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(54) Title: FUEL SUPPLY SYSTEM FOR PISTON ENGINE AND METHOD OF OPERATING FUEL SUPPLY SYSTEM

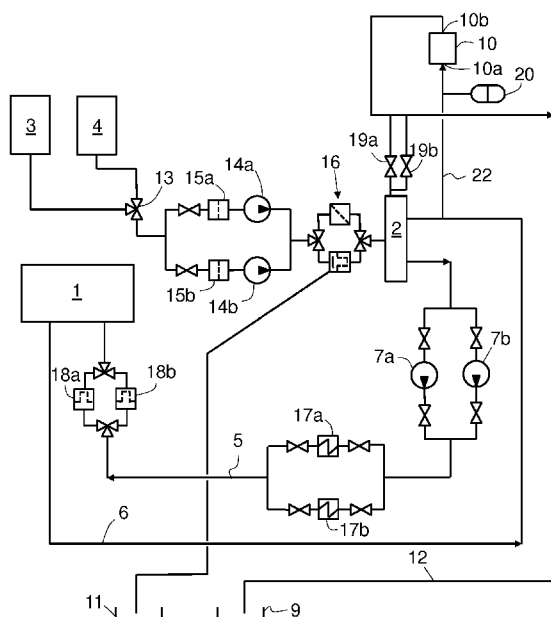


FIG. 1

(57) Abstract: The fuel supply system for a piston engine (1) comprises a fuel feed circuit, which comprises a mixing tank (2) for receiving fuel from a fuel tank (3, 4), a fuel supply line (5) for supplying fuel from the mixing tank (2) to a piston engine (1), a return line (6) for supplying excess fuel from the engine (1) to the mixing tank (2), and at least one fuel circulation pump (7a, 7b) for circulating fuel in the fuel feed circuit. The fuel supply system further comprises a centrifugal filter (10) having an inlet (10a) that is connected to the fuel feed circuit.

Fuel supply system for piston engine and method of operating fuel supply system

Technical field of the invention

5 The present invention relates to a fuel supply system for a piston engine in accordance claim 1. The invention also concerns a method of operating a fuel supply system as defined in the other independent claim.

Background of the invention

10 The fuel supply system of a typical ship engine or other large piston engine is provided with a fuel supply circuit, which can be called as a booster circuit. A booster circuit comprises one or more fuel circulation pumps that supply liquid fuel to the fuel injection pumps of the engine. Typically, the flow rate in the booster circuit is several times the fuel injection rate at full load of the engine. Excess fuel from the engine is supplied to a mixing tank. A problem encountered
15 in the fuel supply systems is the wear caused by hard abrasive particles.

Summary of the invention

20 An object of the present invention is to provide an improved fuel supply system for a piston engine. The characterizing features of the method according to the invention are given in claim 1. Another object of the invention is to provide an improved method of operating a fuel supply system of a piston engine. The characterizing features of the method are given in the other independent claim.

25 The fuel supply system according to the invention comprises a fuel feed circuit, which comprises a mixing tank for receiving fuel from a fuel tank, a fuel supply line for supplying fuel from the mixing tank to a piston engine, a return line for supplying excess fuel from the engine to the mixing tank, and at least one fuel circulation pump for circulating fuel in the fuel feed circuit. The fuel supply system further comprises a centrifugal filter having an inlet that is connected to the fuel feed circuit.

The method according to the invention comprises the steps of circulating fuel in a fuel feed circuit comprising a mixing tank that receives fuel from a fuel tank, a fuel supply line that supplies fuel from the mixing tank to the piston engine, a return line that supplies excess fuel from the engine to the mixing tank, and at
5 least one fuel circulation pump that circulates the fuel in the fuel feed circuit, separating a partial flow from the fuel flow in the fuel feed circuit, and conducting the partial flow through a centrifugal filter.

With the centrifugal filter, hard abrasive particles can be removed from the fuel feed circuit. This reduces wear of the components of the fuel supply system.

