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(11) **EP 2 025 937 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
18.02.2009 Bulletin 2009/08

(51) Int Cl.:
F04B 53/08 *(2006.01)*

(21) Application number: **07425514.2**

(22) Date of filing: **07.08.2007**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC MT NL PL PT RO SE SI SK TR
Designated Extension States:
AL BA HR MK RS

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(54) **Reciprocating pump**

(57) A reciprocating pump (1) comprising a pumping chamber (30) and an intermediate chamber (40), a reciprocating member (50), high pressure seal means (21) between the pumping chamber (30) and the intermediate chamber (40), low pressure seal means (22) between the intermediate chamber (40) and the crankshaft housing (10), a pumping circuit (60) and an auxiliary circuit (70) in fluid separation from the pumping circuit (60). The pump further comprises a recirculating unit (80) whose inlet is connected to the delivery chamber (72) of the auxiliary circuit (70) and whose outlet is connected to the suction chamber (71) of the auxiliary circuit (70). The recirculating unit (80) comprises a recirculating pump (81) which is designed to suck fluid from the delivery chamber (72) and pump such fluid in the suction chamber (71) for fluid recirculating in the auxiliary circuit (70).

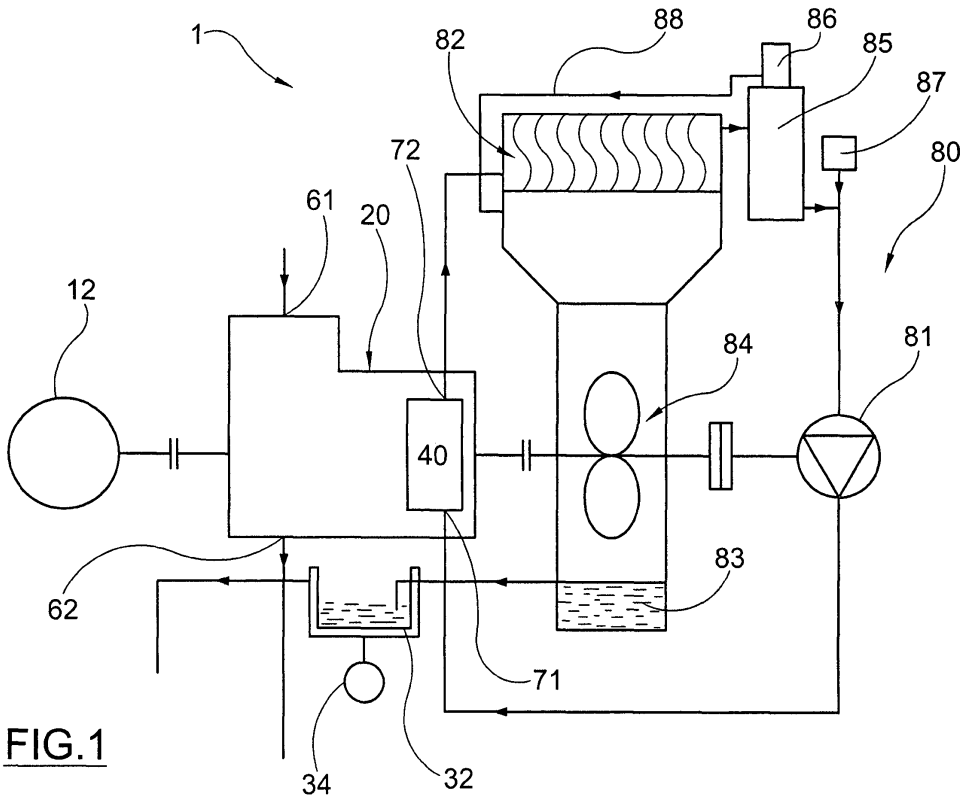

FIG.1

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Description

[0001] The present invention relates to a reciprocating pump in accordance with the preamble of claim 1.

[0002] Reciprocating pumps are known in the art. A prior art reciprocating pump typically comprises a crankshaft housing, a pump housing, a pumping chamber and a recovery chamber within the pump housing, a reciprocating member mounted in the pump housing and extending from the crankshaft housing to the pumping chamber across the recovery chamber, high pressure seal means between the pumping chamber and the recovery chamber, low pressure seal means between the intermediate chamber and the crankshaft housing and a pumping circuit.

[0003] The pumping circuit comprises a suction chamber and a delivery chamber in fluid communication with the pumping chamber through interposed valve means, and the recovery chamber in fluid communication with the suction chamber of the pumping circuit, through the high pressure seal.

[0004] In reciprocating pumps of the above mentioned type, the reciprocating motion of the piston or plunger causes a change in the velocity and pressure of liquid flows in both delivery and suction lines, resulting in hydraulic and mechanical stresses on the seals, at a rate proportional to the period of the reciprocating motion of the piston. Such pressure changes, when combined with the high temperatures being involved cause the formation of air and vapor microbubbles whose implosion causes the phenomenon known as cavitation. Cavitation particularly causes damages to low pressure and high pressure seals and the piston/plunger surface, thereby increasing friction and reducing pump efficiency and performance, and especially generating fluid leakages at the low pressure seal.

[0005] These seals are not only exposed to cavitation problems, but also to feed line variables, such as temperature, specific weight, diameter and length of the line and, last but not least, pressure of the fluid to be pressurized, wherefore they are the first components to be replaced. The deterioration of these seals results in leakages of pumping circuit fluid outside the pump, partly on the ground, possibly causing damages to other underlying members and/or pollution of pump surroundings, and partly, due to the motion of the piston stem, into the mechanical transmission case, thereby polluting the lubricant and consequently causing damages to the transmission members.

