

Pressure-resistant Piston Media Separator, especially for a Linear Drive of a Ship's Steering Gear

The invention concerns a pressure-resistant piston media separator. For example, in a linear drive for a ship's steering gear, a mechanical movement takes place against the external pressure. In order to avoid working against the external pressure, the hydraulic fluid in a pressure-resistant piston media separator is brought to approximately the external pressure by subjecting the hydraulic fluid in the pressure-resistant piston media separator to the external pressure through the ambient medium. A corresponding linear actuator for a ship's steering gear is known from DE 10 2016 204 248 A1. There, the term pressure compensation container is used as an alternative term for the pressure-resistant piston media separator. The piston of the pressure-resistant piston media separator is moved in one direction by incoming hydraulic fluid, in the other by the ambient medium. However, since this piston must also have a very good seal, the piston has a corresponding frictional resistance. As a result, at low external pressure, i.e. very shallow diving depth (including the surfaced state), the pressure on the piston due to the ambient medium, the ambient water, is not sufficient to move it. This can lead to a negative pressure on the side of the hydraulic fluid and thus to outgassing and consequently to bubble formation. This leads to two problems. On the one hand, the dissolution of the bubbles by dissolving them in the hydraulic fluid is very slow. On the other hand, the bubbles lead to unpredictable behaviour. In particular, locking of the rudder position, which is carried out by shutting off the hydraulics, is made more difficult. However, if there are gas bubbles in this region, the rudder position can change unintentionally.

The object of the invention is to create a pressure-resistant piston media separator, which works reliably at high ambient pressures (deep diving depth) but above all at low ambient pressures (shallow diving depth to surface travel).

This object is achieved by the pressure-resistant piston media separator having the features specified in Claim 1, by a linear drive having the features specified in Claim 10 and by a submarine having the features specified in Claim 11. Advantageous developments result from the subclaims, the following description and the drawing.

The pressure-resistant piston media separator according to the invention has a first piston cylinder with a first piston. Preferably, the first piston and the first piston cylinder have a round cross-section, but the invention is not limited to this. Theoretically, it is only necessary that the internal cross-section of the first piston cylinder and the external cross-section of the first piston are the same. The pressure-resistant piston media separator has a first region and a second region, wherein the first region is separated from the second region by the first piston. Preferably, at least one seal is attached to the first piston, which moves with the piston and separates the two regions from each other. This seal is mounted between the piston and piston cylinder in such a way that an exchange of the media from the first region, in particular water, and the second region, in particular hydraulic fluid, is prevented. Thus, the first region and the second region are variable in size by displacement of the first piston. The pressure-resistant piston media separator according to the invention is preferably arranged in a watercraft, particularly preferably in the interior of a pressure body of a submarine. The first region is in contact with the external pressure. For this purpose, the first region is, for example and preferably, connected to the surroundings via a line. Particularly preferably, this line has a pressure body feedthrough, and so connects the pressure-resistant piston media separator according to the invention to the water located outside the pressure body. Particularly preferably, the first region is in contact with surrounding water, in particular seawater. This results in a pressure adjustment to the water depth. The direct contact of the device with the surroundings results in technical challenges. On the one hand, seawater is a corrosive medium, which must be taken into account in the materials used. On the other hand, suspended solids and living beings are included, which can lead to a problem, especially due to vegetation. The second region is connected to a hydraulic system. The hydraulic system is, for example and preferably, part of a linear drive of a ship's steering gear. In a ship's steering gear, the drive rods for the rudder blades must be moved through the pressure body of the submarine against the surrounding water pressure. By adjusting the hydraulic pressure to the surrounding water pressure in the pressure-resistant piston media separator, the required force and the work to be done when adjusting the rudder blades are reduced. Furthermore, the pressure-resistant piston media separator has a piston rod, wherein the piston rod is connected to the first piston. The piston rod preferably runs through the second region. This has the advantage that the area of the first piston that is wetted by the hydraulic fluid on the side of the second region is smaller than the

area of the first piston that is wetted by water on the side of the first region, so that the hydraulic fluid always has a certain low overpressure compared to the external pressure, whereby in the event of a leak the penetration of corrosive seawater into the hydraulic region can be reliably prevented.

