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(72) Inventor: **SAITO, Yoshiyuki**  
**Tokyo 135-8710 (JP)**

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(74) Representative: **Köhler, Walter**  
**Louis, Pöhlau, Lohrentz**  
**Patentanwälte**  
**Postfach 30 55**  
**90014 Nürnberg (DE)**

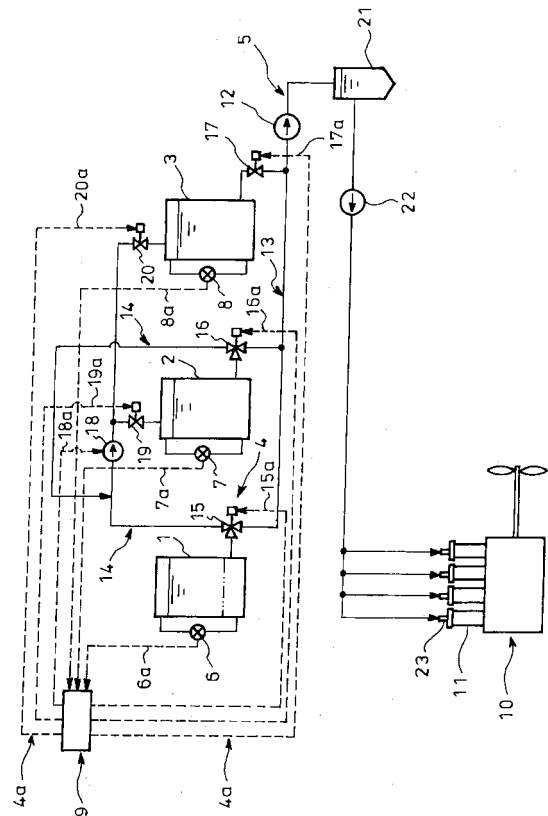
(71) Applicant: **IHI Corporation**  
**Tokyo 135-8710 (JP)**

(54) **FUEL SUPPLY METHOD AND DEVICE FOR INTERNAL COMBUSTION MARINE ENGINE**

(57) Provided are a method and an apparatus for supplying fuel to a marine internal combustion engine which can prevent hard particles from entering in large quantity into an engine and which can prevent scuffing of a piston ring against a cylinder liner.

By outputting switchover signals 4a from a controller 9 to flow passage switchover means 4 of a fuel supply line 5 on the basis of detection signals 6a, 7a and 8a from level detectors 6, 7 and 8, the fuel is sequentially evacuated from fuel tanks 1, 2 and 3. When a detection signal 6a (or 7a) of the level detector 6 (or 7) reveals that the fuel level of the fuel tank 1 (or 2) under evacuation is reduced below a preset value, fuel evacuation from the next fuel tank 2 (or 3) is started, the fuel from the fuel tank 1 (or 2) being at least mixed with the fuel from the next fuel tank 2 (or 3). The fuel with a lowered concentration of hard particles can be injected into respective cylinders 11 of an engine 10.

FIG. 1



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## Description

### Technical Field

**[0001]** The present invention relates to a method and an apparatus for supplying fuel to a marine internal combustion engine.

### Background Art

**[0002]** In general, for a marine internal combustion engine, fuel stored in a fuel tank is pumped by a fuel pump and is supplied through fuel injection valves into respective cylinders of the engine.

**[0003]** General technical level on supply of fuel to a marine internal combustion engine is disclosed, for example, in Patent Literature 1.

[Patent Literature 1] JP 2004-308528A

### Summary of Invention

### Technical Problems

**[0004]** However, fuel contains hard particles of ceramic such as alumina and silica used as reforming catalysts for the fuel, so that evacuation of the fuel reduced in stored quantity in a fuel tank through a bottom of the tank also brings about evacuation of high concentration of hard particles deposited on the bottom of the tank together with the fuel. The evacuated hard particles, which cannot be completely removed by a fuel purifier or filter, enter in large quantity into the engine, disadvantageously resulting in scuffing of a piston ring against a cylinder liner.

**[0005]** The invention was made in view of the above and has its object to provide a method and an apparatus for supplying fuel to a marine internal combustion engine which can prevent hard particles from entering in large quantity into the engine and can prevent scuffing of a piston ring against a cylinder liner.

### Solution to Problems

**[0006]** The invention is directed to a method for supplying fuel to a marine internal combustion engine wherein the fuel stored in a fuel tank is evacuated through a bottom of the tank, is pumped by a fuel pump and is supplied via fuel injection valves into respective cylinders of the engine, which comprises

providing a plurality of fuel tanks adapted for evacuation of the fuel therefrom, mixing the fuel evacuated from the fuel tank under evacuation and fuel of said other fuel tank together when a fuel level of said fuel tank under evacuation is reduced below a preset value, and supplying the mixed fuel with a lowered concentration of hard particles into the respective cylinders of the engine.

**[0007]** With the above construction, the fuel may be evacuated from the fuel tanks; when the fuel level of the

fuel tank under evacuation is reduced below the preset value, the fuel evacuated from said fuel tank under evacuation and with the fuel level reduced below the preset value is mixed together with the fuel of said other fuel tank; and the mixed fuel with the lowered concentration of hard particles is supplied into the respective cylinders of the engine.

**[0008]** As a result, hard particles are prevented from entering in large quantity into the engine and scuffing of a piston ring against a cylinder liner is prevented.

**[0009]** In the above supply method, while the fuel evacuated from the fuel tank with the fuel level reduced below the preset value is guided to an upper portion of said other fuel tank, fuel may be evacuated from a bottom of the other fuel tank.

**[0010]** In the above supply method, alternatively, fuel may be evacuated alternately at a predetermined time interval from the fuel tank with the fuel level reduced below the preset value and from said other fuel tank, the evacuated fuel being mixed together in a settling tank arranged downstream.

**[0011]** In the above supply method, alternatively, fuel may be evacuated concurrently from said fuel tank with the fuel level reduced below the preset value and from said other fuel tank.

**[0012]** In the above supply method, alternatively, fuel may be evacuated from a bottom of said other fuel tank after the fuel evacuated from the fuel tank with the fuel level reduced below the preset value is guided to an upper portion of said other fuel tank.