[0006] In view of eliminating liquid leakages from the low pressure seal, it has been proposed to isolate the pumping circuit from the auxiliary circuit.

[0007] US 2006/0140778 discloses a reciprocating pump comprising a crankshaft housing, a pump housing, a pumping chamber and an intermediate chamber within the pump housing, a reciprocating member mounted in the pump housing and extending from the crankshaft housing to the pumping chamber across the intermediate chamber, high pressure seal means between the pumping chamber and the intermediate chamber, low pressure seal means between the intermediate chamber and the crankshaft housing, a pumping circuit and an auxiliary lubricating and cooling circuit.

[0008] The pumping circuit comprises a suction chamber and a delivery chamber in fluid communication with the pumping chamber through interposed valve means, and the auxiliary circuit comprises a suction chamber and a delivery chamber in fluid communication with the intermediate chamber.

[0009] Particularly, in the reciprocating pump of US 2006/0140778 the pumping circuit, i.e. the suction chamber of the pumping circuit is in fluid separation from the auxiliary flushing circuit.

[0010] The reciprocating pump of the prior art as described above avoids pulsed stresses on the low pressure seal by the liquid in the suction chamber and allows the high pressure seal to maintain its hydraulic efficiency for a longer time than the high pressure seal.

[0011] Nevertheless, the characterizing feature of the reciprocating pump as disclosed in US 2006/0140778, i.e. that the suction chamber of the auxiliary circuit is connected to a running water source and the delivery chamber of the auxiliary circuit discharges to a running water destination, involves considerable water consumption during pump operation and prevents the use of additives in the auxiliary circuit. Furthermore, the pump shall have a series of members, such as check valves, adjustment valves and switchboards for controlling and checking the auxiliary circuit.

[0012] It shall be further noted that, if a polluting fluid (such as solvents, chemicals, powders, abrasives or bacterially charged fluids) is used in the pumping circuit, any hydraulic inefficiency of the high pressure seal may cause such fluid to contact the water of the auxiliary flushing circuit.

[0013] Contamination of the auxiliary flushing circuit water by the fluid of the pumping circuit, depending on the type and amount of the contaminant, requires disposal of the whole amount of water that is used for flushing low pressure seals as a pollutant. It shall be further considered that the amount of contaminant to be used depends on the efficiency of high pressure seals, which is difficult to estimate. Even when the chemico-phyisical characteristics of the flushing water are suitable for it to be discharged, it still has to be noted it is present in non-negligible amounts and that water will be increasingly considered as a valued asset to be preserved. It should be further noted that the flushing circuit has to operate at the same time as the pump with which it associated and that it has to be equipped with accessories such as check and/or adjustment valves, switchboard, instrumentation, etc. to ensure efficiency and reliability. If these components are not supplied and installed with the pump, they involve additional work during pump installation and are also usually considered of secondary importance, therefore they may turn to be inadequate and/or unreli-

able and thwart the flushing benefits. It shall be further considered that the water source for the recirculating circuit may have various characteristics depending on the installation site, and parameters such as temperature, pressure, hardness, salinity may have the effect of reducing flushing efficiency or even cause problems to seals (e.g. limestone deposits).

[0014] Therefore, while the above prior art reciprocating pumps obviate the drawbacks found in reciprocating pumps with no isolation between the suction chamber of the pumping circuit and high pressure seals, they still suffer from serious drawbacks, as mentioned above.

[0015] Therefore, the need is highly felt of providing a structurally simpler reciprocating pump which can avoid flushing liquid wastes.

[0016] The object of this invention is to provide a reciprocating pump that has such structural and functional features as to fulfill the above need, while obviating the drawbacks of prior art.

[0017] This object is achieved by a reciprocating pump as defined in claim 1.

[0018] By the provision of a recirculating unit whose inlet is connected to the delivery chamber of the auxiliary circuit and whose outlet is connected to the suction chamber of the auxiliary circuit, the fluid of the auxiliary circuit may be recirculated.

[0019] This prevents any unnecessary waste of the flushing fluid used for lubrication and/or cooling, and allows the use of fluids, in the auxiliary flushing circuit, that can compensate, support, withstand and oppose the detrimental action that the fluid of the pumping circuit would have on low pressure seals, thereby further involving advantages for high pressure seals, and allows to make pumps with a dedicated auxiliary flushing circuit for any specific application, regardless of any external factors.

[0020] Further characteristics of the reciprocating pump of this invention, as well as the advantages derived therefrom will be apparent from the following description of one preferred embodiment thereof, which is given by way of illustration and without limitation with reference to the accompanying figures, in which:

- Figure 1 is a block diagram of a reciprocating pump of the invention,
- Figure 2 is a partly sectional and schematic perspective view of a first embodiment of the reciprocating pump of the invention,
- Figure 3 is a partly sectional and schematic perspective view of a second embodiment of the reciprocating pump of the invention,
- Figure 4 is a partly sectional and schematic perspective view of a third embodiment of the reciprocating pump of the invention.

[0021] Referring to the annexed figures, numeral 1 generally designates a reciprocating pump of the present invention.

[0022] The pump 1 comprises a crankshaft housing 10 and a pump housing 20. The crankshaft housing 10 has a crankshaft 11 mounted therein which is externally driven, e.g. by the motor 12.

