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(54) **HYDRAULIC AXIAL PISTON PUMP HAVING A FLOATING ROTATORY DRUM**

(57) The invention relates to a pump comprising: a housing (1); a drum (2) having cylinders in which pistons (3) are mounted, which pistons are supported by supporting shoes (32) on a fixed inclined plate (4); and first and second fluid-distributing plates (5a, 5b) having openings (51, 52) for establishing in an alternating manner the connection between first mouths (23) of the cylinders (22) and a first inlet (11) and first outlet (12) of primary

liquid, and between second mouths (24) and a second inlet (13) and second outlet (14) of the secondary liquid. The pump comprises first and second strips (6a, 6b) arranged between the drum (2) and the distributing plates (5a, 5b), said strips being movable in a longitudinal direction and allowing the drum to tilt to a certain extent, forming a sealed closure between the ends of the drum (2) and the distributing plates (5a, 5b).

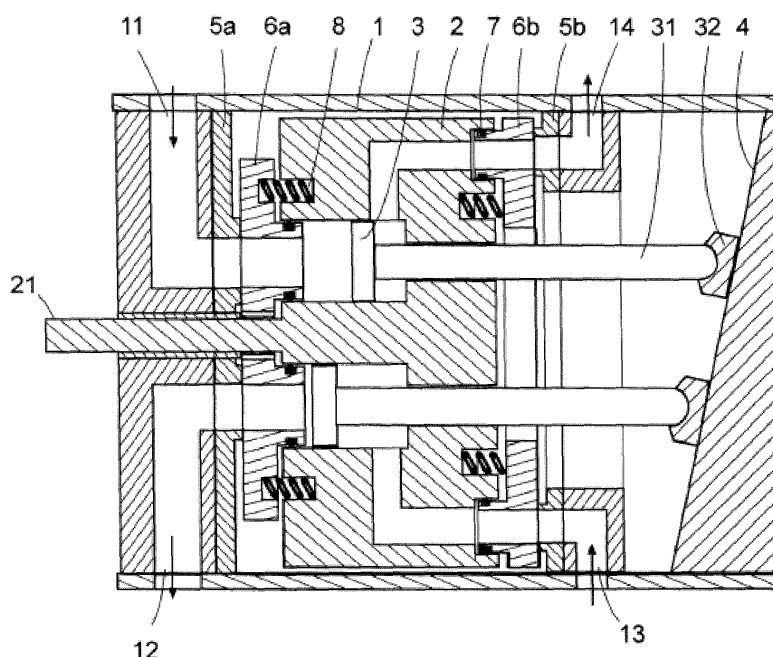


Fig. 1

Description

TECHNICAL FIELD

[0001] The present invention relates to a hydraulic axial piston pump having a floating rotatory drum, which can mainly be applied in seawater reverse osmosis desalination systems.

PRIOR ART

[0002] A number of documents are known which relate to axial piston pumps intended for being used in equipment, for example seawater desalinating equipment, requiring for operation the addition of a primary liquid at a high pressure, propelled by the axial piston pump, and returning a secondary liquid at a pressure that is slightly lower than the feed pressure; said axial piston pumps incorporating means for harnessing the energy of the secondary liquid that is rejected or returned by the equipment in question.

[0003] In the specific case of seawater reverse osmosis desalination equipment, the primary liquid is seawater supplied to the osmosis membranes at a high pressure, whereas the secondary liquid is the reject water with a high salt content supplied by the osmosis membrane at pressure that is lower than the pressure of the primary liquid.

[0004] Some axial piston pumps of this type are described, for example, in the following patent documents: US 7799221 B1 (MACHARG JOHN P), WO 2010025729 A1 (DANFOSS AS ET AL.), or in PCT application ES 2012/000279 (BOLSAPLAST S.L.), which belongs to the same inventor of the present invention.

[0005] Energy-harnessing axial piston pumps described in said documents generally comprise a housing in which a rotatory drum is housed, said drum being provided with a drive shaft for operation by means of an external motor, and with a plurality of cylinders arranged in circular fashion around the geometric axis of said drum and communicated at their ends by first inlet and outlet mouths of a primary liquid and second inlet and outlet mouths of a secondary liquid; said first and second mouths being defined at first and second ends of the rotatory drum.