**[0013]** The invention is further directed to an apparatus for supplying fuel to a marine internal combustion engine wherein the fuel stored in a fuel tank is evacuated through a bottom of the tank, is pumped by a fuel pump and is supplied via fuel injection valves into respective cylinders of the engine, which comprises

a plurality of fuel tanks,  
a fuel supply line with flow passage switchover means switchable for fuel evacuation from said respective fuel tanks,  
level detectors for detecting fuel levels of said fuel tanks, respectively, and

a controller for outputting switchover signals to the flow passage switchover means in said fuel supply line such that, upon evacuation of the fuel from any of said fuel tanks and when a detection signal from the corresponding level detector reveals that the fuel level of said fuel tank under evacuation is reduced below a preset value, the fuel evacuated from said fuel tank with the fuel level reduced below the preset value is mixed together with fuel of said other fuel tank, the mixed fuel with a lowered concentration of hard particles being supplied into the respective cylinders of the engine.

**[0014]** In the above apparatus, the fuel is evacuated from any of the fuel tanks via the fuel supply line, the fuel level of the fuel tank under evacuation being detected by the corresponding level detector; when the detection signal from the level detector reveals that the fuel level of

the fuel tank under evacuation is reduced below the preset value, switchover signals are outputted from the controller to the flow passage switchover means in the fuel supply line so that the fuel evacuated from the fuel tank with the fuel level reduced below the preset value is mixed together with fuel of said other fuel tank, the mixed fuel with a lowered concentration of hard particles being supplied into the respective cylinders of the engine.

**[0015]** As a result, hard particles are prevented from entering in large quantity into the engine and scuffing of a piston ring against a cylinder liner is prevented.

**[0016]** In the above supply apparatus, said fuel supply line may comprise

an evacuation line for connecting bottoms of said respective fuel tanks with the fuel pump and

a bypass line branched from said evacuation line for guiding the fuel evacuated from said fuel tank with the fuel level reduced below the preset value to an upper portion of said other fuel tank, and

said flow passage switchover means may comprise

a three-way valve at a juncture between said evacuation line and said bypass line and switchable for guidance of the fuel of said fuel tank with the fuel level reduced below the preset value from the evacuation line to the bypass line,

an auxiliary pump incorporated in said bypass line for pumping to the upper portion of said other fuel tank the fuel guided not to the evacuation line but to the bypass line through switchover of said three-way valve,

a switchover-for-mixing valve incorporated in the bypass line downstream of said auxiliary pump and switchable for guidance of the fuel of said fuel tank with the fuel level reduced below the preset value to said other fuel tank and an evacuation valve incorporated in the evacuation line connected to the bottom of the fuel tank among the fuel tanks from which the fuel is finally evacuated and opened when the fuel is finally evacuated from said fuel tank.

**[0017]** In the above supply apparatus, alternatively, said fuel supply line may comprise an evacuation line for connecting bottoms of said respective fuel tanks with the fuel pump, and

said flow passage switchover means may comprise an evacuation valve incorporated in the evacuation line connected to the bottoms of said respective fuel tanks and controlled to be selectively opened and closed such that the fuel is evacuated alternately at a predetermined time interval from said fuel tank with the fuel level reduced below the preset value and from said other fuel tank, said evacuated fuels being mixed together in a settling tank arranged downstream.

**[0018]** In the above supply apparatus, alternatively, said fuel supply line may comprise an evacuation line for connecting bottoms of said respective fuel tanks with the fuel pump and

said flow passage switchover means may comprise an evacuation valve incorporated in the evacuation line connected to the bottoms of said respective fuel tanks and controlled to be selectively opened and closed such that

the fuels are evacuated concurrently from said fuel tank with the fuel level reduced below the preset value and from said other fuel tank.

**[0019]** In the above supply apparatus, alternatively, said fuel supply line may comprise

an evacuation line for connecting bottoms of said respective fuel tanks with the fuel pump and

a bypass line branched from said evacuation line downstream of the fuel pump for guiding the fuel of said fuel tank with the fuel level reduced below the preset value to an upper portion of said other fuel tank, and said flow passage switchover means comprises

an evacuation valve incorporated in the evacuation line connected to the bottoms of said respective fuel tanks and controlled to be selectively opened and closed such that the fuel is evacuated from said other fuel tank after the fuel is evacuated from said fuel tank with the fuel level reduced below the preset value,

a three-way valve at a juncture between said evacuation line and said bypass line and switchable for guidance of the fuel of said fuel tank with the fuel level reduced below the preset value from the evacuation line to the bypass line and

a switchover-for-mixing valve incorporated in the bypass line downstream of said three-way valve and switchable

such that after the fuel of said fuel tank with the fuel level reduced below the preset value is guided to an upper portion of said other fuel tank, the fuel evacuated through the bottom of said other fuel tank is guided to the upper portion of the same fuel tank.

#### Advantageous Effects of Invention

**[0020]** A method and an apparatus for supplying fuel to a marine internal combustion engine according to the invention have excellent effects and advantages that hard particles can be prevented from entering in large quantity into the engine and scuffing of a piston ring against a cylinder liner can be prevented.

#### Brief Description of Drawings

##### [0021]

Fig. 1 is an overall schematic diagram showing a first embodiment of the invention;

Fig. 2 is an overall schematic diagram showing a second embodiment of the invention; and

Fig. 3 is an overall schematic diagram showing a third embodiment of the invention.

#### Reference Signs List

##### [0022]

|   |           |
|---|-----------|
| 1 | fuel tank |
| 2 | fuel tank |
| 3 | fuel tank |

|     |                               |
|-----|-------------------------------|
| 4   | flow passage switchover means |
| 4a  | switchover signal             |
| 5   | fuel supply line              |
| 6   | level detector                |
| 6a  | detection signal              |
| 7   | level detector                |
| 7a  | detection signal              |
| 9   | controller                    |
| 10  | engine                        |
| 11  | cylinder                      |
| 12  | fuel pump                     |
| 13  | evacuation line               |
| 14  | bypass line                   |
| 15  | three-way valve               |
| 15' | evacuation valve              |
| 15a | switchover signal             |
| 16  | three-way valve               |
| 16' | evacuation valve              |
| 16a | switchover signal             |
| 17  | evacuation valve              |
| 17a | switchover signal             |
| 18  | auxiliary pump                |
| 18a | switchover signal             |
| 19  | switchover-for-mixing valve   |
| 19a | switchover signal             |
| 20  | switchover-for-mixing valve   |
| 20a | switchover signal             |
| 21  | settling tank                 |
| 22  | supply pump                   |
| 23  | fuel injection valve          |
| 24  | three-way valve               |

#### Description of Embodiments

**[0023]** Embodiments of the invention will be described in conjunction with attached drawings.

**[0024]** Fig. 1 shows a first embodiment of the invention in which a plurality of (three in Fig. 1) fuel tanks 1, 2 and 3 filled with fuel are installed, bottoms of the respective fuel tanks 1, 2 and 3 being connected to a fuel supply line 5 with flow passage switchover means 4 so as to make sequential evacuation possible. The fuel tank 1, 2 and 3 are equipped with level detectors 6, 7 and 8 for detection of fuel levels, respectively. On the basis of the detection signals 6a, 7a and 8a from the level detectors 6, 7 and 8, the controller 9 outputs switchover signals 4a to the flow passage switchover means 4 in the fuel supply line 5 to sequentially evacuate the fuel from the respective fuel tanks 1, 2 and 3. When the detection signal 6a (or 7a) from the level detector 6 (or 7) reveals that the fuel level of the fuel tank 1 (or 2) under evacuation is decreased below a preset value, evacuation of fuel from the next fuel tank 2 (or 3) is started. Thus, the evacuated fuel from the fuel tank 1 (or 2) with the fuel level reduced below the preset value is at least mixed with fuel of the next fuel tank 2 (or 3), so that the mixed fuel with a reduced concentration of hard particles can be supplied into the respective cylinders of the engine 10.