10 According to an embodiment of the invention, the centrifugal filter is connected to the fuel feed circuit by means of a bypass line.

According to an embodiment of the invention, the bypass line is provided with a throttle for reducing pressure pulsations in the centrifugal filter.

15 According to an embodiment of the invention, a pressure accumulator is connected to the bypass line for reducing pressure pulsations in the centrifugal filter.

According to an embodiment of the invention, the inlet of the centrifugal filter is connected to the fuel supply line between the mixing tank and the engine.

20 According to an embodiment of the invention, the inlet of the centrifugal filter is connected to the fuel supply line between the fuel circulation pump and the engine.

According to an embodiment of the invention, the inlet of the centrifugal filter is connected to the fuel supply line between the fuel circulation pump and a heat exchanger.

25 According to an embodiment of the invention, the inlet of the centrifugal filter is connected to the return line upstream from the mixing tank.

According to an embodiment of the invention, the outlet of the centrifugal filter is connected to a pressureless tank. According to an embodiment of the invention, the tank is located below the level of the fuel feed circuit.

30 According to an embodiment of the invention, the outlet of the centrifugal filter is connected to a leak fuel tank.

According to an embodiment of the invention, the centrifugal filter is connected to the leak fuel tank via a leak line that is connected to the mixing tank.

According to an embodiment of the invention, in the method the partial flow is conducted from the centrifugal filter to a pressureless tank.

- 5 According to an embodiment of the invention, the partial flow is at most 50 percent of the fuel flow at the location where the partial flow is separated from the fuel feed circuit

Brief description of the drawings

- 10 Embodiments of the invention are described below in more detail with reference to the accompanying drawings, in which

Fig. 1 shows schematically an example of a fuel supply system of a piston engine,

- 15 Fig. 2 shows schematically another example of a fuel supply system of a piston engine, and

Fig. 3 shows schematically still another example of a fuel supply system of a piston engine.

Description of embodiments of the invention

- 20 Figure 1 shows schematically a simplified example of a fuel supply system of a piston engine 1. For the sake of clarity, figure 1 shows only main parts of the fuel supply system and for example different sensors and meters are omitted. In the example of figure 1, the engine 1 is a ship engine. However, the engine 1 could also be a power plant engine or a large internal combustion engine for
25 some other purpose. The engine 1 can be operated using liquid fuel, such as heavy fuel oil or marine diesel oil. The expression "fuel supply system" refers here to a system that feeds liquid fuel to a fuel injection system of an engine 1. The fuel injection system comprises fuel injectors for injecting fuel into the cylinders of the engine and at least one fuel injection pump for raising the pressure
30 of the fuel. The fuel supply system supplies fuel to the fuel injection system at a

pressure that can be for example in the range of 4 to 15 bar. In the example of figure 1, the fuel supply system supplies fuel to one engine 1. However, the fuel supply system could also supply fuel to several engines.

5 In the embodiment of figure 1, the engine 1 can be operated using selectively either heavy fuel oil or marine diesel oil. The fuel supply system therefore comprises a first fuel tank 3 and a second fuel tank 4. However, the invention is also applicable to a fuel supply system, which is adapted for a single fuel type. The fuel supply system could thus comprise only one fuel tank. Further fuel tanks can be provided upstream from the first fuel tank 3 and the second fuel tank 4.
10 For instance, the first fuel tank 3 and the second fuel tank 4 can be day tanks, which receive fuel from storage tanks.