[0023] The pump housing 20 comprises a pumping chamber 30, an intermediate chamber 40 and a reciprocating member 50 mounted in the pump housing 20 and extending from the crankshaft housing 10 to the pumping chamber 30 across the intermediate chamber 40. The reciprocating member 50, i.e. a piston or a plunger, is linked by a connecting rod 51 to the crankshaft 11 mounted in the crankshaft housing 10. Oil seal means 13 are provided for containing the oil for lubrication of the mechanical transmission elements within the crankshaft housing 10.

[0024] The pump 1 further has high pressure seal means 21 between the pumping chamber 30 and the intermediate chamber 40, and low pressure seal means 22 between the intermediate chamber 40 and the crankshaft housing 10.

[0025] The pump 1 further has a pumping circuit 60 comprising a first suction chamber 61, a first delivery chamber 62 and the pumping chamber 30, where the first suction chamber 61 and the first delivery chamber 32 are in fluid communication with the pumping chamber 30 through respective interposed valve means 63, 64.

[0026] The pump 1 further has an auxiliary circuit 70 comprising a second suction chamber 71, a second delivery chamber 72 and an intermediate chamber 40, where the second suction chamber 71 and the second delivery chamber 72 are in fluid communication with the intermediate chamber 40.

[0027] The pump 1 further has a discharge line 31 connected to a tank 32 for collecting the waste liquid leaking from the low pressure sealing means 22.

[0028] To allow flushing of the high pressure seal 21, the low pressure seal 22 and the reciprocating member 50, the intermediate chamber 40 of the auxiliary circuit 70 is isolated from the suction chamber 61 of the pumping circuit 60, so that the pumping circuit 60 is in fluid separation from the auxiliary circuit 70.

[0029] Isolation of the auxiliary circuit 70 from the pumping circuit 60 can be achieved both on new generation pumps and on existing (retrofit) pumps.

[0030] In the former case, the pumping circuit is separated from the auxiliary circuit by specially designing the body of the pump housing.

[0031] In the latter case, the fluid communication channel between the two pump and auxiliary circuits may be interrupted by a plug or a non-return valve. This will be discussed in greater detail hereinbelow with reference to an embodiment of the invention.

[0032] The reciprocating pump 1 further comprises a recirculating unit 80 whose inlet is connected to the second delivery chamber 72 and whose outlet is connected to the second suction chamber 71 of the auxiliary circuit 70.

[0033] Particularly, the recirculating unit 80 comprises a recirculating pump 81 which is designed to suck fluid

from the delivery chamber 72 and pump such fluid in the second suction chamber 71 for fluid recirculating in the auxiliary circuit 70.

[0034] This prevents any unnecessary consumption of the flushing fluid used for lubrication and/or cooling, through the intermediate chamber 40, of the seals 21, 22.

[0035] Furthermore, this allows the use of fluids, in the auxiliary flushing circuit, that can compensate, support, withstand and oppose the detrimental action that the fluid of the pumping circuit would have on low pressure seals, thereby further involving advantages for high pressure seals, allows to make pumps with a dedicated auxiliary flushing circuit for any specific application, regardless of any external factors, avoids any need for disposal of flushing liquid as a polluting liquid, avoids the need to check the pressure, quality, quantity and characteristics of the flushing fluid, and also avoids any lubrication inefficiency risk within the flushing circuit. It shall be further noted that the possibility of adding lubricant in the auxiliary flushing circuit 70 can not only increase the mechanical wear resistance of low pressure seals 22 but also to control natural hydraulic inefficiencies of high pressure seals 21.

[0036] According to an embodiment, the recirculating pump 81 is connected to the crankshaft 11 of the pump 1 so that the recirculating pump 81 can be rotatably driven by the rotation of the crankshaft 11 of the pump 1. This allows omission of many flushing circuit check and control members, check valves, electric control circuits, as well as the control instrumentation required to control and check the flushing functions, because flushing is started at the same time as the pump. Also, the recirculating pump 81 requires no electrical drive arrangement, as it is driven by the rotation provided by the crankshaft 11 of the reciprocating pump 1.

[0037] Alternatively, the recirculating pump 81 can be provided with actuating means so that it is not connected to the crankshaft 11 of the reciprocating pump 1.

[0038] According to an embodiment, the recirculating unit 80 has heat exchanger means 82 connected at their inlet to the second delivery chamber 72 and at their outlet to the recirculating pump 81. Thus, the fluid sucker by the delivery chamber 72 and heated as it passes through the intermediate chamber 40 and the seals 21, 22 is cooled by the heat exchanger means 82, such as a radiator, and pumped into the suction chamber 71 by the recirculating pump 81.

[0039] According to an embodiment of the invention, the pumping circuit 30 is designed to pump water, aqueous solutions or fluid mixtures. In this case, the recirculating unit 80 is also designed to recirculate water in the auxiliary circuit 70. The provision of the heat exchanger means 82 allows the recirculated fluid to be considerably cooled, wherefore the reciprocating pump 1 can operate at temperatures close to the boiling temperature of the pumped fluid.

[0040] According to an embodiment, the recirculating unit 80 has fan means 84 for forced ventilation of the heat exchanger 82 and an evaporation tank 83 for collecting fluid leakages due to normal efficiency losses of the high pressure seal 21.

[0041] The evaporation tank 83 may be connected to the tank 32 for collecting liquid leakages from low pressure seals 22.