**[0025]** In the embodiment, the fuel supply line 5 comprises an evacuation line 13 which connects the bottoms of the respective fuel tanks 1, 2 and 3 with a fuel pump 12, and a bypass line 14 which is branched from the evacuation line 13 so as to guide the fuel of the fuel tank 1 (or 2) with the fuel level reduced below the preset value to an upper portion of the next fuel tank 2 (or 3).

**[0026]** Flow passage switchover means 4 comprises a three-way valve 15 (or 16) at a juncture between the evacuation line 13 and the bypass line 14 and switchable for guidance of the fuel of the fuel tank 1 (or 2) with the fuel level reduced below the preset value from the evacuation line 13 to the bypass line 14, an auxiliary pump 18 incorporated in the bypass line 14 which pumps to the upper portion of the next fuel tank 1, 2 or 3 the fuel guided from the evacuation line 13 to the bypass line 14 by means of switchover by the three-way valve 15 (or 16), a switchover-for-mixing valve 19, 20 incorporated in the bypass line 14 downstream of the auxiliary pump 18 and switchable for guidance to the next fuel tank 2 (or 3) the fuel of the fuel tank 1 (or 2) with the fuel level reduced below the preset value and an evacuation valve 17 incorporated in the evacuation line 13 connected to a bottom of the last fuel tank 3 (the third one in Fig. 1) among the fuel tanks 1, 2 and 3 from which the fuel is finally evacuated, said evacuation valve 17 being opened when the fuel is finally evacuated from the fuel tank 3.

**[0027]** The switchover signal 4a has a switchover signal 15a for switchover of the three-way valve 15, a switchover signal 16a for switchover of the three-way valve 16, a switchover signal 17a for selective opening and closing of the evacuation valve 17, a switchover signal 18a for selective on and off of the auxiliary pump 18, a switchover signal 19a for selective opening and closing of the switchover-for-mixing valve 19 and a switchover signal 20a for selective opening and closing of the switchover-for-mixing valve 20.

**[0028]** In Fig. 1, reference numeral 21 denotes a settling tank incorporated in the evacuation line 13 downstream of the fuel pump 12; 22, a supply pump for pumping of the fuel in the settling tank 21; and 23, fuel injection valves for injection of the fuel pumped by the supply pump 22 into cylinders 11 of the engine 10.

**[0029]** Since fuel cannot be replenished to the tanks in a ship under way, a total capacity of the fuel tanks 1, 2 and 3 is to sufficiently cover one marine navigation distance, fuel being replenished to the tanks before a fuel level of the fuel tank from which fuel is finally evacuated is reduced below a preset value.

**[0030]** Next, mode of operation of the above embodiment will be disclosed.

**[0031]** In the embodiment, among the plural fuel tanks 1, 2 and 3 filled with fuel, first the fuel is evacuated from the fuel tank 1 via the evacuation line 13 in the fuel supply line 5 and is pumped by the fuel pump 12 into the settling tank 21, the fuel temporarily stored in the settling tank 21 being pumped by the supply pump 22 to the fuel injection valves 23 through which the fuel is injected into the re-

spective cylinders 11 of the engine 10.

**[0032]** In this case, the three-way valve 15 is switched to the evacuation line 13 by the switchover signal 15a from the controller 9, the three-way valve 16 being closed by the switchover signal 16a from the controller 9, the evacuation valve 17 being closed by the switchover signal 17a from the controller 9, the auxiliary pump 18 being switched off by the switchover signal 18a from the controller 9, the switchover-for-mixing valve 19 being closed by the switchover signal 19a from the controller 9, the switchover-for-mixing valve 20 being closed by the switchover signal 20a from the controller 9.

**[0033]** The fuel level in the fuel tank 1 is detected by the level detector 6. When the detection signal 6a from the level detector 6 reveals that the fuel level of the fuel tank 1 under evacuation is reduced below a preset value as shown by imaginary line in Fig. 1, the three-way valve 15 is switched from the evacuation line 13 to the bypass line 14 by the switchover signal 15a from the controller 9, the three-way valve 16 being switched to the evacuation line 13 by the switchover signal 16a from the controller 9, the auxiliary pump 18 being switched on by the switchover signal 18a from the controller 9, the switchover-for-mixing valve 19 being opened by the switchover signal 19a from the controller 9. Thus, while fuel evacuation from the next fuel tank 2 to the evacuation line 13 is started, the fuel evacuated from the fuel tank 1 with the fuel level reduced below the preset value is pumped up to the bypass line 14 by actuation of the auxiliary pump 18 switched on and is guided to the upper portion of the next fuel tank 2 via the opened switchover-for-mixing valve 19 and is mixed together with fuel stored in the next fuel tank 2; then, the fuel in the fuel tank 2 where hard particles are not deposited in high concentration at the bottom is supplied into the respective cylinders 11 of the engine 10 via the fuel pump 12, settling tank 21, supply pump 22 and fuel injection valves 23.

**[0034]** As a result, hard particles are prevented from entering in large quantity into the engine 10 and scuffing of a piston ring against a cylinder liner is prevented.

**[0035]** When the fuel tank 1 is fully evacuated, the three-way valve 15 is closed by the switchover signal 15a from the controller 9, the auxiliary pump 18 being switched off by the switchover signal 18a from the controller 9, the switchover-for-mixing valve 19 being closed by the switchover signal 19a from the controller 9, evacuation of the fuel from the bottom of the fuel tank 2 being continued.