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According to the invention, the pressure-resistant piston media separator has a second piston cylinder and a second piston. The second piston is also connected to the piston rod. Thus, the directions of movement of the first piston in the first piston cylinder and the second piston in the second piston cylinder are identical, preferably coaxial. The pressure-resistant piston media separator has a third region, wherein the third region is a closed gas volume. The third region can be changed in size by the movement of the second piston. In fact, the second piston cylinder with the second piston and the third region thus represent an integrated gas spring. As a result, pressurization in a very compact design is possible by means of the stroke travel of the pressure-resistant piston media separator in order to allow sufficient force to act on the first piston for the region of a low external pressure, for example during surface travel, in order to move it against friction when the hydraulic system extracts hydraulic fluid from the second region and thus the force for displacing the first piston must come from the ambient water.

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Particularly preferably, the first piston cylinder and the second piston cylinder are arranged directly adjacent to each other.

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In a further embodiment of the invention, the third region consists of a fourth region and a fifth region. The fourth region is arranged inside the second piston cylinder and the fifth region is arranged outside the second piston cylinder. The fourth region and the fifth region are connected to each other in a gas gas-conducting manner. This makes it comparatively easy to adjust the pressure profile across all positions of the first piston, and thus, for example, the rudder position of a connected ship's steering gear. The size of the fourth region can therefore in extreme cases assume a minimum size even close

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to 0 at the maximum size of the second region and thus minimum size of the first region. Without the fifth volume, however, the pressure would become extremely large, which would either be possible by a larger dead volume, which would increase the size, or it can be achieved as in this advantageous embodiment just by a connected volume in a fifth region, which reduces the size.

In a further embodiment of the invention, the fifth region is at least partially, preferably completely, surrounding the second piston cylinder. This makes a particularly compact design possible.

In a further embodiment of the invention, the third region has a filling valve. This allows the pressure in the third region to be adjusted in a targeted manner. After filling, the filling valve is closed so that the third region is a closed volume of gas.

In a further embodiment of the invention, the volume of the fifth region corresponds to one to five times the maximum volume of the fourth region.

In a further embodiment of the invention, the third region has a pressure of 2 bar to 5 bar in the central position of the first piston in the first piston cylinder. The central position of the first piston is the position in the middle between the two end positions of the first piston.

In a further embodiment of the invention, the pressure in the first region is 1.5 bar to 3.5 bar higher than the pressure in the second region.

In a further embodiment of the invention, the third region is filled with an inert gas, preferably with nitrogen. As a result, for example, corrosive properties of oxygen or humidity can be easily avoided.

In a further embodiment of the invention, the third region has a pressure of 1.5 bar to 3.5 bar in the end position of the first piston with a minimal second volume of the second region in the first piston cylinder.

In a further embodiment of the invention, the first region is connected to the surroundings via a filter. In particular, the filter serves to keep out suspended particles and, above all, life forms that could settle inside. The disadvantage is that a filter represents a flow resistance. However, this can be compensated in a simple way by the effect of the third region.

In a further embodiment of the invention, the piston rod has a first feedthrough. The first feedthrough extends from the side of the first piston facing the first region to the side of the second piston facing away from the fourth region. The first feedthrough can be closed. As a result, during the first filling of the first region with seawater, the air in the first region can be discharged in a simple and reliable manner. This is particularly preferred if the pressure-resistant piston media separator is arranged vertically, i.e. the first region is arranged below the first piston.

In a further embodiment of the invention, the first piston has a first seal against the first region and a second seal against the second region. The first piston also has a test cavity between the first seal and the second seal. The first piston and the piston rod have a second feedthrough, wherein the second feedthrough connects the test chamber to the side of the second piston facing away from the fourth region. As long as the two seals, the first seal and the second seal, are tight, nothing happens. If the first seal leaks, seawater passes into the test cavity and through the test cavity into the second cavity to the outside and can be detected. It is therefore obvious that the first seal is leaking and therefore needs to be replaced. If the second seal leaks, hydraulic fluid passes into the test cavity and through the test cavity into the second feedthrough to the outside and can be detected. It is therefore obvious that the second seal is leaking and therefore needs to be replaced. The detection can be done either purely visually or with the help of a suitable sensor.