[0042] Advantageously, the fan means 84 are connected to the crankshaft 11 so that the rotation of the crankshaft 11 is transmitted to the fan means 84. Like the recirculating pump 81, the rotation of the crankshaft 11 is utilized, wherefore the fan means 84 require no electric drive arrangement or electronic control system.

[0043] According to an embodiment, the recirculating unit 80 comprises a compensation tank 85 having an overpressure valve 86, and connected to the outlet of the heat exchanger means 82. When a part of the liquid of the pumping circuit 60 leaks from the pumping chamber 30, through the high pressure seal 21, into the intermediate chamber 40, such excess liquid is eliminated by the overpressure valve 86 to restore the correct pressure in the auxiliary circuit 70.

[0044] The excess liquid is eliminated by the forced ventilation operation of the fan means 84.

[0045] Particularly, such excess liquid is carried by the overpressure valve 86, through the discharge line 88, to the heat exchanger 82 and thence, by gravity, into the evaporation tank 83.

[0046] The fan means 84 operate by forced ventilation to cause evaporation of the liquid contained in the evaporation tank 83. If the fan means 84 cannot fully evaporate the liquid contained in the evaporation tank 83, then such excess liquid is eliminated through the tank 32 for collecting the liquids leaking from the low pressure seals 22.

[0047] A sensor 34 may be further provided at the leaking liquid tank 32 to check for the presence of fluid that has not been evaporated by the heat exchanger 82.

[0048] According to an embodiment, the recirculating unit 80 has a lubricant tank 87 connected to the recirculating pump 81 for the lubricant to be pumped into the auxiliary circuit 70. As anticipated above, this allows to not only increase the mechanical wear resistance of low pressure seals 22 but also to control natural hydraulic inefficiencies of high pressure seals 21.

[0049] The pumping circuit 60 may be also designed to pump a liquid other than the liquid to be recirculated in the auxiliary circuit 70 through the recirculating unit 80.

[0050] If the liquid of the auxiliary circuit 70 is compatible with the liquid of the pumping circuit 60 when mixed therewith, the leaking liquid may be reintroduced in the pumping circuit 60.

[0051] For this purpose, according to an embodiment, the auxiliary circuit 70, particularly the suction chamber 71, communicates with the pumping circuit 60, particularly with the suction chamber 61, through a one-way valve or non-return valve 65, which is contained in a line 66 for connection of the suction chamber 61 with the suction chamber 71.

[0052] Particularly, the non-return valve 65 allows fluid

to flow from the auxiliary circuit 70 to the pumping circuit 60 when fluid pressure in the auxiliary circuit 70 exceeds a predetermined threshold, e.g. due to leakages from the high pressure seal 21, so that pressure in the intermediate chamber 40 can be maintained within the maximum limits of the low pressure seal means 22.

[0053] Such reintroduction of liquid leaking from the high pressure seal 21 into the pumping circuit 60 is possible, for instance, when both liquids are water.

[0054] If the liquid in the auxiliary circuit 70 is incompatible with the liquid in the pumping circuit 60 when mixed therewith, e.g. in case of the provision of a solvent in the pumping circuit 60 and water in the auxiliary circuit 70, or milk in the pumping circuit 60 and lubricating oil in the auxiliary circuit 70, then the pump 1 has a recovery chamber 41 between the pumping chamber 30 and the intermediate chamber 40 as well as intermediate seal means 23 between the high pressure seal means 21 and the low pressure seal means 22. In this case, the high pressure seal means 21 are located between the pumping chamber 30 and the recovery chamber 41, the intermediate seal means 23 are located between the recovery chamber 41 and the intermediate chamber 40 and the low pressure seal means 22 are located between the intermediate chamber 40 and the crankshaft housing 10.

[0055] The recovery chamber 41 is connected through the connection line 66 and the non-return valve 65 to the suction chamber 61 of the pumping circuit 60.

[0056] The fluid of the pumping circuit 60 leaks into the recovery chamber 41 from the pumping chamber 30. Thanks to the provision of the intermediate seal means 23, such leaking liquid is recovered without being contaminated by the fluid of the auxiliary circuit 70 and may be reintroduced into the pumping circuit 60 through the connection line 66, as the non-return valve 65 is opened, which valve is appropriately calibrated to maintain the pressure in the auxiliary circuit 70 at preset levels, i.e. to maintain pressure in the intermediate chamber 40 within the maximum limits of the low pressure seals 22.

[0057] As clearly shown in the above description, the reciprocating pump of the present invention fulfills the above mentioned needs and also obviates prior art drawbacks as set out in the introduction of this disclosure.

[0058] As described above, the reciprocating pump of the present invention is structurally simpler and can avoid any flushing liquid waste.

[0059] By the provision of a recirculating unit whose inlet is connected to the delivery chamber of the auxiliary circuit and whose outlet is connected to the suction chamber of the auxiliary circuit, the fluid of the auxiliary circuit may be recirculated.

[0060] This prevents any unnecessary waste of the flushing fluid used for lubrication and/or cooling, and allows the use of fluids, in the auxiliary flushing circuit, that can compensate, support, withstand and oppose the detrimental action that the fluid of the pumping circuit would have on low pressure seals, thereby further involving advantages for high pressure seals, and allows to make pumps with a dedicated auxiliary flushing circuit for any specific application, regardless of any external factors.