[0006] Pistons are mounted axially in the cylinders of the drum and prolonged in rods projecting through a second end of the drum and ending in supporting shoes on a fixed inclined plate, such that when the drum rotates said pistons establish in an alternating manner a forward and backward movement inside the cylinders.

[0007] These pumps comprise first and second fluid-distributing plates facing opposite ends of the drum, provided with openings suitably distributed for establishing in an alternating manner, during rotation of the drum, the connection between first mouths of the cylinders and the first inlet and first outlet of primary liquid of the housing; and the connection between second mouths of the cyl-

inders and the second inlet and second outlet of the secondary liquid; said connections being established such that it is synchronized with the direction of movement of the pistons inside the cylinders.

[0008] A common problem in pumps of this type is determined by the need to form a sealed closure between the opposite ends of the rotatory drum and the corresponding fluid-distributing plates that remain stationary.

[0009] There obviously must be suitable tolerance between the opposite ends of the rotatory drum and the fluid-distributing plates in order to allow the rotation of the drum, however the existence of these tolerances translates into an existence of leakages between the drum and the distributing plates because said drum tends to tilt laterally and to become misaligned with respect to the axial direction due to the axial and opposing movement of the pistons inside the cylinders.

[0010] This lateral tilt or pitch of the drum causes the opposite ends thereof to exert, at diametrically opposite points, excessive pressure against the respective fluid-distributing plates and to be spaced, at diametrically opposite points with respect to the aforementioned points, from said distributing plates, providing liquid leakage areas.

[0011] This problem, which is common in the mentioned prior art, prevents axial pumps of this type with energy recovery from being able to work correctly for a prolonged time since excessive wear occurs due to irregular friction of the drum against the fluid-distributing plates.

[0012] In axial piston pumps of this type with energy recovery, the primary liquid gains access to the inner area of the cylinders through the first inlet mouth in order to be propelled towards the first outlet mouth during the forward movement of the pistons; whereas the secondary liquid gains access to the rear area of the cylinders through the second inlet mouth and collaborates in the forward movement of the pistons before being expelled through the second outlet mouth during the backward movement of said pistons.

[0013] This means that the pressures of the primary liquid and secondary liquid also act on the drum, causing the drum to become imbalanced in the axial direction.

[0014] The technical problem that is posed is the development of a hydraulic axial piston pump with energy recovery of the aforementioned type, but which effectively solves the problems of the mentioned prior art.

DISCLOSURE OF THE INVENTION

[0015] The hydraulic axial piston pump having a floating rotatory drum, object of this invention, which is of the aforementioned type, has constructive particularities which seek to assure a sealed closure between the opposite ends of the rotatory drum and fluid-distributing plates by means of the interposition, between a first end of the drum and the first distributing plate and between a second end of the drum and the second distributing

plate, of first and second strips rotating together with the drum and allowing a floating assembly or being mounted with certain clearance of the rotatory drum in both the longitudinal direction and the axial direction, maintaining said sealing in the closure.

[0016] Another objective of the invention is to achieve cancelling out the horizontal components of the forces produced by the pressures of the primary and secondary liquids on the drum, regardless of the value of said pressures.

[0017] Another objective of the invention is to achieve the operation in the axial direction of the strips responsible for forming the sealed closure between the ends of the drum and the distributing plates with the collaboration of the actual pressures of the primary and secondary liquids.

[0018] The first and second strips rotating together with the drum and responsible for forming a sealed closure against the fluid-distributing plates, have openings facing the first and second mouths of the drum and coupling means suitable for allowing movement of the first and second strips in the axial direction with respect to the drum, and the head-on actuation of said strips against the respective distributing plates, said strips forming a sealed closure between the ends of the drum and the respective distributing plates.

