinder (23) and the lower end of the third piston (24), which may be filled with oil;

conduit means (17) between the fifth volume (V5) and the third volume (V3).

5. Depth compensated actuator according to claim 1 or 2, wherein the volume of the hollow piston rod of the actuator communicates with the volume in the hollow rod of the depth compensator through a stationary cylinder 14 inside the actuator cylinder 11 and a stationary cylinder 23 inside the depth compensator cylinder.

6. Depth compensated actuator according to claim 4 or 5, wherein the piston rod of the depth compensator is ring shaped and may be provided with a stroke limiting device.

7. Depth compensated actuator according to one of the claims 5 to 6, wherein the cylinder of the depth compensator is open downwards and that the inner diameter of the open ended cylinder corresponds to outer diameter of the hollow piston rod.

8. Depth compensated actuator according to one of the claims 5 to 7, wherein the cross sectional area of the hollow piston of the depth compensator exposed to the surrounding water is lager than the corresponding exposed are of the actuator.

9. Hydraulically compensated actuator (0) according to claim 1, comprising:

a first and a second connection means (15) that are connected to either a fixed or movable point;

a cylinder (1), with piston (12) and piston rod (3);

a second cylinder (31) is mounted concentrically on the upper part, the second cylinder (31) has a larger diameter than the first cylinder (1), but shorter length;

the second cylinder features a ring shaped piston (32) connected to a ring shaped piston rod (33);

a conduit means (17) connects the oil side of the ring shaped cylinder (31) and the cylinder (1) together.

10. Hydraulically compensated actuator (0) according to claim 9, where:

the area ratio between the ring shaped piston (32) and the ring shaped piston rod (33) is equal to or smaller than the area ratio between the piston (12) and the piston rod (3).

11. Hydraulically compensated actuator (0) according to one of the claims 9 or 10 where:

the connection means (14) can be at least one of: a padeye and a clevis, but not limited only thereto.

12. Hydraulically depth compensated actuator (0) according to claim 1, comprising:

a hollow rod actuator (10), consisting of a first cylinder (11), a first ring piston (12), a hollow rod (13), connection means (14) at each axial end of the hollow rod actuator (10) and a second cylinder (15), mounted concentric with the first cylinder (11) and fastened to the upper end of the cylinder (11);

the ring piston (12) is adapted to slide on the outer diameter of the second cylinder (15);

a first volume (V1) is formed by the outer diameter of the hollow rod (13), the lower end of the first cylinder (11), the inner diameter of the first cylinder (11) and the ring piston (12), and may be filled with oil or gas;

a second volume (V2) is formed by the outer diameter of the second cylinder (15), the upper end of the first cylinder (11), the inner diameter of the first cylinder (11) and the ring piston (12), and may be filled with oil, gas or be under vacuum;

a third volume (V3) is formed by the inner diameter of the second cylinder (15), the upper end of the first cylinder (11), the inner diameter of the hollow rod (13) and the lower end of the hollow rod (13), and may be filled with oil, gas or be under vacuum;

a depth compensation means is connected to either the second volume (V2) or the third volume (V3) via conduit means.

13. Hydraulically depth compensated actuator (0) according to claim 12 or 13, wherein the depth compensation means is a depth compensator (20), further consisting of:

a third cylinder (21);

a piston (22);

a piston rod (23) exposed to external pressure connected to the piston (22) and adapted for reciprocation inside the third cylinder (21);

forming a fifth (V5) volume between the lower end of the third cylinder (21), the inner diameter of the third cylinder (21), lower end of the piston (22) and the outer diameter of the piston rod (23), which may be filled with gas or be under vacuum;

forming a sixth volume (V6) between the upper end of the third cylinder (21), the inner diameter of the third cylinder (21) and the upper end of the piston (22) which may be filled with oil;

conduit means between the sixth volume (V6) and the second volume (V2).

14. Hydraulically depth compensated actuator (0) according to claim 12-14 wherein the depth compensation means is a ring based depth compensator (30), further consisting of:

a fifth cylinder (31);

a second ring piston (32), adapted for sliding motion of the outside diameter of any cylinder (shown with dashed line in Figure 4);

a ring piston rod (33) connected to the ring piston (32), exposed to external pressure and adapted for reciprocation inside the fifth cylinder (31);

forming an eighth volume (V8) between the upper end of the fifth cylinder (31), the inner diameter of the ring piston rod (33) and the second ring piston (32), which may be filled with gas or be under vacuum;

forming a ninth volume (V9) between the upper end of the fifth cylinder (31), the outer diameter of the ring piston rod (33), the inner diameter of the fifth cylinder (31) and the second ring piston (32), which may be filled with gas or be under vacuum;

forming a tenth (V10) volume between the upper end of the fifth cylinder (31), the upper end of the second ring piston (32), the inner diameter of the fifth cylinder (31), which may be filled with oil;

conduit means between the tenth volume (V10) and the second volume (V2).

15. Hydraulically depth compensated actuator (0) according to one of the claims 12 to 14, wherein oil is replaced by any fluid and/or gas is replaced by any fluid and/or vacuum is replaced by any fluid/gas.

162. Use of aThe hydraulic depth compensated actuator according to (10) as defined in one of the claims 1 to 15, wherein the hydraulic depth compensated actuator (10) is used for active heave compensation by connected the actuator (10) to a gas accumulator comprising the following elements further comprises a depth compensator, the depth compensator comprising:

- a first accumulator cylinder, (42)
- a second accumulator cylinder (45) having a smaller diameter than the first accumulator cylinder (42), and concentrically arranged inside the first accumulator cylinder at one end of the first accumulator cylinder,
- an accumulator piston (40) configured to reciprocate inside the first accumulator cylinder (42), and dividing the first accumulator cylinder (42) into a ninth volume V9 at a side of the first accumulator piston and a tenth volume (V10) at an opposite side of the first accumulator piston, and
- an accumulator piston rod (41) fixed to and projecting out from the accumulator piston (40), the opposite end of the piston rod (41) being position inside the second accumulator cylinder (45) a second accumulator piston connected to an opposite end of the accumulator piston rod, wherein the second accumulator piston is positioned inside the second accumulator cylinder, and
- a first conduit device (43) for configured to establishing fluid communication between the ninth volume (V9) of the gas accumulator and at least one of the plurality of actuator volumes, (V1) of the actuator; and
- a second conduit device (44) for configured to establishing fluid communication between accumulator the tenth volume (V11) and a separate one of the plurality of the actuator volumes V3), and

a reversible pump (37) forming a part of configured to be positioned along the second conduit device (44).