[0061] Those skilled in the art will obviously appreciate that a number of changes and variants may be made to the reciprocating pump of the invention as described hereinbefore to meet specific needs, without departure from the scope of the invention, as defined in the following claims.

Claims

1. A reciprocating pump (1) comprising:

- a crankshaft housing (10) for a crankshaft (11),
- a pump housing (20);
- a pumping chamber (30) and an intermediate chamber (40) within said pump housing (20),
- a reciprocating member (50) mounted in said pump housing (20) and extending from the crankshaft housing (10) to the pumping chamber (30) across the intermediate chamber (40),
- high pressure seal means (21) between the pumping chamber (30) and the intermediate chamber (40),
- low pressure seal means (22) between the intermediate chamber (40) and the crankshaft housing (10),
- a pumping circuit (60) comprising a first suction chamber (61), a first delivery chamber (62) and said pumping chamber (30), said first suction chamber (61) and said first delivery chamber (62) being in fluid communication with said pumping chamber (30) through respective interposed valve means (63, 64),
- an auxiliary circuit (70) comprising a second suction chamber (71), a second delivery chamber (72) and said intermediate chamber (40), said second suction chamber (71) and said second delivery chamber (72) being in fluid communication with said intermediate chamber (40),

wherein said pumping circuit (60) is in fluid separation from said auxiliary circuit (70),

characterized in that the reciprocating pump comprises

a recirculating unit (80) whose inlet is connected to said second delivery chamber (72) and whose outlet is connected to said second suction chamber (71) of the auxiliary circuit (70),

said recirculating unit (80) comprising a recirculating pump (81) able to suck fluid from said second delivery chamber (72) and pump said fluid in said suction chamber (71) for recirculating said fluid in said auxiliary circuit (70).

2. A reciprocating pump (1) as claimed in claim 1, wherein said recirculating pump (81) is connected

to the crankshaft (11) of the reciprocating pump (1), so that the rotation of said crankshaft (11) is transmitted to said recirculating pump (81).

3. A reciprocating pump (1) as claimed in claim 1 or 2, wherein said recirculating unit (80) has heat exchanger means (82) connected at their inlet to said second delivery chamber (72) and at their outlet to said recirculating pump (81), for cooling the fluid sucked from the second delivery chamber (72) and introducing said cooled fluid into said second suction chamber (71).

4. A reciprocating pump (1) as claimed in claim 3, wherein said recirculating unit (80) comprises a compensation tank (85) having an overpressure valve (86), and connected at its inlet to the outlet of said heat exchanger means (82) and at its outlet to said recirculating pump (81).

5. A reciprocating pump (1) as claimed in claim 4, wherein said overpressure valve (86) is connected at its outlet to said heat exchanger means (82) for evaporating any excess liquid in said auxiliary circuit (70), which has leaked into the intermediate chamber (40) through the high pressure seal means (21).

6. A reciprocating pump (1) as claimed in claim 5, wherein said recirculating unit comprises an evaporation tank (83) for receiving the liquid that has not been evaporated by said heat exchanger means (82) and fan means for evaporating the liquid contained in said evaporation tank (83).

7. A reciprocating pump (1) as claimed in claim 6, wherein said fan means (84) are connected to the crankshaft (11), so that the rotation of said crankshaft (11) is transmitted to said fan means (84).

8. A reciprocating pump (1) as claimed in any one of claims 1 to 7, wherein said recirculating unit (80) comprises a lubricant tank (87) connected to said recirculating pump (81) for pumping the lubricant into the auxiliary circuit (70).

9. A reciprocating pump (1) as claimed in any one of claims 1 to 8, wherein said pumping circuit (60) is designed to pump a fist fluid and said recirculating unit (80) is designed to recirculate a second fluid in said auxiliary circuit (70).

10. A reciprocating pump (1) as claimed in claim 9, wherein said second fluid is compatible with said first fluid when mixed with said first fluid, said reciprocating pump (1) comprising a line (66) for connecting said pumping circuit (60) with said auxiliary circuit (70) and a non-return valve (65) housed in said connection line (66), said non-return valve (65) allowing fluid to flow from said auxiliary circuit (70) to said pumping circuit (60) when fluid pressure in said auxiliary circuit (70) exceeds a predetermined threshold, so that pressure in the intermediate chamber (40) can be maintained within the maximum limits of the low pressure seal means (22).

11. A reciprocating pump (1) as claimed in claim 10, wherein said first fluid and said second fluid are both water.

12. A reciprocating pump (1) as claimed in claim 9, wherein said second fluid is incompatible with said first fluid when mixed with said first fluid, said reciprocating pump (1) comprising a recovery chamber (41) between the pumping chamber (30) and the intermediate chamber (40) and intermediate seal means (23) between the high pressure seal means (21) and the low pressure seal means (22).

13. A reciprocating pump (1) as claimed in claim 12, wherein said high pressure seal means (21) are located between the pumping chamber (30) and the recovery chamber (41), the intermediate seal means (23) are located between the recovery chamber (41) and the intermediate chamber (40) and the low pressure seal means (22) are located between the intermediate chamber (40) and the crankshaft housing (10).

14. A reciprocating chamber (1) as claimed in claim 12 or 13, wherein the recovery chamber (41) is connected through a connection line (66) and a non-return valve (65) to the suction chamber (61) of the pumping circuit (60).