[0019] The openings of the strips are peripherally prolonged in sleeves suitable for being housed in the first and second mouths of the drum with the interposition of sealing elements, allowing a certain tilt or misalignment of the drum, and for receiving, by action of the pressure of the primary and secondary liquids, a thrust that axially moves said strips against the distributing plates.

[0020] This coupling between the drum and the strips assures that the strips remain parallel to one another and form a sealed closure against the distributing plates even if the rotatory drum tilts or does not remain perfectly aligned.

[0021] Said sleeves are also suitable for receiving, by action of the pressure of the primary and secondary liquids, axial thrusts which move the first and second strips head-on against the respective distributing plates, said strips forming a sealed closure between the opposite ends of the drum and the respective distributing plates.

[0022] Another relevant feature of the invention consists of the surfaces of the drum intended for coming into contact with the primary and secondary liquids being suitably arranged and sized so that the resultant of the forces generated by the pressure of the primary and secondary liquids on the drum have a zero component in the axial direction. The drum therefore remains balanced.

[0023] The invention comprises springs, oriented in the axial direction and suitable to assure a certain pressure of said strips against the respective distributing plates, between a first end of the drum and the first strip, and between a second end of the drum and the second strip.

[0024] These springs are particularly effective during the initial pump starting phase in which the first liquid and

the second liquid are not yet pressurized.

[0025] These springs also initially contribute to centering the drum with respect to the first and second strips.

[0026] As mentioned above, this pump also has features that seek to achieve balance of the drum in the axial direction, preventing the forces caused by the pressures of the primary liquid and secondary liquid on the drum from tending to move it in the axial direction.

[0027] To that end and according to the invention, the first inlet and outlet mouths of the primary liquid are axially aligned with the cylinders of the drum and have diameters coinciding with those of said cylinders for preventing the pressure of the primary liquid from producing a thrusting force on the drum in the axial direction.

[0028] In turn, the second inlet and outlet mouths of the secondary liquid are connected to the cylinders of the drum by means of suitably shaped and sized conduits so that the resultant of the set of forces generated by the pressure of the secondary liquid on the drum has a zero component in the axial direction.

DESCRIPTION OF THE DRAWINGS

[0029] To complement the description that is being made and for the purpose of aiding to better understand the features of the invention, a set of drawings is attached to the present specification in which the following is depicted in an illustrative and non-limiting manner:

Figure 1 shows a schematic elevational view of an embodiment of the hydraulic axial piston pump having a floating rotatory drum, according to the invention, sectioned by a vertical plane.

Figure 2 shows an exploded view of the different internal elements of the pump.

DETAILED DISCLOSURE OF THE INVENTION

[0030] As can be seen in the attached drawings, the pump comprises a housing (1) with a first inlet (11) and a first outlet (12) of a primary liquid, and a second inlet (13) and a second outlet (14) of a secondary liquid.

[0031] The rotatory drum (2) is arranged inside the housing (1) and can be operated by a drive element (not depicted) through the drive shaft (21).

[0032] The drum (2) has a plurality of cylinders (22) arranged in circular fashion around its geometric axis.

[0033] The cylinders (22) are communicated with first inlet and outlet mouth (23) of the primary liquid and with a second inlet and outlet mouth (24) of the secondary liquid.

[0034] Pistons (3) are mounted in the cylinders (22) and prolonged at one of their ends in rods (31) going through openings made on the rear surface of the cylinders (22) and projecting from the drum (2), and ending in respective shoes (32) acting on a fixed inclined plate (4).

[0035] The pump comprises first and second liquid-distributing plates (5a, 5b) facing the respective ends of the drum (2) and provided with openings for the alternating connection between the first mouth (23) of the cylinders and the first inlet (11) and the first outlet (12) of primary liquid, and the alternating connection between the second mouth (24) of the cylinders (22) and the second inlet (13) and the second outlet (14) of secondary liquid during rotation of the drum (2).

[0036] The arrangement of the first mouth (23) and second mouth (24) facing the inlets and outlets of primary liquid and secondary liquid is synchronized with the alternating axial movement of the pistons (3) as they move over the inclined plate (4).

