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(54) **VEICOLO, IN PARTICOLARE IMBARCAZIONE, CON UN SISTEMA DI CONVERSIONE DI ENERGIA PER GENERARE UNA PRESSIONE IDRAULICA**

(57) A vehicle, defined in particular by a boat (1), is provided with an energy conversion system (100), having a hydraulic circuit (101) and a hydraulic cylinder (120), which includes a barrel (121), a rod (122) axially sliding in the barrel (121), and a piston (124), fixed with respect to the rod (122); the piston (124) is coupled to the barrel (121) in a fluid-tight manner so as to axially separate two chambers (126), communicating with the hydraulic circuit (101) by check valves (137,140), and is placed in an axial

reference position, in rest conditions, by spring members (132); a component (10), having an oscillatory or vibratory motion, is connected to one of the barrel (121) and the rod (122), so as to make the hydraulic cylinder (120) operate as a reciprocating linear pump, in response to such oscillatory/vibratory motion, for generating a hydraulic pressure which can be exploited in a hydraulic system (5) of the vehicle, connected to the hydraulic circuit (101) of the system (100).

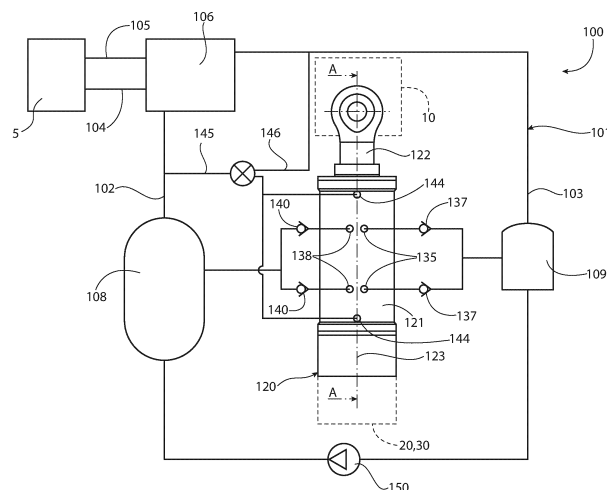


FIG. 2

Description

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This patent application claims priority from Italian patent application no. 102023000025704 filed on December 1st, 2023, the entire disclosure of which is incorporated herein by reference.

TECHNICAL FIELD

[0002] The invention relates to a vehicle provided with an energy conversion system for generating a hydraulic pressure, starting from an oscillatory movement or a vibration of a vehicle component.

[0003] In particular, the energy conversion system of the present invention exploits external loads of variable magnitude which are normally present during the navigation of a boat (such as inertial accelerations due to the wave motion of the sea, the wind acting on sails under tension, variable loads due to water acting on immersed members, etc.).

PRIOR ART

[0004] In the nautical field, and more generally in the field of vehicles, it is known to provide hydraulic actuators supplied by oil under pressure to operate various devices which are provided on board.

[0005] Obviously, the generation of hydraulic pressure requires a pump powered by electrical energy, which is generally produced by motion of an internal combustion engine, also arranged on board and supplied, in turn, with fossil fuels.

[0006] This configuration involves some drawbacks, including: the emission of pollutants produced by the combustion of fossil fuel, the weight of the fuel on board, and the sizing of the tanks for containing such fuel.

[0007] The need is felt to limit the aforesaid drawbacks by exploiting alternative energy sources. In this perspective, especially with regard to boats, the need is felt to exploit forces or accelerations which are normally present during the journey and generate an oscillatory or vibratory motion on one or more components of the vehicle. In particular, the need is felt to exploit such forces/accelerations to generate a hydraulic pressure, which will replace or supplement the one provided by the electric pump, thus limiting the energy consumed by such a pump.

[0008] The object of the present invention is thus to meet the need described above, preferably in a simple and/or reliable and/or effective manner.

SUMMARY OF THE INVENTION

[0009] The object is achieved by a vehicle, in particular a boat, with an energy conversion system according to claim 1.