**[0036]** Then, the fuel level of the fuel tank 2 is detected by the level detector 7. When the detection signal 7a from the level detector 7 reveals that the fuel level of the fuel tank 2 under evacuation is reduced below the preset value, the three-way valve 16 is switched from the evacuation line 13 to the bypass line 14 by the switchover signal 16a from the controller 9, the evacuation valve 17 being opened by the switchover signal 17a from the controller 9, the auxiliary pump 18 being switched on again by the switchover signal 18a from the controller 9, the switcho-

ver-for-mixing valve 20 being opened by the switchover signal 20a from the controller 9. Thus, while evacuation of the fuel from the next fuel tank 3 to the evacuation line 13 is started, the fuel evacuated from the fuel tank 2 with the fuel level reduced below the preset value is pumped up to the bypass line 14 by the actuation of the auxiliary pump 18 switched on and is guided to the upper portion of the next fuel tank 3 via the opened switchover-for-mixing valve 20 and is mixed with fuel stored in the next fuel tank 2, the fuel in the fuel tank 3 where no high concentration of hard particles are deposited at a bottom is supplied to the respective cylinders 11 of the engine 10 via the fuel pump 12, settling tank 21, supply pump 22 and fuel injection valves 23. As a result, there is no fear about entering of hard particles in large quantity into the engine 10 and resultant scuffing of a piston ring against a cylinder liner.

**[0037]** Before the fuel level of the fuel tank 3 from which the fuel is finally evacuated is reduced below the preset value, the fuel is replenished to the tanks and the operations as mentioned in the above are repeated.

**[0038]** Thus, the hard particles can be prevented from entering in large quantity into the engine 10 and the piston ring can be prevented from scuffing to the cylinder liner.

**[0039]** Fig. 2 shows a second embodiment of the invention in which parts similar to those shown in Fig. 1 are represented by the same reference numerals and whose fundamental structure is similar to that shown in Fig. 1. The embodiment is **characteristic in that**, as shown in Fig. 2, the fuel supply line 5 comprises an evacuation line 13 connecting bottoms of the respective fuel tanks 1, 2 and 3 with the fuel pump 12, the flow passage switchover means 4 comprising evacuation valves 15', 16' and 17 incorporated in the evacuation line 13 connected to bottoms of the respective fuel tanks 1, 2 and 3, the evacuation valves 15', 16' and 17 being controlled to be selectively opened and closed by the switchover signals 15a', 16a' and 17a based on the detection signals 6a, 7a and 8a from the level detectors 6, 7 and 8, the fuel being evacuated alternately at a constant time interval from the fuel tank 1 (or 2) with the fuel level reduced below the preset value and from the next fuel tank 2 (or 3) and being mixed in the settling tank 21 arranged downstream.

**[0040]** In the embodiment shown in Fig. 2, among the plural fuel tanks 1, 2 and 3 filled with fuel, first the fuel is evacuated from the fuel tank 1 via the evacuation line 13 of the fuel supply line 5 and is pumped by the fuel pump 12 into the settling tank 21 where the fuel is temporarily stored, the fuel temporarily stored in the settling tank 21 being pumped by the supply pump 22 into the fuel injection valves 23 through which the fuel is injected to the respective cylinders 11 of the engine 10.

**[0041]** In this case, the evacuation valve 15' is opened by the switchover signal 15a' from the controller 9, the evacuation valve 16' being closed by the switchover signal 16a' from the controller 9, the evacuation valve 17 being closed by the switchover signal 17a from the con-

troller 9.

**[0042]** The fuel level in the fuel tank 1 is detected by the level detector 6. When the detection signal 6a from the level detector 6 reveals that the fuel level of the fuel tank 1 under evacuation is reduced below the preset value as shown by imaginary line in Fig. 2, the evacuation valves 15' and 16' are alternately closed and opened for a predetermined time period by the switchover signals 15a' and 16a' from the controller 9, the fuel being alternately evacuated at a constant time interval from the fuel tank 1 with the fuel level reduced below the preset value and from the next fuel tank 2, the fuels being mixed at the settling tank 21 arranged downstream, the mixed fuel with reduced hard particles concentration being supplied from the settling tank 21 into the respective cylinders 11 of the engine 10 via the supply pump 22 and the fuel injection valves 23.

**[0043]** As a result, hard particles are prevented from entering in large quantity into the engine 10 and scuffing of a piston ring against a cylinder liner is prevented.

**[0044]** When the fuel tank 1 is fully evacuated, the evacuation valve 15' is closed by the switchover signal 15a' from the controller 9 and the evacuation valve 16' is kept opened by the switchover signal 16a' from the controller 9 so that the fuel evacuation is continued solely through the bottom of the fuel tank 2.

**[0045]** Then, the fuel level of the fuel tank 2 is detected by the level detector 7. When the detection signal 7a from the level detector 7 reveals that the fuel level of the fuel tank 2 under evacuation is reduced below the preset value, the evacuation valves 16' and 17 are alternately opened and closed at a predetermined time interval by the switchover signals 16a' and 17 from the controller 9 so that the fuel is evacuated alternately at the predetermined time interval from the fuel tank 2 with the fuel level reduced below the preset value and from the next fuel tank 3, the fuels being mixed together in the settling tank 21 arranged downstream, the fuel with a lowered concentration of hard particles being supplied from the settling tank 21 via the supply pump 22 and fuel injection valves 23 into the respective cylinders 11 of the engine 10. As a result, there is no fear about entering of hard particles in large quantity into the engine 10 and resultant scuffing of a piston ring against a cylinder liner.

**[0046]** Before the fuel level of the fuel tank 3 from which the fuel is finally evacuated is reduced below the preset value, the fuel is replenished to the tanks and the operations similar to the above are repeated.

**[0047]** Thus, also in the embodiment shown in Fig. 2, similarly to the embodiment shown in Fig. 1, the hard particles can be prevented from entering in large quantity into the engine 10 and scuffing of the piston ring against the cylinder liner can be prevented.

**[0048]** Alternatively, with a structure similar to that shown in Fig. 2 where the evacuation valve 15', 16' and 17 are controlled to be selectively opened and closed by switchover signals 15a', 16a' and 17 outputted from the controller 9 on the basis of the detection signals 6a, 7a

and 8a from the level detectors 6, 7 and 8, respectively, the fuels may be evacuated concurrently from the fuel tank 1 (or 2) with the fuel level reduced below the preset value and from the next fuel tank 2 (or 3).

**[0049]** Also in this case, among the plural fuel tanks 1, 2 and 3 filled with fuel, first the fuel is evacuated from the fuel tank 1 and via the evacuation line 13 of the fuel supply line 5 and is pumped by the fuel pump 12 to the settling tank 21. The fuel temporarily stored in the tank 21 is pumped by the supply pump 22 to the fuel injection valves 23 and is injected through the injection valves 23 into the respective cylinders 11 of the engine 10.