[0037] The entry of primary liquid at a low pressure, in the range of 2 bar, into any one of the cylinders (22) is done during the backward movement of the corresponding piston (3), whereas the entry of secondary liquid into the same cylinder will be done during the forward movement of said piston (3), the pressure of said secondary liquid contributing, together with the action of the inclined plate (4), to moving the piston (3) towards the front area and propelling the primary liquid towards the first outlet (12) of primary liquid.

[0038] First and second closure strips (6a, 6b) rotating together with the drum (2) are mounted between the opposite ends of the drum and the respective distributing plates (5a, 5b) to form an effective closure between said elements.

[0039] For the passage of the primary and secondary liquids, said strips (6a, 6b) are provided with openings prolonged along the periphery in sleeves (61 and 62) coupled in the first mouths (23) and the second mouths (24) of the drum, respectively, with the interposition of sealing elements (7) depicted as O-ring seals.

[0040] These couplings allow a certain tilt or pitch of the drum (2) while the strips (6a, 6b) remain parallel to the first and second distributing plates (5a, 5b), exerting a closure against same due to the thrust of the primary and secondary liquids against the ends of said sleeves (61 and 62) of the strips (6a and 6b).

[0041] Springs (8) pressing said strips (6a, 6b) against respective distributing plates (5a, 5b), contributing to the formation of a sealed closure, are arranged between the opposite ends of the drum (2) and the closure strips (6a, 6b).

[0042] The first inlet and outlet mouths of the primary liquid are axially aligned with the cylinders (22) of the drum and have diameters coinciding with those of said cylinders (22), preventing the pressure of the primary liquid from transmitting a thrusting force in the axial direction to the drum (2).

[0043] The second inlet and outlet mouths (24) of the secondary liquid are connected to the corresponding cylinders (22) by means of respective conduits (25), the second mouths (24) having a section identical to that end surface of the corresponding cylinder (22) which is exposed to the pressure of the secondary liquid, such that

the set of forces generated by the pressure of the secondary liquid on the drum has a zero component in the axial direction, as do the forces generated by the pressure of the primary liquid, so the drum (2) is kept balanced during the operation of the pump.

[0044] Having sufficiently described the nature of the invention as well as a preferred embodiment thereof, it is hereby stated that the materials, shape, size and arrangement of the described elements could be modified, provided that this does not change the essential features of the invention claimed below.

Claims

1. A hydraulic axial piston pump having a floating rotatory drum, comprising:

- a housing (1) provided with: a first inlet (11) for the intake of a primary liquid; a first outlet (12) for the delivery of said primary liquid at a high pressure; a second inlet (13) for the intake of a secondary liquid at a pressure that is lower than the delivery pressure of the primary liquid and a second outlet (14) for the delivery of said secondary liquid;
- a drum (2) provided with a drive shaft (21) and with a plurality of cylinders (22) arranged in circular fashion around the geometric axis of said drum (2) and communicated at its ends with first inlet and outlet mouths (23) of the primary liquid and with second inlet and outlet mouths (24) of the secondary liquid, said first and second mouths (23, 24) being defined at a first end and at a second end of the drum (2);
- pistons (3) mounted in the respective cylinders (22) and being prolonged in rods (31) projecting through one end of the drum (2) and ending in supporting shoes (32) on a fixed inclined plate (4);
- a first fluid-distributing plate (5a) and a second fluid-distributing plate (5b), facing opposite ends of the drum (2) and provided with openings (51, 52) suitably distributed for establishing in an alternating manner, during rotation of the drum (2), the connection between first mouths (23) of the cylinders (22) and the first inlet (11) and first outlet (12) of primary liquid of the housing (1), and the connection between second mouths (24) of the cylinders (22) and the second inlet (13) and second outlet (14) of the secondary liquid, said connections being established such that it is synchronized with the direction of movement of the pistons (3) inside the cylinders (22);