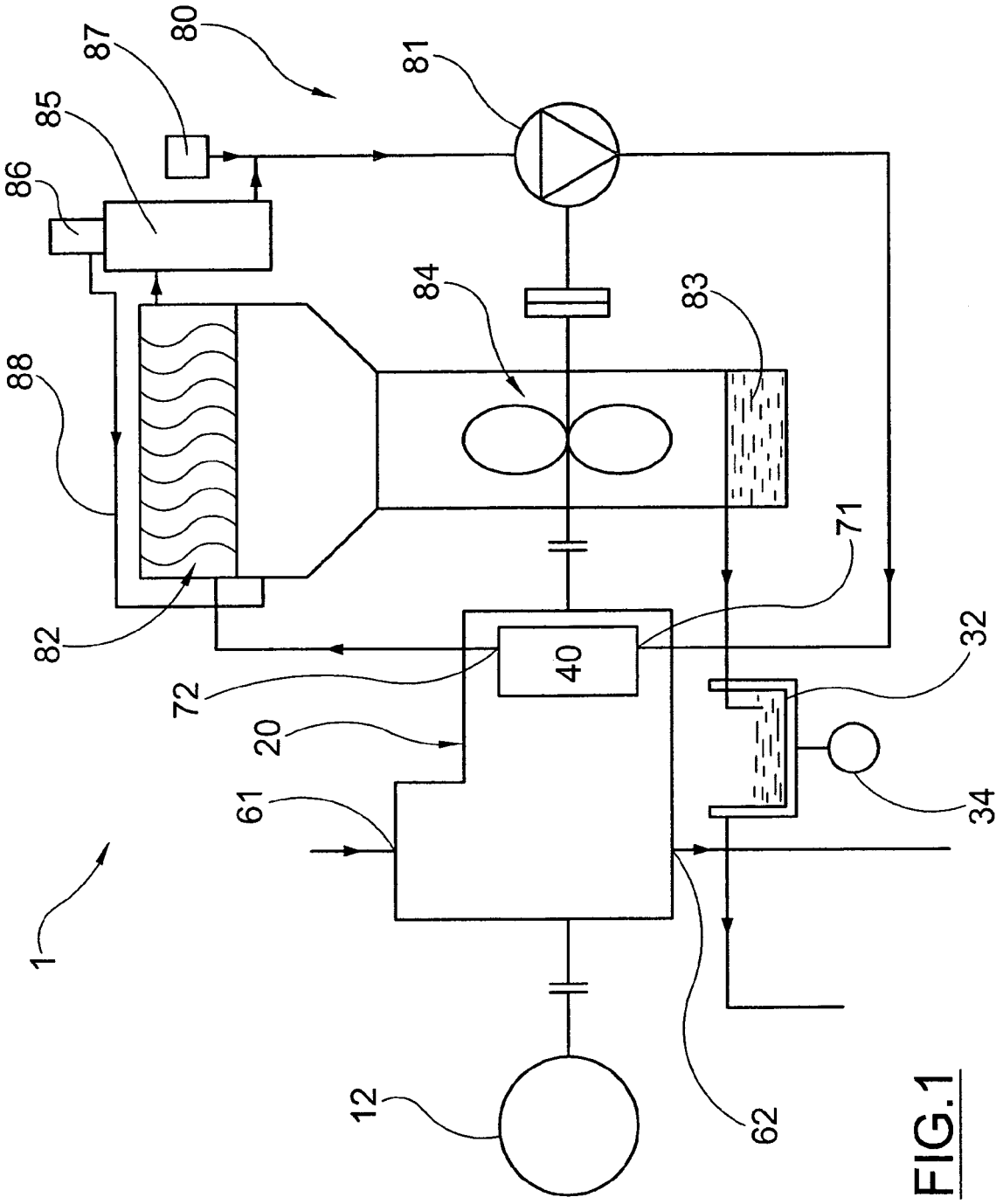

FIG.1

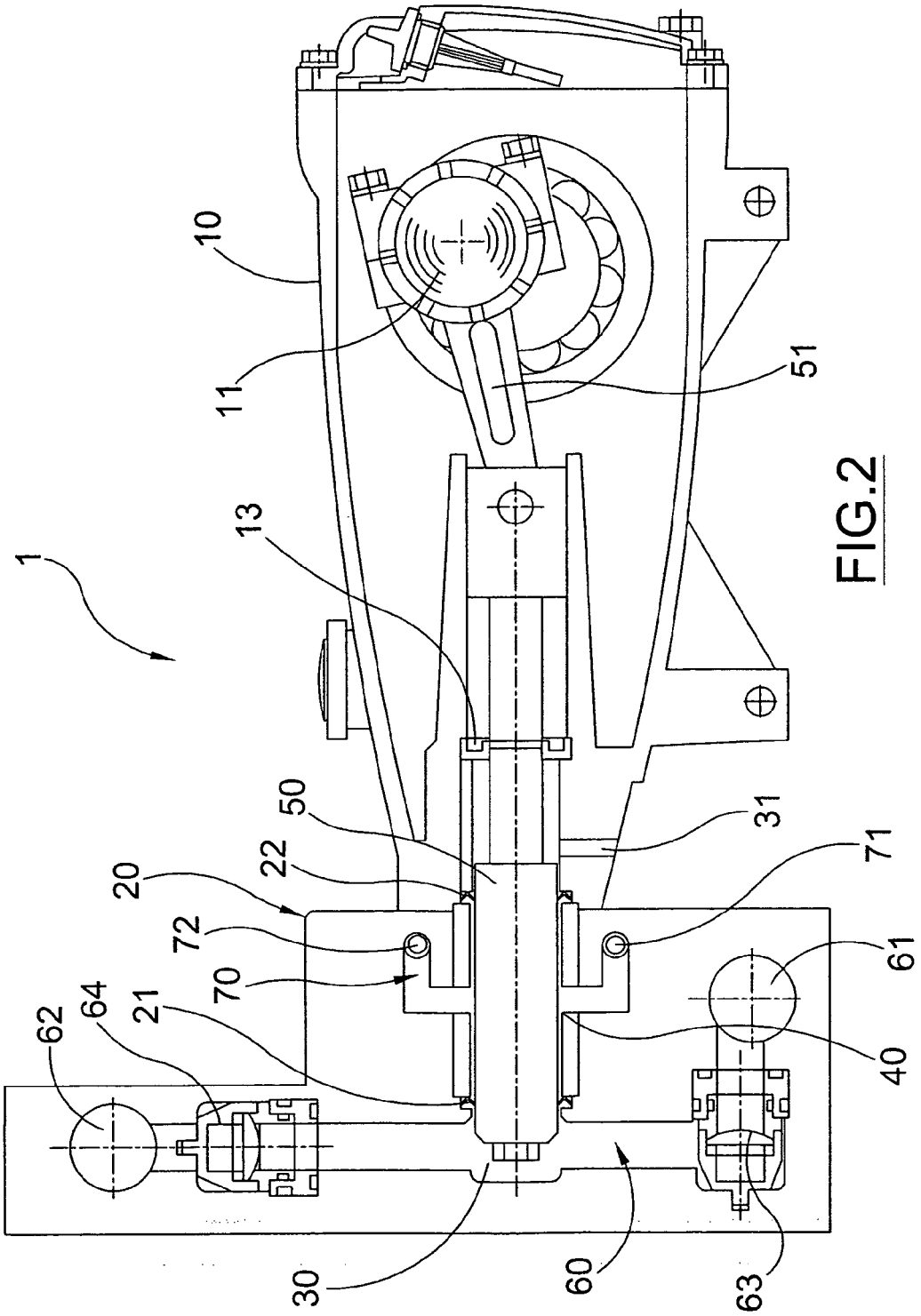

FIG.2

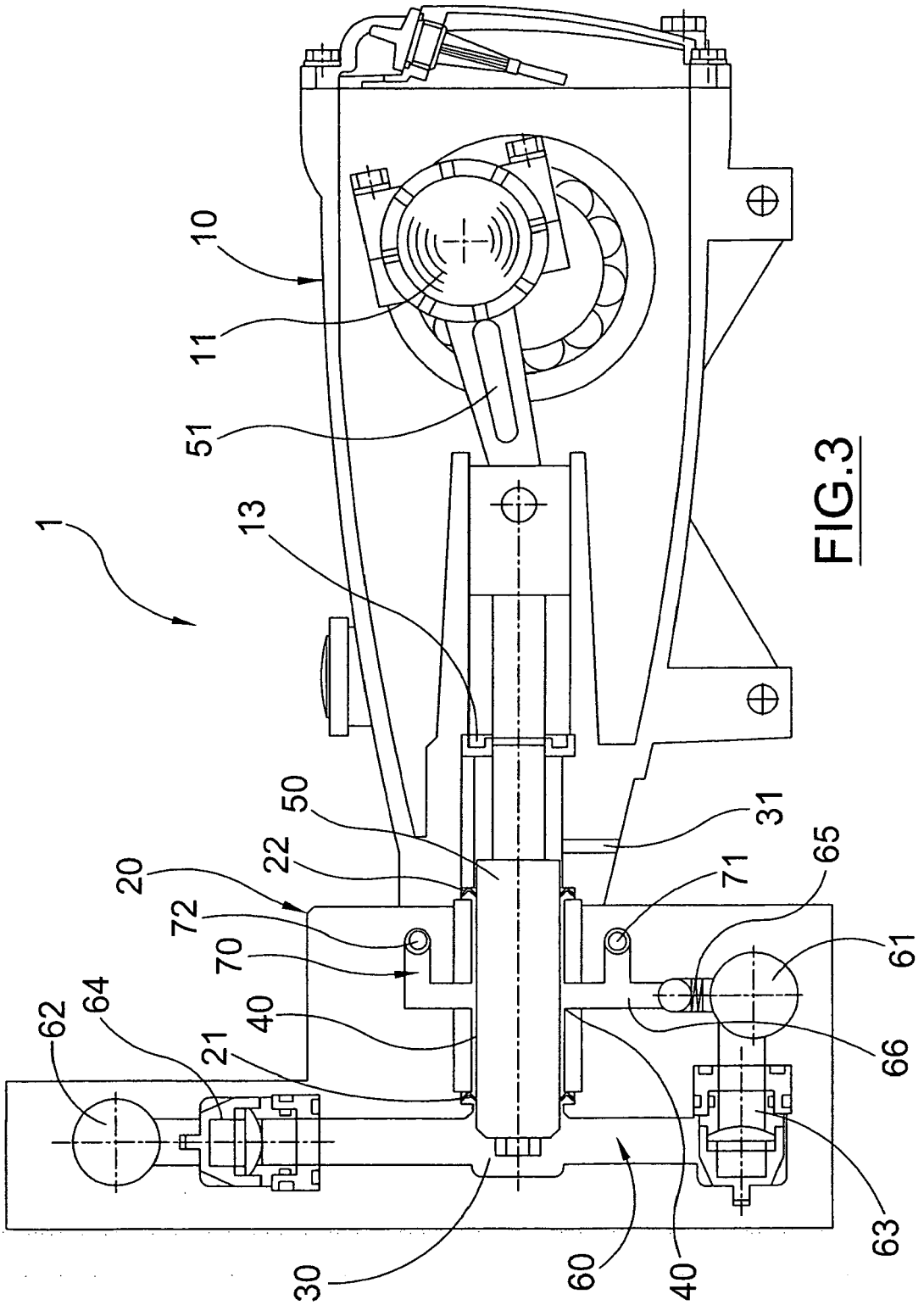

FIG.3

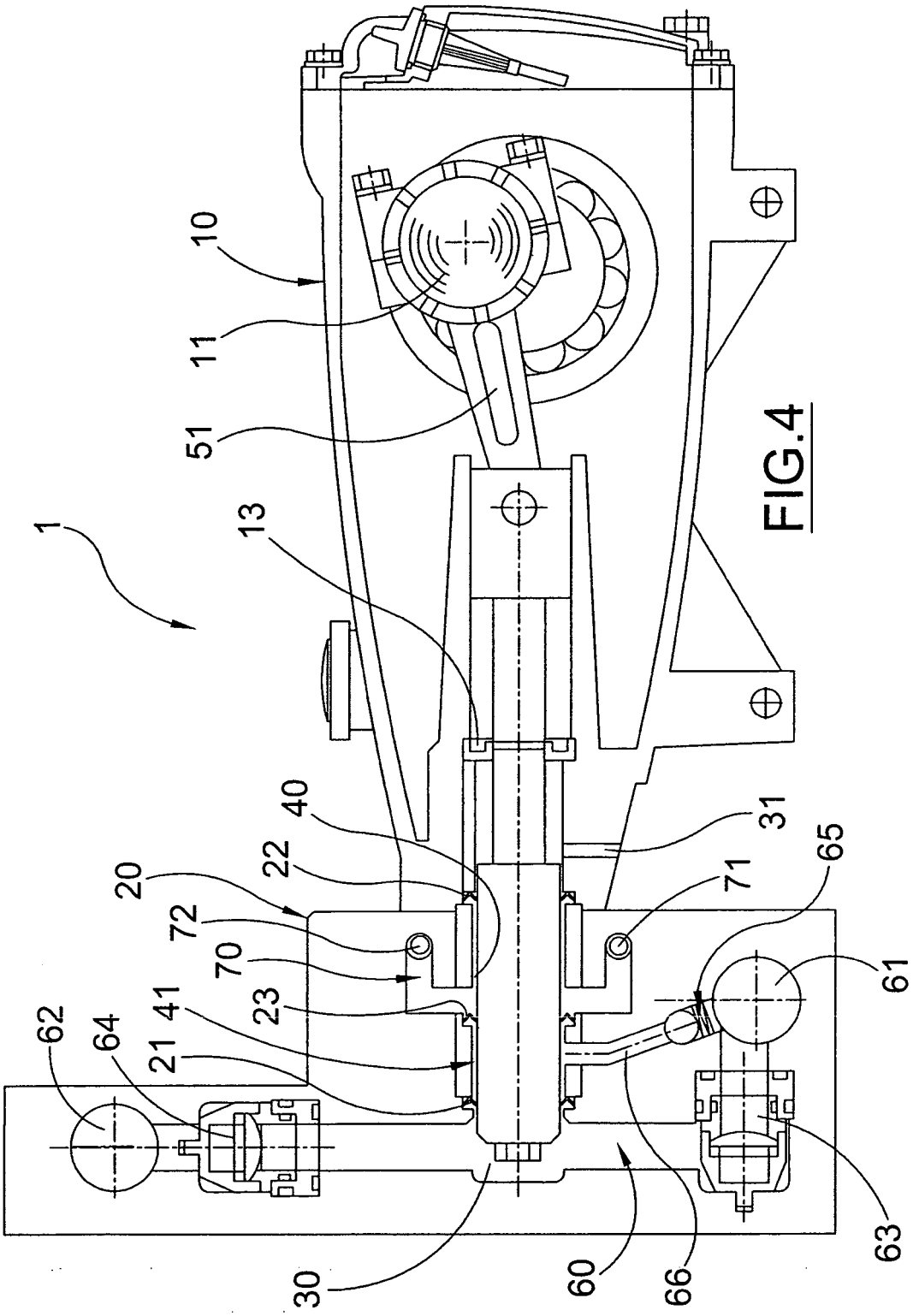

FIG.4

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EUROPEAN SEARCH REPORT

Application Number
EP 07 42 5514

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y,D	US 2006/140778 A1 (WARREN LESLIE J [GB]) 29 June 2006 (2006-06-29) * abstract; claim 1; figure * -----	1-14	INV. F04B53/08
Y	EP 0 976 993 A (EMBRACO EUROP SRL [IT]) 2 February 2000 (2000-02-02) * abstract; figure 5 * * paragraphs [0052] - [0054] * -----	1-14	
Y	US 3 379 033 A (GRANT WHITNEY I) 23 April 1968 (1968-04-23) * column 3, line 3 - column 3, line 19 * * figure 1 * -----	1-14	
			TECHNICAL FIELDS SEARCHED (IPC) F04B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	26 November 2007	Pinna, Stefano

CATEGORY OF CITED DOCUMENTS

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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