The first fuel tank 3 is configured to store first fuel, such as marine diesel oil and the second fuel tank 4 is configured to store second fuel, such as heavy fuel oil. The fuel supply system is provided with a changeover valve 13, which allows
15 selection of either the first fuel tank 3 or the second fuel tank 4. From the changeover valve 13, fuel is supplied further to fuel feed pumps 14a, 14b. The fuel supply system of figure 1 is provided with two fuel feed pumps 14a, 14b for redundancy. The fuel feed pumps 14a, 14b are arranged in parallel. In case redundancy is not required, it is sufficient to have a single fuel feed pump in the
20 fuel supply system. The fuel feed pumps 14a, 14b raise the pressure of the fuel to a first pressure level, which can be, for instance, in the range of 4–6 bar. Fuel supply from the fuel tanks 3, 4 could also be based on gravity, and in that case the fuel feed pumps 14a, 14b would not be needed. The fuel feed pumps 14a, 14b are thus not an essential part of the fuel supply system.

25 In the embodiment of figure 1, a filter 15a, 15b is arranged upstream from each fuel feed pump 14a, 14b. In case of a single fuel feed pump 14a, 14b or gravity-based fuel feeding, the fuel supply system could be provided either with a single filter or with two filters arranged in parallel, depending on whether redundancy is required. An automatic filter 16 is arranged on the downstream side of the fuel
30 feed pumps 14a, 14b.

From the automatic filter 16, fuel is supplied to a mixing tank 2. The mixing tank 2 and the components downstream from the mixing tank 2 form a fuel feed circuit. From the mixing tank 2, fuel is supplied to fuel circulation pumps 7a, 7b. In the embodiment of figure 1, two fuel circulation pumps 7a, 7b are provided for

- redundancy. However, if redundancy is not required, a single fuel circulation pump is sufficient. Instead of the two fuel circulation pumps 7a, 7b of figure 1, the fuel supply system could be provided with an engine-driven fuel circulation pump and with a stand-by pump arranged in parallel with the engine-driven fuel
- 5 circulation pump. The fuel circulation pumps 7a, 7b raise the pressure of the fuel from the first pressure level to a second pressure level. The second pressure level can be, for instance, 7–10 bar. The flow rate in the fuel feed circuit is typically 3–6 times the fuel consumption of the engine 1 or the combined fuel consumption of all the engines that are connected to the same fuel feed circuit.
- 10 From the fuel circulation pumps 7a, 7b, the fuel is supplied to heat exchangers 17a, 17b, which can be used for heating the fuel. By controlling the temperature of the fuel, the viscosity of the fuel can be adjusted. Two heat exchangers 17a, 17b are needed only in case redundancy is required. If the engine 1 is not operated using heavy fuel oil, the heat exchangers 17a, 17b are not needed.
- 15 Two filters 18, 18b are arranged in parallel between the heat exchangers 17a, 17b and the engine 1. By having two filters 18a, 18b in parallel, fuel supply is allowed even in case one of the filters 18a, 18b is clogged. If redundancy is not required, a single filter is sufficient. From the filters 18a, 18b, fuel is supplied to
- 20 the fuel injection system of the engine 1, where the required amount of fuel is injected into prechambers or directly into the cylinders of the engine 1. Each cylinder of the engine 1 can be provided with an own fuel injection pump. The fuel injection pumps raise the pressure of the fuel from the second pressure level to a third pressure level, which is suitable for direct fuel injection.
- Excess fuel from the engine 1 is supplied back to the mixing tank 2 through a
- 25 return line 6. The mixing tank 2 also functions as a de-aeration tank. The mixing tank 2 is connected to a leak line 12 via vent valves 19a, 19b. The leak line 12 connects the mixing tank 2 to a leak fuel tank 9. In the embodiment of figure 1, the leak fuel tank 9 is a clean leak tank. The fuel supply system further comprises a second leak fuel tank 11 for dirty fuel.
- 30 The fuel supply system according to the invention further comprises a centrifugal filter 10, which is connected to the fuel feed circuit. The centrifugal filter 10 removes abrasive particles from the fuel feed circuit, and thus reduces wear of the components of the fuel feed circuit and the fuel injection system. The centrifugal filter 10 is connected to the fuel feed circuit by means of a bypass line 22. The