**[0050]** In this case, the evacuation valve 15' is opened by the switchover signal 15a' from the controller 9, the evacuation valve 16' being closed by the switchover signal 16a' from the controller 9, the evacuation valve 17 being closed by the switchover signal 17a from the controller 9.

**[0051]** The fuel level of the fuel tank 1 is detected by the level detector 6. When the detection signal 6a from the level detector 6 reveals that the fuel level of the fuel tank 1 under evacuation is reduced below the preset value shown by imaginary line in Fig. 2, in addition to the opened evacuation valve 15', the evacuation valve 16' is concurrently opened by the switchover signal 16a' from the controller 9, so that the fuels are evacuated concurrently from the fuel tank 1 with the fuel level reduced below the preset value and from the next fuel tank 2. As a result, the fuel with a lowered concentration of hard particles is supplied via the fuel pump 12, settling tank 21, supply pump 22 and fuel injection valves 23 into the respective cylinders 11 of the engine 10.

**[0052]** As a result, the hard particles are prevented from entering in large quantity into the engine 10, and scuffing of the piston ring against the cylinder liner is prevented.

**[0053]** When the fuel tank 1 is fully evacuated, then the evacuation valve 15' is closed by the switchover signal 15a' from the controller 9, the evacuation valve 16' being kept opened by the switchover signal 16a' from the controller 9, so that the evacuation of the fuel is continued solely through the bottom of the fuel tank 2.

**[0054]** Then, the fuel level of the fuel tank 2 is detected by the level detector 7. When the detection signal 7a from the level detector 7 reveals that the fuel level of the fuel tank 2 under evacuation is reduced below the preset value, in addition to the opened evacuation valve 16', the evacuation valve 17 is concurrently opened by the switchover signal 17a from the controller 9, so that the fuels are evacuated concurrently from the fuel tank 2 with the fuel level reduced below the preset value and from the next fuel tank 3, the fuel with a lowered concentration of hard particles being supplied via the fuel pump 12, settling tank 21, supply pump 22 and fuel injection valves 23 into the respective cylinders 11 of the engine 10. As a result, there is no fear about entering of hard particles in large quantity into the engine 10 and resultant scuffing of a piston ring against a cylinder liner.

**[0055]** Before the fuel level of the fuel tank 3 from which the fuel is finally evacuated is reduced below the preset value, the fuel is replenished to the tanks and the operations as mentioned in the above are repeated.

**[0056]** Thus, also in the case where the structure similar to that shown in Fig. 2 is used and only control of the structure is change, as in the case of the embodiment of Fig. 1, the hard particles can be prevented from entering in large quantity into the engine 10 and scuffing of the piston ring to the cylinder liner can be prevented.

**[0057]** Fig. 3 shows a third embodiment of the invention in which parts similar to those in Figs. 1 and 2 are represented by the same reference numerals and which is similar in basic construction to that shown in Fig. 1. This embodiment is **characteristic in that**, as shown in Fig. 3, the fuel supply line 5 comprises an evacuation line 13 which connects bottoms of the respective fuel tanks 1, 2 and 3 with the fuel pump 12 and the bypass line 14 branched from the evacuation line 13 downstream of the fuel pump 12 so as to guide the fuel of the fuel tank 1 (or 2) with the fuel level reduced below the preset value to an upper portion of the next fuel tank 2 (or 3); and the flow passage switchover means 4 comprises evacuation valves 15', 16' and 17 incorporated in the evacuation line 13 connected to bottoms of the respective fuel tanks 1, 2 and 3, respectively, and controlled to be selectively opened and closed such that, after the fuel is evacuated from the fuel tank 1 (or 2) with the fuel level reduced below the preset value, fuel is evacuated through a bottom of the next fuel tank 2 (or 3), a three-way valve 24 at a juncture between the evacuation line 13 and the bypass line 14 and switchable from guidance to the evacuation line 13 of the fuel of the fuel tank 1 (or 2) with the fuel level reduced below the preset value to guidance to the bypass line 14, a switchover-for-mixing valve 19, 20 incorporated in the bypass line 14 downstream of the three-way valve 24 and switchable such that, after the fuel of the fuel tank 1 (or 2) with the fuel level reduced below the preset value is guided to the upper portion of the next fuel tank 2 (or 3), fuel evacuated through the bottom of the next fuel tank 2 (or 3) is guided to the upper portion of the same fuel tank 2 (or 3); the evacuation valves 15', 16' and 17, three-way valve 24 and switchover-for-mixing valves 19 and 20 are controlled to be selectively opened and closed by the switchover signals 15a', 16a', 17a, 24a, 19a and 20a outputted from the controller 9 on the basis of the detection signals 6a, 7a and 8a from the level detectors 6, 7 and 8, respectively; after the fuel evacuated from the fuel tank 1 (or 2) with the fuel level reduced below the preset value is guided to the upper portion of the next fuel tank 2 (or 3), the fuel is evacuated through the bottom of the next fuel tank 2 (or 3).

**[0058]** In the embodiment shown in Fig. 3, among the plural fuel tanks 1, 2 and 3 filled with fuel, first the fuel is evacuated from the fuel tank 1 via the evacuation line 13 of the fuel supply line 5 and is pumped by the fuel pump 12 into the settling tank 21 where the fuel is once stored,

the fuel temporarily stored in the settling tank 21 being pumped by the supply pump 22 into the fuel injection valves 23 through which the fuel is injected to the respective cylinders 11 of the engine 10.

**[0059]** In this case, the evacuation valve 15' is opened by the switchover signal 15a' from the controller 9, the evacuation valve 16' being closed by the switchover signal 16a' from the controller 9, the evacuation valve 17 being closed by the switchover signal 17a from the controller 9, the three-way valve 24 being switched by the switchover signal 24a from the controller 9 for guidance of the fuel not to the bypass line 14 but to the settling tank 21, the switchover-for-mixing valve 19 being closed by the switchover signal 19a from the controller 9, the switchover-for-mixing valve 20 being closed by the switchover signal 20a from the controller 9.

**[0060]** The fuel level of the fuel tank 1 is detected by the level detector 6. When the detection signal 6a of the level detector 6 reveals that the fuel level of the fuel tank 1 under evacuation is reduced below the preset value as shown by imaginary line of Fig. 3, the three-way valve 24 is switched by the switchover signal 24a from the controller 9 to guidance to the bypass line 14, the switchover-for-mixing valve 19 is opened by the switchover signal 19a from the controller 9. Thus, the fuel evacuated from the fuel tank 1 with the fuel level reduced below the preset value is bypassed via the three-way valve 24 to the bypass line 14 by the activation of the fuel pump 12 and guided via the opened switchover-for-mixing valve 19 into the upper portion of the next fuel tank 2 and is mixed with the fuel stored in the next fuel tank 2.

