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Inventor                 Kevin T. Tompkins  
                               Jerome S. Stefanko  
                               Brian L. Owsenek  
                               Lawrence W. Tomlinson  
                               Joseph A. Gavin

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3 OILY WASTE WATER TREATMENT SYSTEM

4 The present invention relates in general to filtration of an effluent from a non-chemical  
5 type of oil/water separator for further reduction in oil concentration of oily wastewater in the  
6 cleansed discharge from such separator.

7  
8 BACKGROUND OF THE INVENTION

9 Currently, oily wastewater collected in a shipboard holding tank is processed within a  
10 non-chemical, parallel-plate type of oil/water separator for removal of oil from such wastewater  
11 prior to its overboard discharge. Such processing of oily wastewater has recently become less  
12 effective because of the presence of detergents in the wastewater. Also, more stringent  
13 requirements of environmental regulations often exceed the oil reducing capabilities of the  
14 aforesaid non-chemical type of wastewater processing systems. It is therefore an important object  
15 of the present invention to provide for increased reduction in oil content of the non-chemically  
16 processed oily wastewater, despite contamination thereof and without excessive space-occupying  
17 equipment, which is of particular concern for shipboard installations.

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19 SUMMARY OF THE INVENTION

20  
21 Oily waste bilge water withdrawn from a holding tank and processed by an oil/water  
22 separator into an effluent having a reduced oil content, is further processed in accordance with the  
23 present invention by treatment within series connected membrane filtration units for overboard  
24 discharge of a substantially oil-cleansed permeate. The effluent from the oil/water separator is  
25 discharged into a feed tank for delivery to downstream filtration units via a feed pump. The feed  
26 tank level is controlled by a continuous level sensor in the feed tank and a permeate control valve  
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1 in the piping downstream of ceramic membranes forming an ultrafiltration system and  
2 interconnecting electronics. A recirculation pump induces axial flow through the membranes to  
3 reduce contaminant build-up. By use of an automatic bleed valve associated with permeate and  
4 bleed flow sensors, a high ratio of feed to waste volumes is attained. To prevent membrane  
5 fouling while the ultrafiltration system and recirculation pump are idle, an automatic valve is  
6 provided to backflush the membranes with potable water and rinse out accumulated oil and  
7 debris. Diluted oil and debris is routed by an automatic drain valve to an oily waste holding tank  
8 for future reprocessing. Pressure, flow-rate and temperature gauges as well as sampling valves  
9 provide means for monitoring operation and collecting data necessary to enable the exercise of  
10 manual and/or automatic control through selector and actuated valves to obtain proper  
11 coordinated system operations, including timely operation of the aforementioned feed,  
12 recirculation and flush pumps.  
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15 Effluent from the oil/water separator is buffered by use of a small feed tank, active level  
16 sensors and control valve to allow installation of downstream filtration membrane units without  
17 need for electrical interconnection with the oil/water separator. Automatic draining of the feed  
18 tank each operational cycle returns overflow to the holding tank. The filtration membranes are  
19 mounted in vertical relation to each other to limit exposure to floating oil. Provisions are also  
20 made for periodically timed removal of concentrated waste fed to a disposal tank.  
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### 23 BRIEF DESCRIPTION OF THE DRAWING FIGURES

24 A more complete appreciation of the invention and many of its attendant advantages will  
25 be readily appreciated as the same becomes better understood by reference to the following  
26 detailed description when considered in connection with the accompanying drawing wherein:  
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1           FIG. 1 is a block diagram of a shipboard system for disposal of bilge waste in accordance  
2 with one embodiment of the invention; and

3           FIGS. 2, 3 and 4 are flow circuit diagrams showing in greater detail different portions of  
4 the system depicted in FIG. 1.  
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6                           DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

7           Referring now to the drawing in detail, FIG. 1 diagrams a shipboard system for processing  
8 oily wastewater, such as a source 10 of bilge waste, in order to provide an overboard discharge 12  
9 having a reduced oil content. Reference numeral 14 in FIG. 1 generally denotes a section of the  
10 waste water processing system which corresponds to one being currently utilized on seagoing  
11 vessels of the U.S. Navy. In accordance with the present invention such waste water processing  
12 section 14 is associated with and modified by an ultra-filtration section 16.  
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14           With continued reference to FIG. 1, the oily waste from bilge 10 is received within a  
15 holding tank 18 in section 14 of the system from which it is delivered to a generally well known,  
16 parallel plate type of oil/water separator 20. Bulk oil thereby initially separated from the oily  
17 wastewater in accordance with prior art processing is fed to a waste oil tank 22 in section 14,  
18 while the oil reduced effluent from the separator 20 is delivered to the filtration section 16 for  
19 further reduction in oil content before disposal by return to the seawater through overboard  
20 discharge 12. Flow of the effluent from separator 20 is routed and regulated for further  
21 processing through flow control 24 of section 16 so as to direct such effluent for ultrafiltration  
22 treatment in membrane system 26 within section 16. Outflowing permeate from the ultrafiltration  
23 membrane treatment system 26 is continuously monitored for oil content through display 30  
24 during recirculation by diverter valve 27 to the holding tank 18 to which the permeate is diverted  
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2 in the event high oil levels is sensed therein. Flow regulation through flow control 24 is  
3 controlled by a control unit 29, as diagrammed in FIG. 1, which also controls operation of a  
4 potable water flush 28 for the membrane system 26 to which the flow control 24 is connected for  
5 supply of effluent thereto.