centrifugal filter 10 has an inlet 10a and an outlet 10b. The inlet 10a of the centrifugal filter 10 is connected to the fuel feed circuit. The centrifugal filter 10 is preferably connected to the fuel feed circuit at a location, where pressure pulsations are at minimum. In the embodiment of figure 1, the bypass line 22 and thus
5 also the inlet 10a of the centrifugal filter 10 is connected to the return line 6 between the engine 1 and the mixing tank 2. The outlet 10b of the centrifugal filter 10 is connected to the leak fuel tank 9. In the embodiment of figure 1, the outlet 10b of the centrifugal filter 10 is connected to the leak fuel tank 9 via the leak line 12, which is the leak line for clean fuel. The centrifugal filter 10 could
10 also be provided with an own outlet line for connecting it to the leak fuel tank 9. For reducing pressure pulsations in the centrifugal filter 10, a pressure accumulator 20 is connected to the bypass line 22.

The fuel supply system of figure 2 is similar to the fuel supply system of figure 1, but the centrifugal filter 10 is connected to the fuel feed circuit at a different
15 location. In the embodiment of figure 2, the bypass line 22 and the inlet 10a of the centrifugal filter 10 are connected to the fuel supply line 5 between the fuel circulation pumps 7a, 7b and the engine 1. The connection point is between the heat exchangers 17a, 17b and the filters 18a, 18b. The outlet 10b of the centrifugal filter 10 is connected to the leak line 12. In the embodiment of figure 2,
20 pressure pulsations in the centrifugal filter 10 are reduced by providing the bypass line 22 with a throttle 21. Instead of the throttle 21 or in addition to it, the bypass line 22 could also be provided with a pressure accumulator 20 in the same way as in the embodiment of figure 1. Similarly, the bypass line 22 of figure 1 could be provided with a throttle 21 in addition to or instead of the pressure
25 accumulator 20. Pressure pulsations could also be reduced in both embodiments by making the bypass lines 22 of pipes having a greater inner diameter than the fuel supply line 5 and the return line 6.

The embodiment of figure 3 is similar to the embodiments of figures 1 and 2. In the embodiment of figure 3, the bypass line 22 is connected to the fuel supply
30 line 5 between the fuel circulation pumps 7a, 7b and the heat exchangers 17a, 17b. The outlet 10b of the centrifugal filter 10 is connected to the leak line 12. The bypass line 22 is provided with a pressure accumulator 20 for reducing pressure pulsations.

The operating principle of all the fuel supply systems of figures 1 to 3 is the
35 same. Fuel is circulated in the fuel feed circuit, and a partial flow is separated

from the fuel flow and conducted through the centrifugal filter 10. The fuel conducted through the centrifugal filter 10 is clean, and the outlet 10b of the centrifugal filter 10 could thus be connected almost anywhere in the fuel supply system. A separate tank could be provided for receiving fuel from the centrifugal filter 10, or the centrifugal filter 10 could be connected to a day tank, settling tank, service tank or some other tank of the fuel supply system. Preferably the fuel is conducted to a pressureless tank to ensure proper functioning of the centrifugal filter 10. The tank is preferably located vertically below the fuel feed circuit. The centrifugal filter 10 is configured so that a suitable flow rate of the partial flow is achieved. The centrifugal filter 10 is provided with nozzles arranged inside a rotor to control the flow through the centrifugal filter 10. The partial flow can be configured to be, for instance, at most 50 percent of the fuel flow at the location where the partial flow is separated from the fuel feed circuit.

It will be appreciated by a person skilled in the art that the invention is not limited to the embodiments described above, but may vary within the scope of the appended claims.