[0010] The dependent claims define particular embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] In order to better understand the invention, an embodiment thereof is described in the following by way of non-limiting example and with reference to the accompanying drawings, wherein:

- Figure 1 is a schematic side view of a boat, defining a preferred embodiment of the vehicle with an energy conversion system according to the present invention,
- Figure 2 is a diagram illustrating the energy conversion system according to the present invention, connected to a hydraulic system of the vehicle, and
- Figure 3 is a cross section according to the line A-A of Figure 2 and shows a hydraulic cylinder forming part of the energy conversion system.

PREFERRED EMBODIMENTS OF THE INVENTION

[0012] In Figure 1, reference numeral 1 is used to indicate, as a whole, a boat (partially and schematically illustrated), in particular a sail boat.

[0013] The boat 1 comprises a hydraulic system 5, of known type and schematically illustrated, for feeding oil under pressure to a plurality of hydraulic users (which include, for example, at least one hydraulic cylinder 21).

[0014] The boat further comprises a plurality of components 10 which are subjected, during navigation, to forces or accelerations suitable to cause an oscillatory or vibratory motion on the same components 10. In particular, such forces or accelerations can be defined by external loads of variable magnitude due, for example, to normal changes in wind speed and direction, wave motion, normal variations in water thrust on parts immersed in water, or aerodynamic loads on the sails, etc.

[0015] According to an embodiment, the components 10 are defined by movable members coupled to respective actuators 20, which are operated to keep such components 10 in a predefined position. For example, the actuators 20 can be defined by:

- hydraulic cylinders 21 supplied and operated by the system 5, for example to keep a component 10 in a given position, defined by a movable member 22 immersed in water (a hydrofoil, a keel, etc.) and/or
- cables or ropes 23, which keep a component 10 defined by a sail 24 deployed and can be tensioned by electric motors, hydraulic actuators, pneumatic actuators, or so-called winches (i.e., manually manoeuvred winches), not illustrated.

[0016] According to other embodiments, the components 10 are arranged in a predefined position and are constrained to a fixed structure 30 of the boat 1, and thus

are not operated by an actuator, but are naturally provided with an oscillation or a vibration due to variable external loads.

[0017] According to other embodiments, the components 10 are defined by masses which are coupled to the fixed structure 30 so as to move substantially freely and are subject to natural inertial forces, due to wave motion and/or the consequent rocking of the boat, whereby they have an oscillatory motion of an inertial nature.

[0018] In general, the components 10 potentially having vibratory or oscillatory motion during navigation may be of a different type with respect to those mentioned above, and are known to the person skilled in the art, whereby they are not listed in detail here for the sake of brevity.

[0019] Furthermore, the same situation (with components potentially having an oscillatory or vibratory motion) can also be found on other types of vehicles, provided with a hydraulic system.

[0020] According to the present invention, the boat 1 comprises an energy conversion system 100 configured so as to recover energy which is naturally associated with the aforesaid oscillations/vibrations, and thus convert this energy into a hydraulic pressure, which can be transferred to the hydraulic system 5 and used in the latter (for example to operate the hydraulic cylinders 21).

[0021] With reference to the diagram in Figure 2, the energy conversion system 100 comprises a hydraulic circuit 101 connected to the hydraulic system 5. In particular, the hydraulic circuit 101 comprises a high pressure branch 102 and a low pressure branch 103, respectively connected to a delivery branch 104 and to a return branch 105 of the hydraulic system 5, by one or more valves 106.

[0022] Preferably, the hydraulic circuit 101 further comprises a high pressure accumulator 108, of known type and not described in detail, arranged along the high pressure branch 102 and configured so as to receive and accumulate oil under pressure, and thus feed the accumulated oil towards the delivery branch 104 (opening the valves 106). More preferably, the hydraulic circuit 101 further comprises a low pressure accumulator 109, of known type and not described in detail, arranged along the low pressure branch 103, and configured so as to receive oil from the return branch 105.

[0023] The energy conversion system 100 further comprises a hydraulic cylinder 120 which couples one of the components 10 to a corresponding actuator 20 (or to the fixed structure 30). The hydraulic cylinder 120 comprises a barrel 121 and a rod 122, which extends along an axis 123 and has an axial end arranged outside the barrel 121. In particular, the barrel 121 is fixed directly to the actuator 20 (or to the fixed structure 30), and the outer end of the rod 122 is connected, directly or indirectly, to the component 10. However, an opposite configuration could be envisaged, with the axial end of the rod 122 fixed directly to the actuator 20 (or to the fixed structure 30), and with the barrel 121 connected, directly or indirectly, to the component 10.