**[0061]** When the fuel tank 1 is fully evacuated, the evacuation valve 15' is closed by the switchover signal 15a' from the controller 9 and the evacuation valve 16' is opened by the switchover signal 16a' from the controller 9, so that the fuel of the fuel tank 2 with no high concentration of hard particles being deposited on the bottom of the tank is once bypassed via the three-way valve 24 into the bypass line 14 by the activation of the fuel pump 12 and is guided through the opened switchover-for-mixing valve 19 into the upper portion of the fuel tank 2, whereby the fuel with a high concentration of hard particles remaining in the evacuation line 13 of the fuel supply line 5 is replaced by the fuel with a lowered concentration of hard particles.

**[0062]** After the fuel with the high concentration of hard particles remaining in the evacuation line 13 of the fuel supply line 5 is replaced by the fuel with the lowered concentration of hard particles, the three-way valve 24 is switched again by the switchover signal 24a from the controller 9 and the switchover-for-mixing valve 19 is closed by the switchover signal 19a from the controller 9, the fuel from the next fuel tank 2 being supplied via the fuel pump 12, three-way valve 24, settling tank 21, supply pump 22 and fuel injection valves 23 into the respective cylinders 11 of the engine 10.

**[0063]** As a result, the hard particles are prevented from entering in large quantity into the engine 10, and

scuffing of the piston ring against cylinder liner is prevented.

**[0064]** Then, the fuel level of the fuel tank 2 is detected by the level detector 7. When the detection signal 7a of the level detector 7 reveals that the fuel tank 2 under evacuation is reduced below the preset value, the three-way valve 24 is switched by the switchover signal 24a from the controller 9 into guidance to the bypass line 14 and the switchover-for-mixing valve 20 is opened by the switchover signal 20a from the controller 9. Thus, the fuel evacuated from the fuel tank 2 with the fuel level being reduced below the preset value is bypassed via the three-way valve 24 into the bypass line 14 by the activation of the fuel pump 12 and is guided through the opened switchover-for-mixing valve 20 into the upper portion of the next fuel tank 3 and is mixed with the fuel stored in the next fuel tank 3.

**[0065]** When the fuel tank 2 is fully evacuated, the evacuation valve 16' is closed by the switchover signal 16a' from the controller 9 and the evacuation valve 17 is opened by the switchover signal 17a from the controller 9, so that the fuel of the fuel tank 3 with no high concentration of hard particles being deposited on the bottom of the tank is once bypassed via the three-way valve 24 into the bypass line 14 by the activation of the fuel pump 12 and is guided through the opened switchover-for-mixing valve 20 into the upper portion of the fuel tank 3, whereby the fuel with a high concentration of hard particles remaining in the evacuation line 13 in the fuel supply line 5 is replaced by the fuel with a lowered concentration of hard particles.

**[0066]** After the fuel with a high concentration of hard particles remaining in the evacuation line 13 of the fuel supply line 5 is replaced by the fuel with a lowered concentration of hard particles, the three-way valve 24 being switched again by the switchover signal 24a from the controller 9 and the switchover-for-mixing valve 20 being closed by the switchover signal 20a from the controller 9, the fuel from the next fuel tank 3 being supplied via the fuel pump 12, three-way valve 24, settling tank 21, supply pump 22 and fuel injection valves 23 into the respective cylinders 11 of the engine 10. Thus, the hard particles are prevented from entering in large quantity into the engine 10 and scuffing of the piston ring against the cylinder liner is prevented.

**[0067]** Before the fuel level of the fuel tank 3 from which the fuel is finally evacuated is reduced below the preset value, the fuel is replenished to the tanks and the operations as mentioned in the above are repeated.

**[0068]** Thus, also in the case of the embodiment shown in Fig. 3, just like the embodiments shown in Figs. 1 and 2, the hard particles can be prevented from entering in large quantity into the engine 10 and scuffing of the piston ring against the cylinder liner can be prevented.

**[0069]** Further, in the embodiment shown in Fig. 3 where the bypass line 14 extends downstream of the fuel pump 12 to the fuel tanks 2 and 3, so that unlike the embodiment shown in Fig. 1, no return pipes from the

fuel tank 1, 2 are needed.

**[0070]** It is to be understood that a method and an apparatus for supplying fuel to a marine internal combustion engine according to the invention are not limited to the above embodiments and that various changes and modifications may be made without leaving the scope of the invention. For example, the number of the fuel tanks is not limited to three; it may be two or may be four or more.

## Claims

1. A method for supplying fuel to a marine internal combustion engine wherein the fuel stored in a fuel tank is evacuated through a bottom of the tank, is pumped by a fuel pump and is supplied via fuel injection valves into respective cylinders of the engine, which comprises providing a plurality of fuel tanks adapted for evacuation of the fuel therefrom, mixing the fuel evacuated from the fuel tank under evacuation and fuel of said other fuel tank together when a fuel level of said fuel tank under evacuation is reduced below a preset value, and supplying the mixed fuel with a lowered concentration of hard particles into the respective cylinders of the engine.
2. A method for supplying fuel to a marine internal combustion engine as claimed in claim 1, wherein fuel is evacuated through the bottom of said other fuel tank while the fuel evacuated from said fuel tank with the fuel level reduced below the preset value is guided to an upper portion of said other fuel tank.
3. A method for supplying fuel to a marine internal combustion engine as claimed in claim 1, wherein the fuel is evacuated alternately at a predetermined time interval from said fuel tank with the fuel level reduced below the preset value and from the other fuel tank, said evacuated fuel being mixed together in a settling tank arranged downstream.
4. A method for supplying fuel to a marine internal combustion engine as claimed in claim 1, wherein the fuels are evacuated concurrently from said fuel tank with the fuel level reduced below the preset value and from the other fuel tank.
5. A method for supplying fuel to a marine internal combustion engine as claimed in claim 1, wherein fuel is evacuated through the bottom of said other fuel tank after the fuel evacuated from said fuel tank with the fuel level reduced below the preset value is guided to an upper portion of said other fuel tank.
6. An apparatus for supplying fuel to a marine internal combustion engine wherein the fuel stored in a fuel tank is evacuated through a bottom of the tank, is

pumped by a fuel pump and is supplied via fuel injection valves into respective cylinders of the engine, which comprises  
 a plurality of fuel tanks,  
 a fuel supply line with flow passage switchover means switchable for fuel evacuation from said respective fuel tanks,  
 level detectors for detecting fuel levels of said fuel tanks, respectively, and  
 a controller for outputting switchover signals to the flow passage switchover means in said fuel supply line such that, upon evacuation of the fuel from any of said fuel tanks and when a detection signal from the corresponding level detector reveals that the fuel level of the fuel tank under evacuation is reduced below a preset value, the fuel evacuated from said fuel tank with the fuel level reduced below the preset value is mixed together with fuel of said other fuel tank, the mixed fuel with a lowered concentration of hard particles being supplied into the respective cylinders of the engine.