Claims

1. A fuel supply system for a piston engine (1), the fuel supply system comprising a fuel feed circuit, which comprises
 - a mixing tank (2) for receiving fuel from a fuel tank (3, 4),
 - 5 - a fuel supply line (5) for supplying fuel from the mixing tank (2) to a piston engine (1),
 - a return line (6) for supplying excess fuel from the engine (1) to the mixing tank (2), and
 - at least one fuel circulation pump (7a, 7b) for circulating fuel in the fuel
 - 10 feed circuit,wherein the fuel supply system comprises a centrifugal filter (10) having an inlet (10a) that is connected to the fuel feed circuit.
2. A fuel supply system according to claim 1, wherein the centrifugal filter (10) is connected to the fuel feed circuit by means of a bypass line (22).
- 15 3. A fuel supply system according to claim 2, wherein the bypass line (22) is provided with a throttle (21) for reducing pressure pulsations in the centrifugal filter (10).
4. A fuel supply system according to claim 2 or 3, wherein a pressure accumulator (20) is connected to the bypass line (22) for reducing pressure pulsations in the centrifugal filter (10).
- 20 5. A fuel supply system according to any of the preceding claims, wherein the inlet (10a) of the centrifugal filter (10) is connected to the fuel supply (5) line between the mixing tank (2) and the engine (1).
6. A fuel supply system according to any of the preceding claims, wherein the inlet (10a) of the centrifugal filter (10) is connected to the fuel supply (5) line between the fuel circulation pump (7a, 7b) and the engine (1).
- 25 7. A fuel supply system according to any of the preceding claims, wherein the inlet (10a) of the centrifugal filter (10) is connected to the fuel supply line (5) between the fuel circulation pump (7a, 7b) and a heat exchanger (17a, 17b).
- 30 8. A fuel supply system according to any of claims 1 to 4, wherein the inlet (10a) of the centrifugal filter (10) is connected to the return line (6) upstream from the mixing tank (2).

9. A fuel supply system according to any of the preceding claims, wherein the outlet (10b) of the centrifugal filter (10) is connected to a pressureless tank (9).

10. A fuel supply system according to claim 9, wherein the tank (9) is located below the level of the fuel feed circuit.

5 11. A fuel supply system according to any of the preceding claims, wherein the outlet (10b) of the centrifugal filter (10) is connected to a leak fuel tank (9).

12. A fuel supply system according to claim 11, wherein the centrifugal filter (10) is connected to the leak fuel tank (9) via a leak line (12) that is connected to the mixing tank (2).

10 13. A method of operating a fuel supply system of a piston engine, the method comprising the steps of

- circulating fuel in a fuel feed circuit comprising a mixing tank (2) that receives fuel from a fuel tank (3, 4), a fuel supply line (5) that supplies fuel from the mixing tank (2) to the piston engine (1), a return line (6) that
15 supplies excess fuel from the engine (1) to the mixing tank (2), and at least one fuel circulation pump (7a, 7b) that circulates the fuel in the fuel feed circuit,
- separating a partial flow from the fuel flow in the fuel feed circuit, and
- conducting the partial flow through a centrifugal filter (10).

20

14. A method according to claim 13, wherein the partial flow is conducted from the centrifugal filter (10) to a pressureless tank (9).

15. A method according to claim 13 or 14, wherein the partial flow is at most 50 percent of the fuel flow at the location where the partial flow is separated from
25 the fuel feed circuit.