[0024] With reference to Figure 3, the hydraulic cylinder 120 further comprises a piston 124, which is axially arranged at an intermediate portion of the rod 122, is fixed with respect to the latter, and is coupled to an inner surface 125 of the barrel 121 so as to be able to axially move and so as to axially separate, in a fluid-tight manner, two chambers 126 provided inside the barrel 121.

[0025] In particular, the two chambers 126 are delimited radially by the inner surface 125, and axially by respective bottom walls 128, facing the piston 124 and arranged on opposite axial parts of the piston 124. Preferably, the rod 122 projects axially from both opposite faces of the piston 124, i.e., in both chambers 126, and axially crosses both bottom walls 128 in a fluid-tight manner. More in particular, the rod 122 has the same diameter in both chambers 126.

[0026] Preferably, the chambers 126 house respective spring members 132, axially coupled against the piston 124, on one side, and against the respective bottom walls 128, on the other side. More preferably, each of the spring members 132 is defined by a respective set of disc springs.

[0027] In rest conditions (i.e., in the absence of pressure in the chambers 126, and in the absence of forces acting on the rod 122) the two axial elastic thrusts of the spring members 132 are opposite each other and tend to keep the piston 124 in an intermediate reference position. Preferably, the spring members 132 are equal and symmetrical to one another, whereby the reference position is arranged centrally between the bottom walls 128.

[0028] According to variants not illustrated, to define a reference position for the piston 124, it is sufficient to provide even only one of the two spring members 132, and their housing inside the chambers 126 is not essential.

[0029] As diagrammed in Figure 2, each of the two chambers 126 has a respective inlet 135 communicating with the low pressure branch 103 by a corresponding check valve 137, and a respective outlet 138 communicating with the high pressure branch 102 by a corresponding check valve 140. The check valves 137 and 140 are arranged so as to allow an oil flow which only goes from the low pressure branch 103 towards the chambers 126 and from the latter towards the high pressure branch 102; in other words, the check valves 137 and 140 prevent the oil flow in the opposite direction. In particular, the check valves 137 communicate with the low pressure branch 103 through the low pressure accumulator 109, and the check valves 140 communicate with the high pressure branch 102 through the high pressure accumulator 108.

[0030] It is therefore evident that the hydraulic cylinder 120 is a double-acting cylinder. However, according to a variant not illustrated, the hydraulic cylinder 120 could be of the single-acting type, with only one of the chambers 126 connected to the hydraulic circuit 101.

[0031] Still with reference to Figures 2 and 3, based on the oscillations or vibrations of the component 10 along

the axis 123, the rod 122 and therefore the piston 124 move axially starting from the aforesaid reference position, against the positioning/centring action which is exerted by the thrust of the spring members 132. The chambers 126 and the hydraulic circuit 101 are filled with oil: as a consequence of the axial movement of the piston 124, one of the two chambers 126 increases the volume thereof and therefore sucks oil from the low pressure branch 103, through the corresponding check valve 137 and the corresponding inlet 135, while the other chamber 126 tends to decrease in volume, and the oil therein is compressed. Such oil then flows towards the high pressure branch 102 through the corresponding outlet 138.

[0032] When the movement direction of the rod 122 is reversed, the behaviour of the two chambers 126 is also reversed.

[0033] It is therefore evident that the hydraulic cylinder 120 defines an reciprocating linear pump, which is operated by the oscillation or vibration of the component 10 and pressurizes the oil in the high pressure branch 102 (and, in more detail, in the high pressure accumulator 108). In other words, the hydraulic cylinder 120 converts the natural oscillatory or vibratory motion of the component 10 into a hydraulic pressure which becomes available in the high pressure accumulator 108. As a direct consequence, it will be possible to feed oil under pressure from the high pressure accumulator 108 to the delivery branch 104, opening the valves 106 (preferably with a simultaneous outflow of oil from the return branch 105 towards the low pressure branch 103).