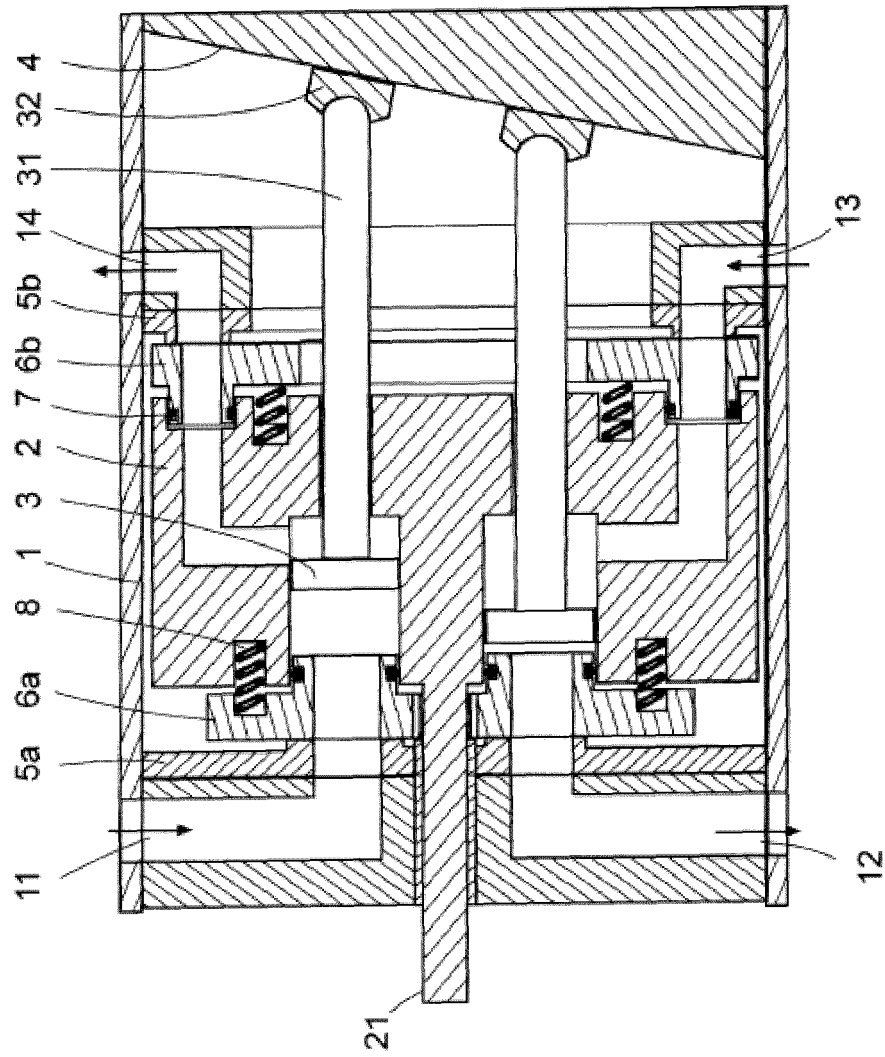
characterized in that:

first and second strips (6a, 6b) rotating together

with the drum (2) are mounted with certain clearance in the axial direction between a first end of the rotatory drum (2) and the first distributing plate (5a), and between a second end of the drum (2) and the second distributing plate (5b); said first and second strips (6a, 6b) having openings facing the first and second mouths (23, 24) of the drum and coupling means suitable for allowing a movement of the first and second strips (6a, 6b) in the axial direction with respect to the drum (2) and the head-on actuation of said strips (6a, 6b) against the respective distributing plates (5a, 5b), said strips (6a, 6b) forming a sealed closure between the ends of the drum (2) and the respective distributing plates (5a, 5b).

posed to the pressure of the secondary liquid, such that the resultant of the set of forces generated by the pressure of the secondary liquid on the drum (2) has a zero component in the axial direction.