7. An apparatus for supplying fuel to a marine internal combustion engine as claimed in claim 6, wherein said fuel supply line comprises  
 an evacuation line for connecting bottoms of said respective fuel tanks with the fuel pump and  
 a bypass line branched from said evacuation line for guiding the fuel evacuated from said fuel tank with the fuel level reduced below the preset value to an upper portion of said other fuel tank, and  
 said flow passage switchover means comprises a three-way valve at a juncture between said evacuation line and said bypass line and switchable for guidance of the fuel of said fuel tank with the fuel level reduced below the preset value from the evacuation line to the bypass line,  
 an auxiliary pump incorporated in said bypass line for pumping to the upper portion of said other fuel tank the fuel guided not to the evacuation line but to the bypass line through switchover of said three-way valve,  
 a switchover-for-mixing valve incorporated in the bypass line downstream of said auxiliary pump and switchable for guidance of the fuel of said fuel tank with the fuel level reduced below the preset value to said other fuel tank, and  
 an evacuation valve incorporated in the evacuation line connected to the bottom of the fuel tank among said fuel tanks from which the fuel is finally evacuated and opened when the fuel is finally evacuated from said fuel tank.
8. An apparatus for supplying fuel to a marine internal combustion engine as claimed in claim 6, wherein said fuel supply line comprises an evacuation line for connecting bottoms of said respective fuel tanks with the fuel pump, and

said flow passage switchover means comprises an evacuation valve incorporated in the evacuation line connected to the bottoms of said respective fuel tanks and controlled to be selectively opened and closed such that the fuel is evacuated alternately at a predetermined time interval from said fuel tank with the fuel level reduced below the preset value and from said other fuel tank, said evacuated fuels being mixed together in a settling tank arranged downstream.

9. An apparatus for supplying fuel to a marine internal combustion engine as claimed in claim 6, wherein said fuel supply line comprises an evacuation line for connecting bottoms of said respective fuel tanks with the fuel pump and  
 said flow passage switchover means comprises an evacuation valve incorporated in the evacuation line connected to the bottoms of said respective fuel tanks and controlled to be selectively opened and closed such that the fuels are evacuated concurrently from said fuel tank with the fuel level reduced below the preset value and from said other fuel tank.
10. An apparatus for supplying fuel to a marine internal combustion engine as claimed in claim 6, wherein said fuel supply line comprises  
 an evacuation line for connecting bottoms of said respective fuel tanks with the fuel pump and  
 a bypass line branched from said evacuation line downstream of the fuel pump for guiding the fuel of said fuel tank with the fuel level reduced below the preset value to an upper portion of said other fuel tank, and said flow passage switchover means comprises  
 an evacuation valve incorporated in the evacuation line connected to the bottoms of said respective fuel tanks and controlled to be selectively opened and closed such that the fuel is evacuated from said other fuel tank after the fuel is evacuated from said fuel tank with the fuel level reduced below the preset value,  
 a three-way valve at a juncture between said evacuation line and said bypass line and switchable for guidance of the fuel of said fuel tank with the fuel level reduced below the preset value from the evacuation line to the bypass line and  
 a switchover-for-mixing valve incorporated in the bypass line downstream of said three-way valve and switchable such that after the fuel of said fuel tank with the fuel level reduced below the preset value is guided to an upper portion of said other fuel tank, the fuel evacuated through the bottom of said other fuel tank is guided to the upper portion of the same fuel tank.