[0034] In the preferred embodiment illustrated in Figure 2, the hydraulic circuit 101 further comprises a bypass pump 150, which connects the low pressure branch 103 to the high pressure branch 102, in parallel to the hydraulic cylinder 120, and is operated (for example by an electric motor not illustrated) when the movement of the rod 122 is insufficient for pressurizing the high pressure accumulator 108. In other words, oil under pressure can be fed by the pump 150 from the low pressure branch 103 to the high pressure accumulator 108, by-passing the hydraulic cylinder 120. In particular, the pump 150 can be activated and deactivated in response to a pressure signal provided by a sensor, not illustrated, associated with the high pressure accumulator 108: for example, the pump 150 is activated and deactivated when such a signal becomes lower and, respectively, higher than two predefined threshold values, so as to maintain the pressure in the high pressure accumulator 108 in the range between such values.

[0035] In the embodiments in which the components 10 are kept in a given position by the actuators 20 and are subjected to loads of variable magnitude, such components 10 can be provided with an axial clearance around such a position. In other words, the components 10 (sails 24, movable members 22, etc.) are left to oscillate around a predefined position, instead of being kept perfectly stopped by the actuators 20 in such a position.

[0036] This axial oscillation clearance must be rela-

tively small and is defined by the maximum axial excursion of the piston 124 inside the barrel 121.

[0037] This excursion is adjustable in the preferred embodiment illustrated in Figure 3, thanks to the fact that the two bottom walls 128 are floating along the axis 123 with respect to the barrel 121 and the rod 122.

[0038] In fact, the bottom walls 128 are coupled in a fluid-tight manner to the inner surface 125 and to the rod 122, and axially delimit respective preloading chambers 142, provided at opposite axial ends of the barrel 121. The chambers 142 are used in a preliminary or initial setting phase, before using the hydraulic cylinder 120 as a reciprocating linear pump. In this phase, the energy conversion system 100 is set up to set the maximum axial excursion of the piston 124. In detail, the chambers 142 have respective inlet/outlet ports 144, connected to a source of oil 145 under pressure, for example by a valve 146 (Figure 3); in the particular example illustrated, the source 145 is defined by the high pressure branch 102, but could be defined by the hydraulic system 5, or by another oil supply system, of an independent type. When the valve 146 is opened, the source 145 feeds oil under pressure in both chambers 142 through the ports 144. The pressure of this oil exerts the same axial force on the bottom walls 128, since the latter have the same outer diameter. Such an axial force axially moves both bottom walls 128 towards the piston 124 and therefore compresses the spring members 132 against the piston 124. In other words, a preload is provided to both spring members 132 by the pressurization of the two chambers 142.

[0039] During this pressurization, the reference position of the piston 124 remains substantially unchanged, since the compression acting on the bottom walls 128 is equal, and the spring members 132 are equal and symmetrical with one another with respect to the piston 124 (in summary, the spring members 132 have the same rigidity).

[0040] During this setting, preferably, the pressurization of the chambers 142 ends when the spring members 132 reach a predefined deformation and/or when the bottom walls 128 reach a predefined axial position. At this point, the oil present in each of the two chambers 142 remains closed and isolated, whereby it tends to define a rigid system which keeps the corresponding bottom wall 128 in a fixed axial position. This axial position of the bottom walls 128 will define, in practice, a new end-stroke for the piston 124 during normal use of the hydraulic cylinder 120 as a reciprocating linear pump.

[0041] During this use, as mentioned above, the hydraulic cylinder 120 allows the component 10 to oscillate or vibrate around a predefined position thereof, corresponding to the reference position of the piston 124, while the rod 122 transfers, to the same piston 124, the force/acceleration which causes such oscillation/vibration. Thanks to the energy associated with the transferred force/acceleration, the piston 124 pressurizes the oil present in the chambers 126, with a reciprocating motion,

and thus pumps the oil in the high pressure accumulator 108 through the valves 137: it is therefore evident that the energy conversion system 100 pressurizes the high pressure branch 102 and, therefore, the hydraulic system 5 by exploiting an energy which is naturally associated with oscillatory or vibratory motions of the components 10, so as to save energy.