In a further aspect, the invention concerns a linear drive for a ship's steering gear with a pressure-resistant piston media separator according to the invention. The linear actuator is preferably designed according to DE 10 2016 204 248 A1, only with a pressure-resistant piston media separator according to the invention.

In a further embodiment of the invention, the linear drive is electrically operated.

In a further embodiment of the invention, the linear drive has a first linear drive region and a second linear drive region, wherein the first linear drive region and the second linear drive region are filled with hydraulic fluid. When the linear drive is displaced, the volumes of the first linear drive region and the second linear drive region change. The first linear drive region and the linear drive region are fluidically connected to the second region of the pressure-resistant piston media separator. Particularly preferably the connection between the second region of the pressure-resistant piston media separator and the first linear drive region and the connection between the second region of the pressure-resistant piston media separator and the second linear drive region can each be closed separately, for example by means of valves. Preferably, the connection between the first linear drive region and the second linear drive region is closed, so that the linear drive is thereby fixed in its position.

In a further embodiment of the invention, the volume of the second region of the pressure-resistant piston media separator is equal to or greater than the volume difference between the sum of the volumes of the first linear drive region and the second linear drive region at a stop of the linear drive and the sum of the volumes of the first linear drive region and the second linear drive region at the opposite stop of the linear drive.

In a further aspect, the invention concerns a submarine with a pressure-resistant piston media separator according to the invention. Preferably, the pressure-resistant piston media separator is arranged inside a pressure body of the submarine and the first region of the pressure-resistant piston media separator is connected to the surroundings of the submarine. For this purpose, the connection between the first region and the surroundings has a pressure body feedthrough.

The pressure-resistant piston media separator according to the invention is explained in more detail below on the basis of an exemplary embodiment shown in the drawing.

Fig. 1 Example of a pressure-resistant piston media separator

Fig. 1 shows an exemplary pressure-resistant piston media separator 10 schematically and not to scale in cross-section. The part of the pressure-resistant piston media separator 10 shown on the left consists of a first piston cylinder 20, in which a first piston 30 is movably arranged. On one side, here on the left, a first region 40 is arranged, which is at the ambient pressure via a connection to the surroundings 60, for example a seawater connection. On the other side, the second region 50 is arranged, in which a hydraulic fluid is arranged, which can be supplied and removed via a connection to the hydraulic system 70. The piston rod 80 also runs within the second region 50.

The second piston cylinder 90 with the second piston 100 is essential. The second piston 100 is also connected to the piston rod 80 and thus performs the same movement as the first piston 30. In order to make the gas-tight third region as compact as possible, it consists in the example shown of a fourth region 110 within the second piston cylinder 90 and a fifth region 120 surrounding the second piston cylinder on the outside. By means of a filling valve 140, the gas pressure inside the third region can be adjusted in a targeted manner, in particular with nitrogen. Here, the fourth region 110 and the fifth region 120 are connected to each other via a gas-conducting connection 130.

In order to facilitate an initial filling of the first region 40 with water, the piston rod 80 has a first feedthrough 150, which has a feedthrough closure 160 on the side of the second piston 100 and thus easily accessible from the outside, so that in normal operation no water from the surroundings can penetrate into the interior. Thus, however, the feedthrough closure 160 must be able to withstand the maximum immersion pressure.

Furthermore, the first piston 30 has a first seal 170 against the water side of the first region 40 and a second seal 180 against the hydraulic side of the second region 50. In order to be able to detect a leakage of one of these seals 170, 180, a test cavity 190 is arranged between the seals 170, 180, which is connected to the second feedthrough 200. In the event of a leak of the first seal 170, seawater can thus pass into the region outside the second piston 100 and be easily detected. Likewise, in the event of a leak of the second seal 180, hydraulic fluid can pass into the region outside the second piston 100 and be easily detected.