6 Referring now to FIG. 2 diagramming the flow control 24, a buffer feed tank 32 receives  
7 effluent from the separator 20 of section 14 under control of a supply valve 34. The effluent may  
8 also be diverted through selector valve 36 directly to the overboard discharge 12 and sampled  
9 through valve 38. Overflow of the oily waste holding tank 18 is indicated by level sensor 42,  
10 while sensor 44 provides a continuous level indication. Outflow of the effluent from the feed tank  
11 32 is induced by a feed pump 46 through isolation valve 48. A by-pass valve 50 controls return of  
12 effluent from pump 46 to tank 32 for protection of the pump from overheating. A temperature  
13 gauge 52 is also connected to the outflow side of the feed pump 46 for monitoring the temperature  
14 of the effluent before it flows into a duplex type of strainer 54. Pressure gauges 56a and 56b  
15 monitor effluent pressures entering and leaving such strainer. The effluent outflow from the  
16 strainer is then supplied to the ultrafiltration treatment system 26 through an isolation valve 58.

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19 Outflow of oil concentrate separated from the effluent during treatment in system 26 is  
20 conducted through a magnetic type flow gauge 60 in series with sampling and bleed valves 62  
21 and 64, to an actuated bleed control valve 66 from which the oil concentrate is supplied by  
22 outflow valve 68 to the waste oil tank 22 in section 14. A sampling valve 70 is connected  
23 between valves 64 and 66. In addition to effluent from section 14 being fed to the overboard  
24 discharge 12 through valve 38, selector valve 72 and control valve 74 supply the filtration  
25 processed permeate from the ultrafiltration treatment system 26 to the overboard discharge 12 as  
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1 diagrammed in FIG. 2. Sampling of the latter delivery of effluent from control valve 74 may be  
2 effected through valve 76.

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4 As diagrammed in FIG. 3, filtration processed permeate from the ultrafiltration treatment  
5 system 26 is delivered to the control valve 74 of flow control 24 through a valve 78 from three  
6 series connected, ceramic membrane type of filtration units 82, 84 and 86 through a conduit 80.  
7 The flow rate and pressure of the permeate in conduit 80 is monitored through flow rate and  
8 pressure gauges 88 and 90 while the flow rate of effluent outflow from each of the three filtration  
9 units are respectively monitored by flow rate gauges 92, 94 and 96. The conduit 80 is also  
10 connected by a backflush valve 98 to the water flush 28. Also, an oil cleansed permeate is  
11 delivered by the filtration unit 86 to the downstream end of a recirculation loop 100 through an  
12 isolation valve 102. The upstream end of loop 100 is connected to a recirculation pump 104, the  
13 output of which is connected by an isolation valve 106 to the inlet of filtration unit 82 through a  
14 flow rate monitoring gauge 108. Inflow of effluent from separator 20 received from isolation  
15 valve 58 of the flow control 24 is conducted in series through the filtration units under pressure of  
16 the feed pump 46 and the recirculation pump 104. A by-pass valve 110 is provided to prevent  
17 overheating of the recirculation pump 104. The pressures of inflow to the filtration unit 82 is  
18 monitored by pressure gauge 112 at the upstream end of the recirculation loop, while the  
19 downstream end connected to a drain valve 114 is monitored for pressure by a gauge 116. The  
20 effluent treated in system 26 is delivered to the waste oil tank 22 through a bleed valve 122 in  
21 series with an upstream magnetic flowmeter 123.