[0042] The fact that the hydraulic cylinder 120 is double-acting allows pumping oil regardless of the movement direction of the rod 122. Furthermore, the presence of two chambers 142 for adjusting the excursion of the piston 124 allows keeping the piston 124 in a central position in rest conditions (regardless of the preload assigned to the spring members 132).

[0043] Furthermore, the compression of the oil in the chambers 126 by the piston 124 can also be used to dampen the magnitude of the oscillatory or vibratory motion of the components 10, with respect to a reference situation in which the hydraulic cylinder 120 is not provided.

[0044] Other advantages are then evident to a person skilled in the art on the basis of what is set forth in the present discussion and illustrated in the accompanying drawings.

[0045] Finally, it is evident that modifications and variants can be made to the vehicle described above without however departing from the scope of protection defined by the appended claims.

[0046] In particular, the dimensions and proportions between the various parts of the hydraulic cylinder 120 could be different from what is schematically illustrated and simplified in the accompanying figures. Furthermore, the bottom walls 128 could be fixed with respect to the barrel 121, thus excluding the possibility of adjusting the axial excursion of the piston 124; or one of the two bottom walls 128 could be fixed, and the other floating.

Claims

1. A vehicle comprising

- a hydraulic system (5);
- a component (10) having, in use, an oscillatory or vibratory motion;
- an energy conversion system (100) comprising:

- a) a hydraulic circuit (101) connectable to said hydraulic system (5) for transferring a flow of oil under pressure and comprising a high pressure branch (102) and a low pressure branch (103);
- b) a hydraulic cylinder (120) comprising:

- (1) a barrel (121);
- (2) a rod (122), which extends along an axis (123) and is axially movable with

respect to said barrel (121);

(3) a piston (124), fixed with respect to said rod (122) and coupled to said barrel (121) in a fluid-tight manner so as to axially separate two chambers (126) from each other; at least one of said chambers (126) communicating with said high pressure branch (102) and with said low pressure branch (103) by respective check valves (137, 140), which allow oil flows only from said hydraulic cylinder (120) to said high pressure branch (102) and from said low pressure branch (103) to said hydraulic cylinder (120);

(4) at least one spring member (132) configured to place said piston (124) in an axial reference position with respect to said barrel (121) in rest conditions;

said component (10) being connected to one of said barrel (121) and said rod (122) so as to make said hydraulic cylinder (120) operate as a reciprocating linear pump in response to said oscillatory/vibratory motion.

2. The vehicle according to claim 1, wherein said vehicle is defined by a boat (1).
3. The vehicle according to any one of the preceding claims, wherein both said chambers (126) communicate with said high pressure branch (102) and with said low pressure branch (103) by said check valves (137, 140), and wherein the reference position in rest conditions is an intermediate axial position defined by two spring members (132) arranged on opposite axial sides of said piston (124).
4. The vehicle according to any one of the preceding claims, wherein said spring member (132) is housed in one of said chambers (128) and is axially arranged between said piston (124) and a bottom wall (128).
5. The vehicle according to claim 4, wherein said bottom wall (128) is axially floating with respect to said barrel (121) and said rod (121), so as to define, with said barrel (121), a preloading chamber (142), which can be pressurized during a preliminary setting phase to move said bottom wall (128) towards said piston (124) and vary a preload of said spring member (132).
6. The vehicle according to claim 5, wherein said chambers (126) house respective spring members (132), axially arranged between said piston (124) and respective bottom walls (128), which are axially floating with respect to said barrel (121) and said rod (121), so as to define, with said barrel (121), respec-

tive preloading chambers (142), which can be pressurized during the preliminary setting phase.