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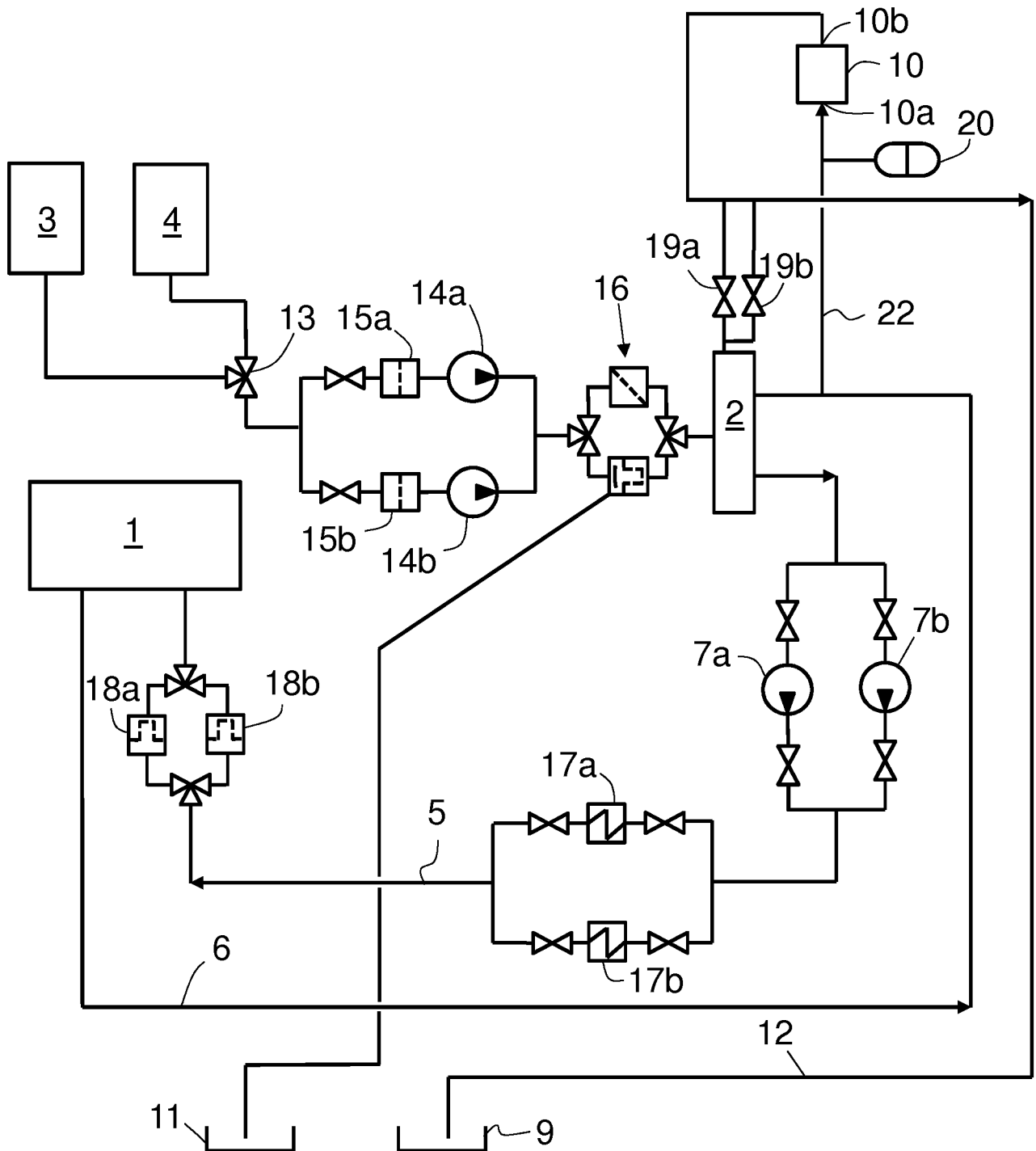