FIG. 2

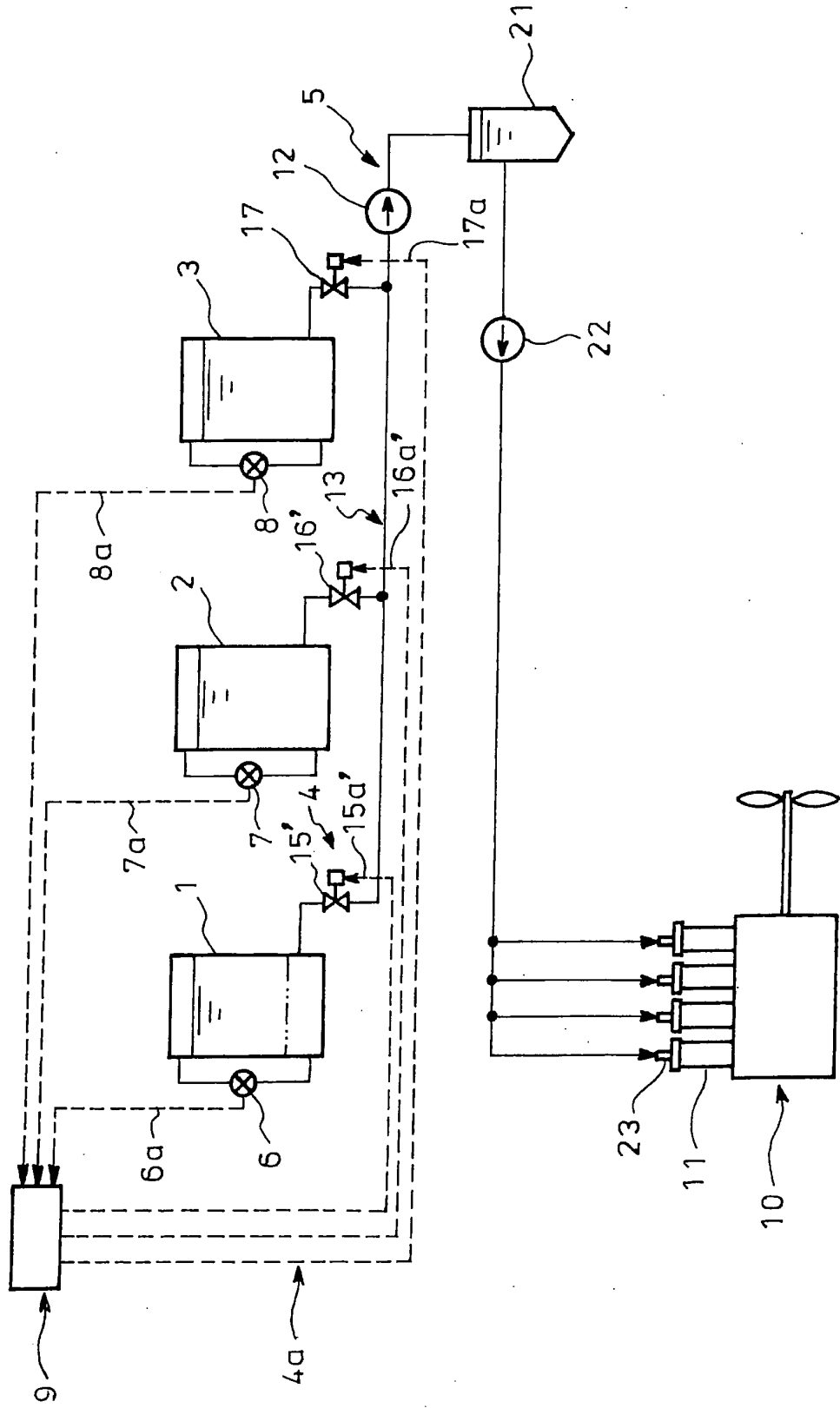
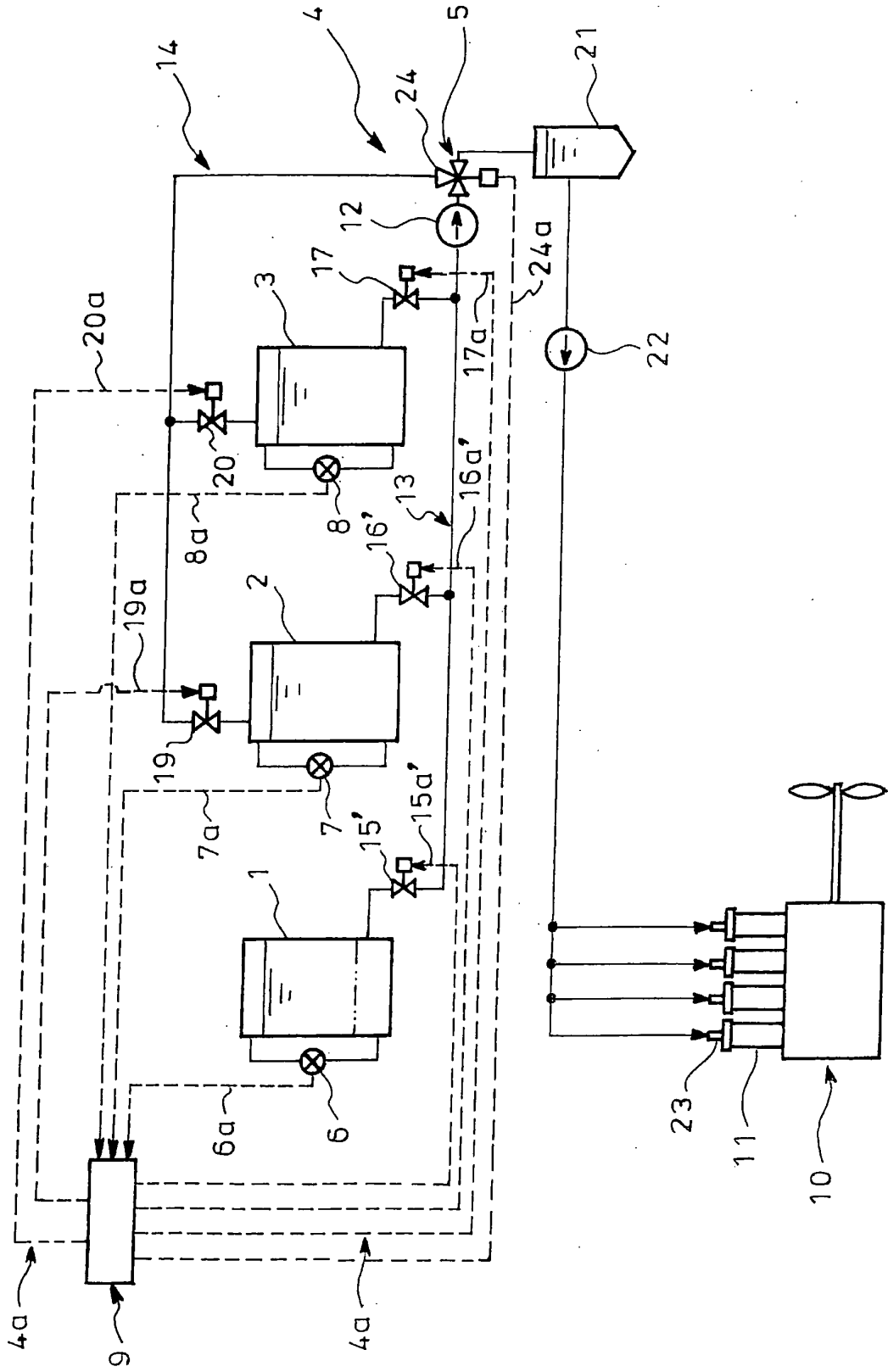


FIG. 3



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2008/000984

| A. CLASSIFICATION OF SUBJECT MATTER<br>B63H21/38(2006.01) i, F02M37/00(2006.01) i   |  |   |
|---|--|---|
| 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)<br>B63H21/38, F02M37/00   |  |   |
| Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched<br>Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2008<br>Kokai Jitsuyo Shinan Koho 1971-2008 Toroku Jitsuyo Shinan Koho 1994-2008 |  |   |
| Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  |  |   |
| C. DOCUMENTS CONSIDERED TO BE RELEVANT  |  |   |
| Category*   | Citation of document, with indication, where appropriate, of the relevant passages   | Relevant to claim No.                             |
| A   | JP 51-120588 A (Dodwell & Co., Ltd.),<br>21 October, 1976 (21.10.76),<br>Full text; all drawings<br>(Family: none)   | 1-10  |
| A   | Microfilm of the specification and drawings<br>annexed to the request of Japanese Utility<br>Model Application No. 60004/1981(Laid-open<br>No. 172159/1982)<br>(Hitachi Zosen Corp.),<br>29 October, 1982 (29.10.82),<br>Full text; all drawings<br>(Family: none) | 1-10  |
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| C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT |  |                       |
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| Category*   | Citation of document, with indication, where appropriate, of the relevant passages   | Relevant to claim No. |
| A   | JP 11-200973 A (Ishikawajima-Harima Heavy Industries Co., Ltd.),<br>27 July, 1999 (27.07.99),<br>Full text; all drawings<br>(Family: none) | 1-10                  |
| A   | JP 2004-308528 A (Heishin Pump Works Co., Ltd.),<br>04 November, 2004 (04.11.04),<br>Full text; all drawings<br>(Family: none)             | 1-10                  |

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**REFERENCES CITED IN THE DESCRIPTION**

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