7. The vehicle according to any one of the preceding claims, wherein each of said spring members is defined by a respective set of disc springs. 5
8. The vehicle according to any one of the preceding claims, wherein said hydraulic circuit (101) comprises a high pressure accumulator (108) arranged along said high pressure branch (102). 10
9. The vehicle according to any one of the preceding claims, wherein said hydraulic circuit (101) comprises a low pressure accumulator (109) arranged along said low pressure branch (103). 15
10. The vehicle according to any one of the preceding claims, wherein said hydraulic circuit (101) comprises a pump (150) connecting said low pressure branch (103) to said high pressure branch (102), in parallel with said hydraulic cylinder (120). 20
11. The vehicle according to any one of the preceding claims, wherein the other one of said barrel (121) and said rod (122) is fixed to an actuator (20), operated to maintain said component (10) around a given position. 25
12. The vehicle according to claim 11, wherein the vehicle comprises at least one hydraulic cylinder actuator (21) operated by said hydraulic system (5), and wherein said actuator (20) is defined by said hydraulic cylinder actuator (21) . 30
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13. The vehicle according to claim 11, wherein the vehicle comprises at least one cable or rope (23), in tension, and wherein said actuator (20) is defined by said cable or rope (23) . 40
14. The vehicle according to any one of claims 1 to 10, wherein the vehicle (1) comprises a fixed structure (30), and wherein the other one of said barrel (121) and said rod (122) is fixed to said fixed structure (30). 45

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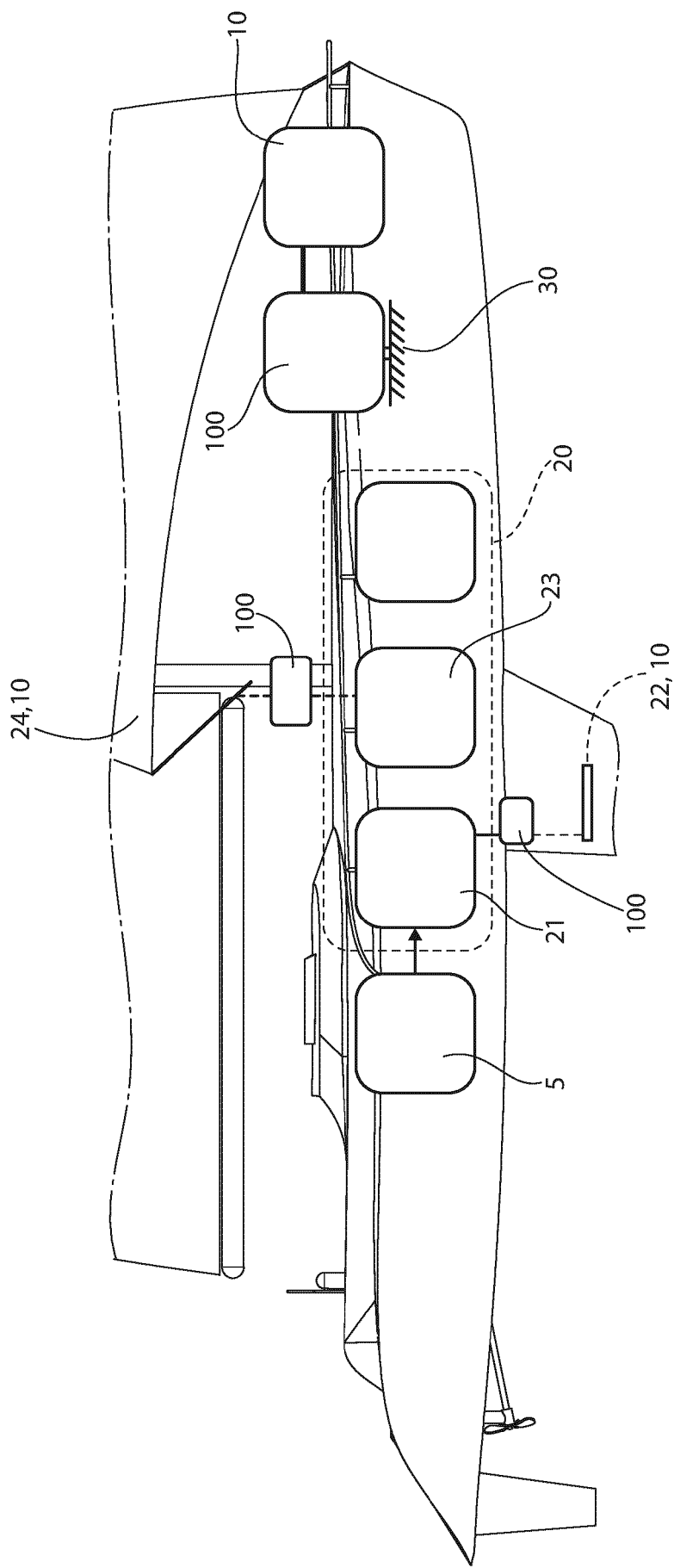