FIG. 1

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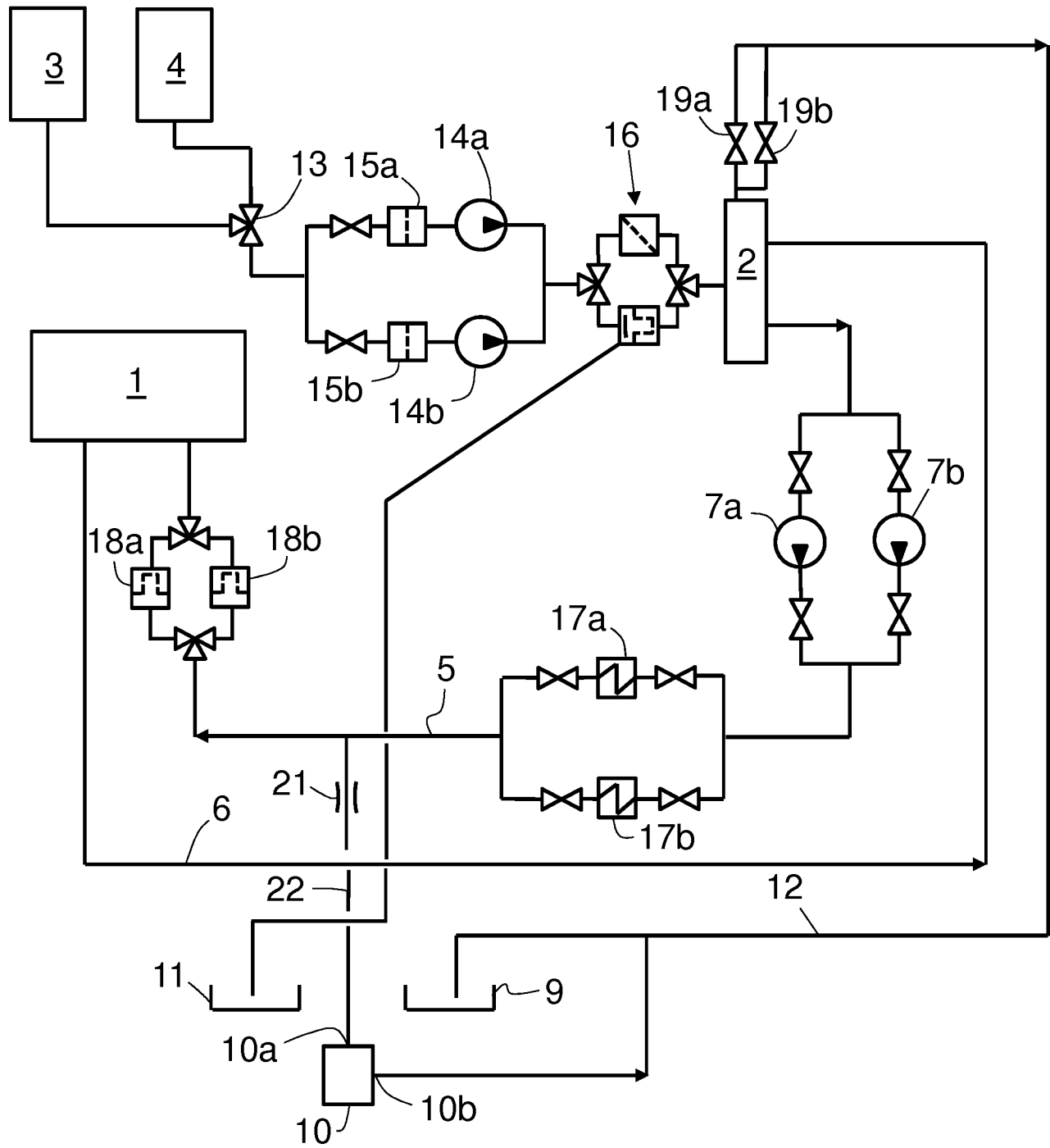