2. The pump according to claim 1, **characterized in that** the surfaces of the drum (2) intended for coming into contact with the primary and secondary liquids are suitably arranged and sized so that the resultant of the forces generated by the pressure of the primary and secondary liquids on the drum (2) have a zero component in the axial direction.
3. The pump according to claim 1, **characterized in that** the openings of the strips (6a, 6b) are peripherally prolonged in sleeves (61, 62) suitable for being housed in the first and second mouths (23, 24) of the drum (2) with the interposition of sealing elements (7), allowing a certain tilt or misalignment of the drum, and for receiving, by action of the pressure of the primary and secondary liquids, a thrust that axially moves said strips (6a, 6b) against the distributing plates (5a, 5b).
4. The pump according to claim 1, **characterized in that** it comprises springs (8) oriented in the axial direction, suitable to assure certain pressure of said strips (6a, 6b) against the respective distributing plates (5a, 5b), between a first end of the drum (2) and the first strip (6a), and between a second end of the drum (2) and the second strip (6b).
5. The pump according to claim 2, **characterized in that** the first mouths (23) of the drum (2) are axially aligned with the cylinders (22) of the drum and have diameters coinciding with those of said cylinders for preventing the pressure of the primary liquid from causing a thrusting force on the drum (2) in the axial direction.
6. The pump according to claim 1, **characterized in that** the second mouths (24) of the drum (2) are oriented axially and connected to the cylinders (22) by means of intermediate conduits (25), the second mouths (24) having a section that is equal to an end surface (26) of the corresponding cylinder (22) ex-