Reference characters

	10	pressure-resistant piston media separator
	20	first piston cylinder
5	30	first piston
	40	first region
	50	second region
	60	connection to the surroundings
	70	connection to the hydraulic system
10	80	piston rod
	90	second piston cylinder
	100	second piston
	110	fourth region
	120	fifth region
15	130	gas-conducting connection
	140	filling valve
	150	first feedthrough
	160	feedthrough closure
	170	first seal
20	180	second seal
	190	test cavity
	200	second feedthrough

Claims

1. Pressure-resistant piston media separator (10), wherein the pressure-resistant piston media separator (10) has a first piston cylinder (20) with a first piston (30),
 5 wherein the pressure compensation container (10) has a first region (40) and a second region (50), wherein the first region (40) is separated by the first piston (30) from the second region (50), wherein the first region (40) is in contact with the surroundings, wherein the second region (50) is connected to a hydraulic system, wherein the pressure-resistant piston media separator (10) has a piston rod (80),
 10 wherein the piston rod (80) is connected to the first piston (30), **characterized in that** the pressure-resistant piston media separator (10) has a second piston cylinder (90) and a second piston (100), wherein the second piston (100) is connected to the piston rod (80), wherein the pressure-resistant piston media separator (10) has a third region, wherein the third region is a closed gas volume,
 15 wherein the size of the third region can be varied by the second piston (100).
2. Pressure-resistant piston media separator (10) according to Claim 1,
characterized in that the third region consists of a fourth region (110) and a fifth region (120), wherein the fourth region (110) is arranged within the second piston cylinder (90), wherein the fifth region (120) is arranged outside the second piston cylinder (90), wherein the fourth region (110) and the fifth region (120) are gas-conductively connected to each other.
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3. Pressure-resistant piston media separator (10) according to Claim 2,
characterized in that the fifth region (120) is arranged surrounding the second piston cylinder (90).
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4. Pressure-resistant piston media separator (10) according to any one of Claims 2 to 3, **characterized in that** the third region has a filling valve (140).
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5. Pressure-resistant piston media separator (10) according to any one of Claims 2 to 4, **characterized in that** the volume of the fifth region (120) corresponds to one to five times the maximum volume of the fourth region (110).

6. Pressure-resistant piston media separator (10) according to any one of the preceding claims, **characterized in that** the third region has a pressure of 2 bar to 5 bar in the central position of the first piston (30) in the first piston cylinder (20).
- 5 7. Pressure-resistant piston media separator (10) according to any one of the preceding claims, **characterized in that** the pressure in the first region (40) is 1.5 bar to 3.5 bar higher than the pressure in the second region (50).
- 10 8. Pressure-resistant piston media separator (10) according to any one of the preceding claims, **characterized in that** the third region is filled with an inert gas, preferably with nitrogen.
- 15 9. Pressure-resistant piston media separator (10) according to any one of the preceding claims, **characterized in that** the third region in the end position of the first piston (30) has a pressure of 1.5 bar to 3.5 bar with a minimal second volume of the second region (50) in the first piston cylinder (20).
- 20 10. Pressure-resistant piston media separator (10) according to any one of the preceding claims, **characterized in that** the first region (40) is connected to the surroundings via a filter.
- 25 11. Pressure-resistant piston media separator (10) according to any one of the preceding claims, **characterized in that** the piston rod (80) has a first feedthrough (150), wherein the first feedthrough (150) extends from the side of the first piston (40) facing the first region (40) to the side of the second piston (100) facing away from the fourth region (110), wherein the first feedthrough (150) can be closed.
- 30 12. Pressure-resistant piston media separator (10) according to any one of the preceding claims, **characterized in that** the first piston (30) has a first seal (170) against the first region (40) and a second seal (180) against the second region (50), wherein the first piston (30) has a test cavity (190) between the first seal (170) and the second seal (180), wherein the first piston (30) and the piston rod (80) have a second feedthrough (200), wherein the second feedthrough (200) connects the test cavity (190) to the side of the second piston (100) facing away from the
35 fourth region (110).

13. Linear drive for a ship's steering gear with a pressure-resistant piston media separator (10) according to any one of the preceding claims.

5 14. Submarine with a pressure-resistant piston media separator (10) according to any one of the preceding claims.