FIG. 2

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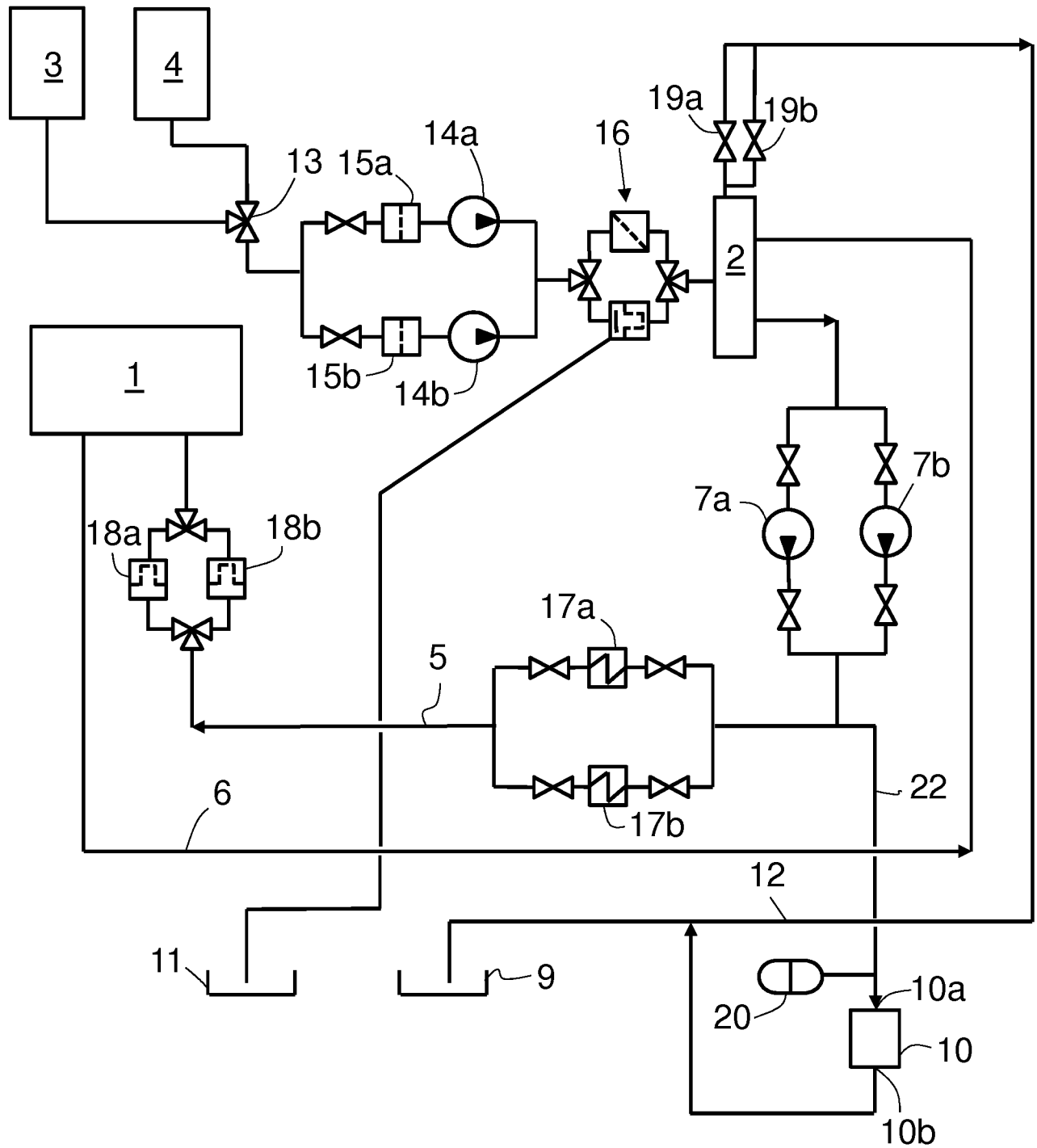


FIG. 3

INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER

INV. F02M37/32 F02D19/06 F02M43/00
ADD.

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)

F02M F02D

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)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP S61 192846 A (HIRANO SHINSAKU) 27 August 1986 (1986-08-27)	1,8-14
Y	figure 1	2-7
Y	JP S60 156937 A (HITACHI LTD; HITACHI ENG CO LTD) 17 August 1985 (1985-08-17) the whole document	2-7
X	FR 1 275 998 A (.) 10 November 1961 (1961-11-10) figure 1	1,5-7,9, 13-15



Further documents are listed in the continuation of Box C.



See patent family annex.

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2019/053486

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
JP S61192846	A	27-08-1986	NONE	
JP S60156937	A	17-08-1985	NONE	
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