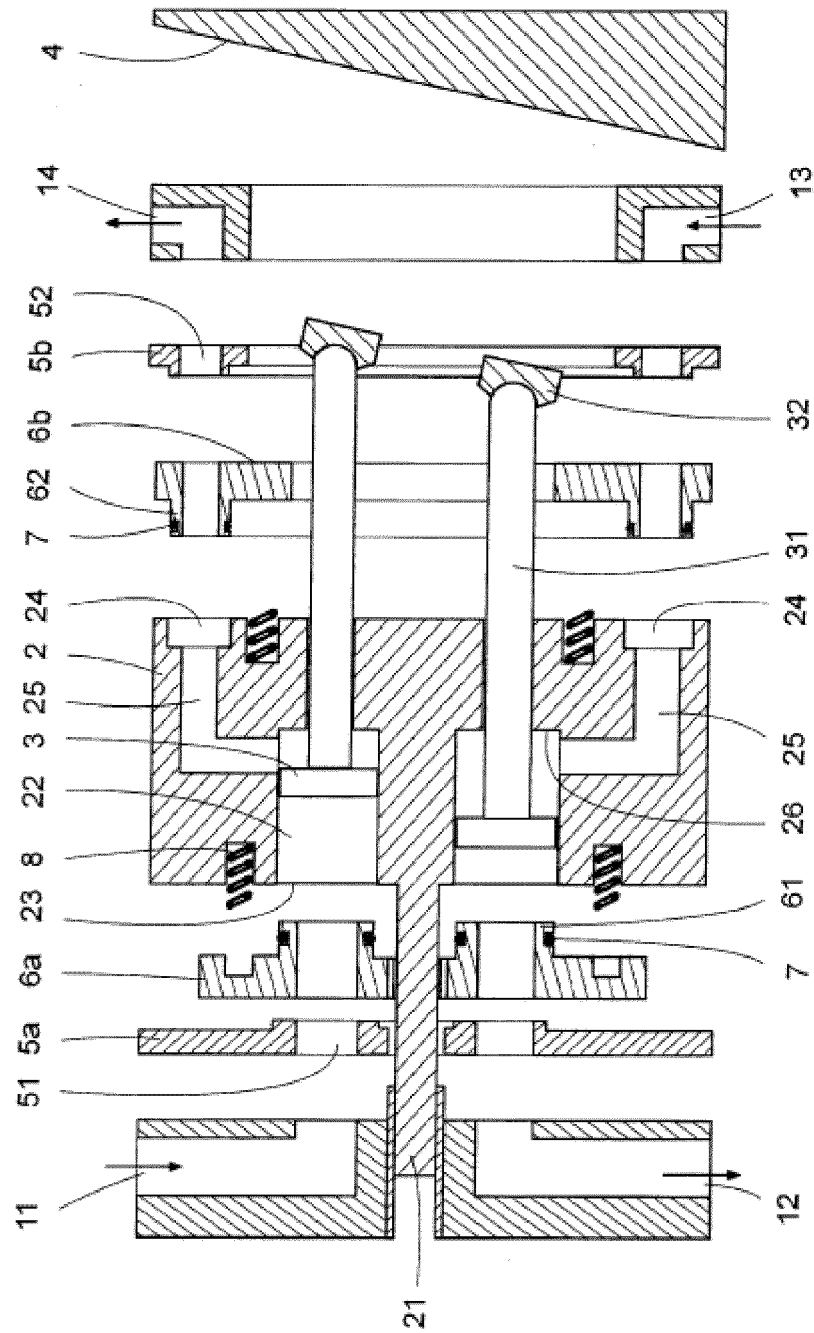


Fig. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/ES2013/000251

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F04B, B01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPODOC, INVENES

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 7799221 B1 (MACHARG JOHN P) 21/09/2010, column 7, line 37 - column 12, line 33; figures.	1-6
Y	ES 408674 A1 (PLESSEY HANDEL INVESTMENT AG) 01/11/1975, page 6, line 14 - page 12, line 9; figures.	1-6
A	JP S58128477 A (HITACHI CONSTRUCTION MACHINERY) 01/08/1983, abstract; figures.	1-5
A	US 5279205 A (CARLSON JR GUY C ET AL.) 18/01/1994, the whole document.	1-4
A	US 4007663 A (NAGATOMO KUNIYASU ET AL.) 15/02/1977, column 2, lines 8 - 21; figures 1 - 2.	1-5

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance.	
"E" earlier document but published on or after the international filing date	
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"O" document referring to an oral disclosure use, exhibition, or other means.	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other documents, such combination being obvious to a person skilled in the art
"P" document published prior to the international filing date but later than the priority date claimed	"&" document member of the same patent family

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18/07/2014

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Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/ES2013/000251

C (continuation).	DOCUMENTS CONSIDERED TO BE RELEVANT	
Category *	Citation of documents, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2005018782 A1 (DANFOSS AS ET AL.) 03/03/2005, page 12, line 12 - page 15, line 17; figures.	1-6

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/ES2013/000251

Information on patent family members

Patent document cited in the search report	Publication date	Patent family member(s)	Publication date
US7799221 B1	21.09.2010	US2011006006 A1 US8419940 B2	13.01.2011 16.04.2013
ES408674 A1	01.11.1975	JPS4858403 A US3808950 A IT970428 B FR2160157 A5 DE2255156 A1 CA966009 A1 NL7214995 A AU4856672 A GB1398272 A BE791148 A1	16.08.1973 07.05.1974 10.04.1974 22.06.1973 17.05.1973 15.04.1975 15.05.1973 09.05.1974 18.06.1975 01.03.1973
JPS58128477 A	01.08.1983	JPH0251074B B2	06.11.1990
US5279205 A	18.01.1994	KR100254182B B1 WO9314298 A1 JPH06506522 A JP3386463B B2 GB2276212 A GB2276212 B DE4294699T T1	15.04.2000 22.07.1993 21.07.1994 17.03.2003 21.09.1994 12.04.1995 13.01.1994
US4007663 A	15.02.1977	GB1482817 A FR2260003 A1 FR2260003 B1 DE2504562 A1 DE2504562 B2 CH592247 A5 JPS50106724U U JPS50108603 A JPS5834674B B2	17.08.1977 29.08.1975 15.04.1977 21.08.1975 16.04.1981 14.10.1977 02.09.1975 27.08.1975 28.07.1983
WO2005018782 A1	03.03.2005	EP1508361 A1 EP1508361 B1 AT422958T T	23.02.2005 18.02.2009 15.03.2009

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/ES2013/000251

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CLASSIFICATION OF SUBJECT MATTER

F04B1/20 (2006.01)

F04B5/02 (2006.01)

B01D61/06 (2006.01)

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 7799221 B1, MACHARG JOHN P [0004]
- WO 2010025729 A1, DANFOSS AS [0004]
- ES 2012000279 W, BOLSAPLAST S.L. [0004]