FIG. 1

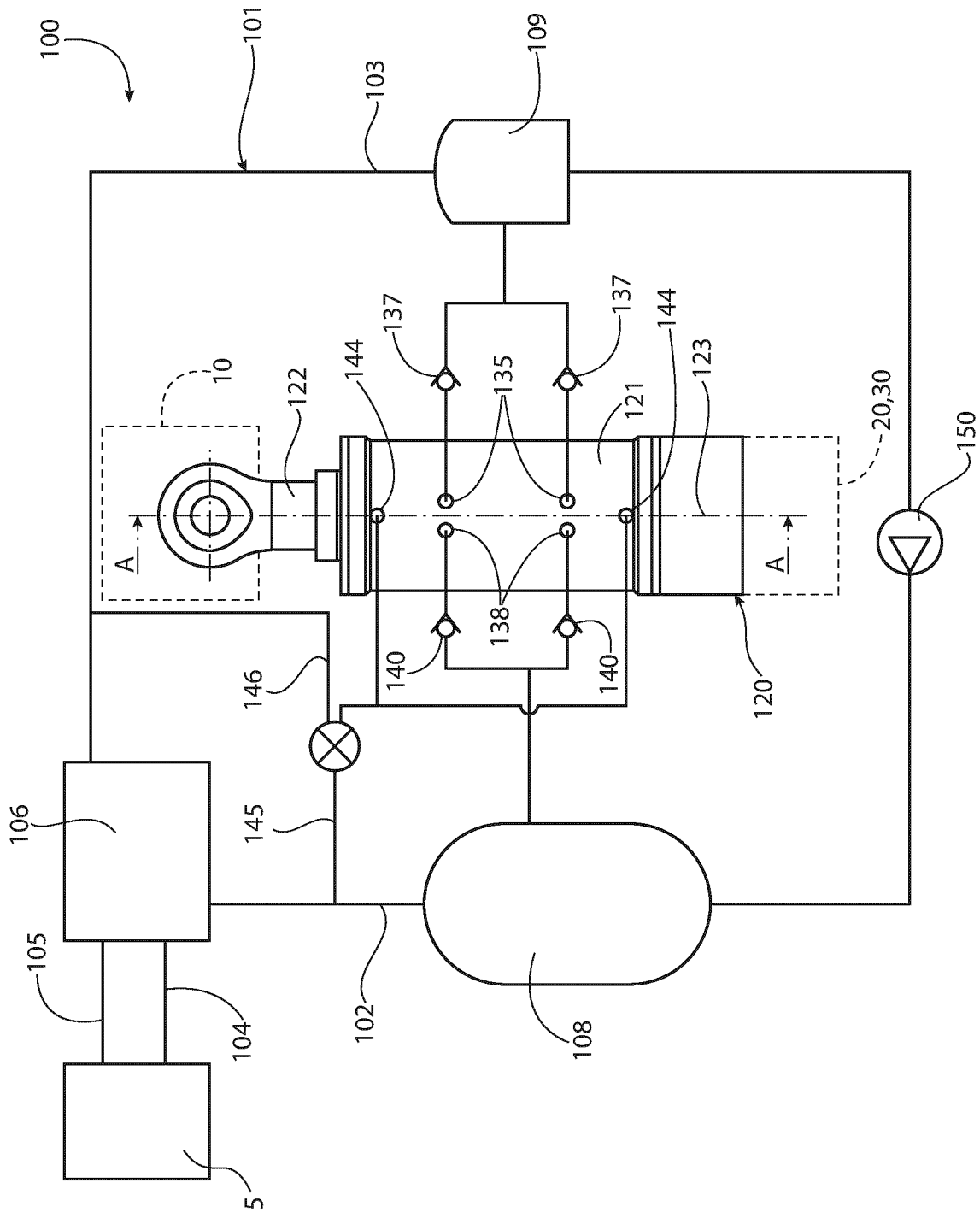


FIG. 2

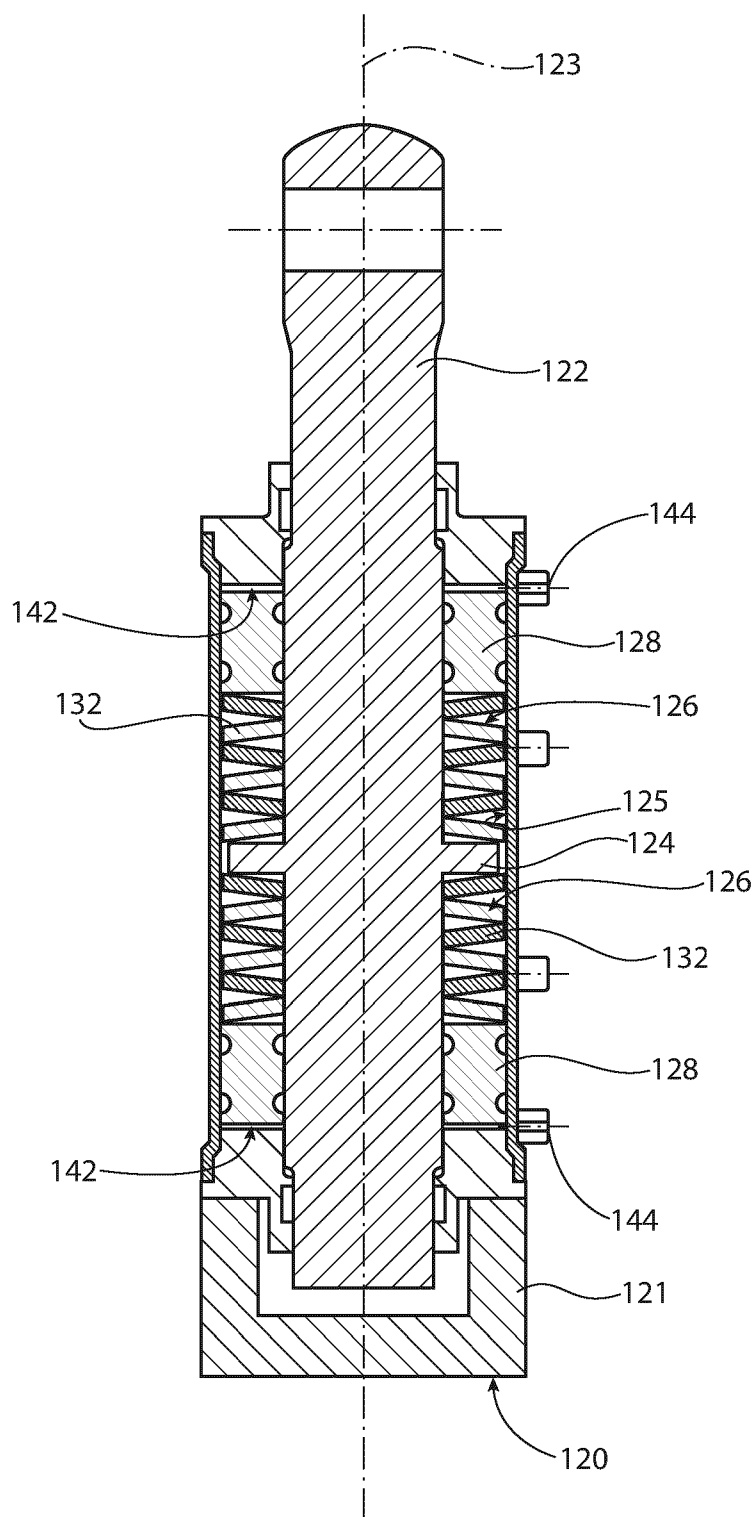


FIG. 3



EUROPEAN SEARCH REPORT

Application Number

EP 24 21 5012

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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 9 April 2025	Examiner Di Renzo, Raffaele
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