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25 As result of the foregoing described arrangement, oil concentrate outflow from conduit  
26 118 or 120 interconnecting the filtration units 82, 84 and 86 is fed to the waste oil tank 22 in  
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1 section 14 during timed cycles through actuated bleed valve 122, which remains open during each  
2 bleed cycle until the desired volume reduction ratio is achieved as calculated from flowmeters  
3 123 and 88. Drain valves 128 and 130 are also respectively connected to the outflow conduits  
4 118 and 120, while a drain valve 132 is connected to the outlet sides of the selector valves 124  
5 and 126 together with a pressure monitoring gauge 134. The outlets of the drain valves 128 and  
6 130 are connected to air eliminators 137 and 139. The pressure of the oil concentrate in conduit  
7 118 is monitored by gauge 136, while pressure and temperature of the concentrate in conduit 120  
8 is monitored by gauges 138 and 140. By such monitoring of pressures, flow rates and  
9 temperatures through the gauges 90, 92, 94, 96, 108, 112, 116, 134, 136, 138 and 140 as  
10 hereinbefore described, data is supplied to the monitor display 30 through which control over the  
11 system is exercised by the selector and control valves hereinbefore described.  
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14 As hereinbefore indicated, the membrane filtration units 82, 84 and 86 may also be  
15 supplied through conduit 80 with cleansing water from the water flush 28 through backflush valve  
16 98. As diagrammed in FIG. 4, the water flush 28 includes a potable water source 142 from which  
17 a backflush tank 144 is filled to a desired level as detected by level sensor 146. Water from tank  
18 144 is fed through isolation valve 148 to the inlet of a backflush pump 150 having a drain valve  
19 152 connected thereto. The outlet of tank 144 also has a pump by-pass valve 154 through which  
20 water from the tank is directly fed to actuated control valve 156 to which the outlet of pump 150  
21 is connected. The control valve 156 is selectively actuated to regulate supply of water from tank  
22 144 through a hose 158 to the aforementioned filter backflush valve 98 in the ultrafiltration  
23 treatment system 26. The temperature and pressure of the backflush water supplied to the control  
24 valve 156 from tank 144 is monitored through temperature and pressure gauges 160 and 162. The  
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1 flush tank 144 may also be filled with permeate during operation of the membrane system 26 by  
2 opening of valve 156 until the tank level indicator 146 indicates a predetermined high level.

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4 Each of the filtration units 82, 84 and 86 hereinbefore described is of the silica-coated  
5 ceramic membrane type through which effluent from the oil/water separator 20 may be processed  
6 under control of valve 34 through which the flow rate of the effluent supplied to feed tank 32,  
7 thereby interfaced with the membrane treatment system 26, is adjusted in accordance with  
8 feedback from the level sensors 42 and 44 for the feed tank 32 so as to match the effluent outflow  
9 from the separator 20 with flow through the membrane treatment system 26. Any excess flow of  
10 effluent from separator 20 drains through an overflow line 160 from feed tank 32 as shown in  
11 FIG. 2, under normal operation when the membranes of system 26 have fouled beyond the point  
12 at which separator output can be matched. The supply of effluent from the feed tank 32 to the  
13 membrane treatment system 26 at the matching flow rate is enabled by feed pump 46. The  
14 filtration membranes of units 82, 84 and 86 are furthermore backflushed between effluent  
15 processing cycles by supply of potable water or permeate thereto under pressure of pump 150  
16 from flush tank 144. Oil concentrate is removed from the filtration units 82, 84 and 86 through  
17 the selector bleed valves 124 and 126 during timed cycles for disposal by supply to the oily waste  
18 holding tank 18 by passage through the backflush valve 122, thereby maximizing the cleansing of  
19 the further processed effluent that is fed from filtration treatment system 26 through valves 78, 74  
20 and 72 to the overboard discharge 12.  
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24 The flow rate, pressure and temperature gauges disposed throughout the system as  
25 hereinbefore described allow measurement for evaluation of system performance while the  
26 sampling valves allow collection of oily waste separated effluent, filtration permeates and oil  
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1 concentrates in connection with said evaluation of system performance and prevention of  
2 improper performance by operational modification through the selector valves. For example,  
3 during normal operation the feed tank 32 monitored through sensors 42 and 44 is maintained at a  
4 preset level by feedback control of the filtration permeate valve 78, while the outflow of oil  
5 concentrate is fed to the waste oil tank 22 at a flow rate monitored by gauge 60. Such outflow  
6 may be automatically enabled through the bleed valve 66 in order to maintain a desired oil  
7 concentration factor. During manual operation of the system, the ultrafiltration treatment within  
8 system 26 in section 16 is performed simultaneously with operation of section 14 and in  
9 coordination therewith to maintain flow rate matching of inflow to and outflow from the filtration  
10 treatment system 26 as aforementioned. Cyclic operation may be automatically started by  
11 operation of feed pump 46 when the level sensor 40 detects rise in the volume of effluent in the  
12 feed tank 32 above a preset limit, while detection of a drop in effluent volume in feed tank 32  
13 below a lower limit by level sensor 44 shuts down the pump 46. Such cyclic operation may  
14 continue until overruled by operator intervention.

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18 The system as hereinbefore described is equipped with interlocks and time delays to  
19 prevent improper operation. Thus, simultaneous operation of the flush pump 150 and the feed  
20 pump 46 is prevented. Recirculation pump 104 starts after feed pump 46 following a time delay.  
21 Only during powered operation, the bleed valve 66 and flush valve 122 cycle open and closed.  
22 Opening of flush valve 122 occurs however only if the feed pump 46 is off or following a time  
23 delay after start up of the flush pump 150. The flush tank valve 156 will be opened either while  
24 the feed pump 46 is off or following a time delay after start up of the flush pump 150.  
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1 Obviously, other modifications and variations of the present invention may be possible in  
2 light of the foregoing teachings. It is therefore to be understood that

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4 the invention may be practiced otherwise than as specifically described.

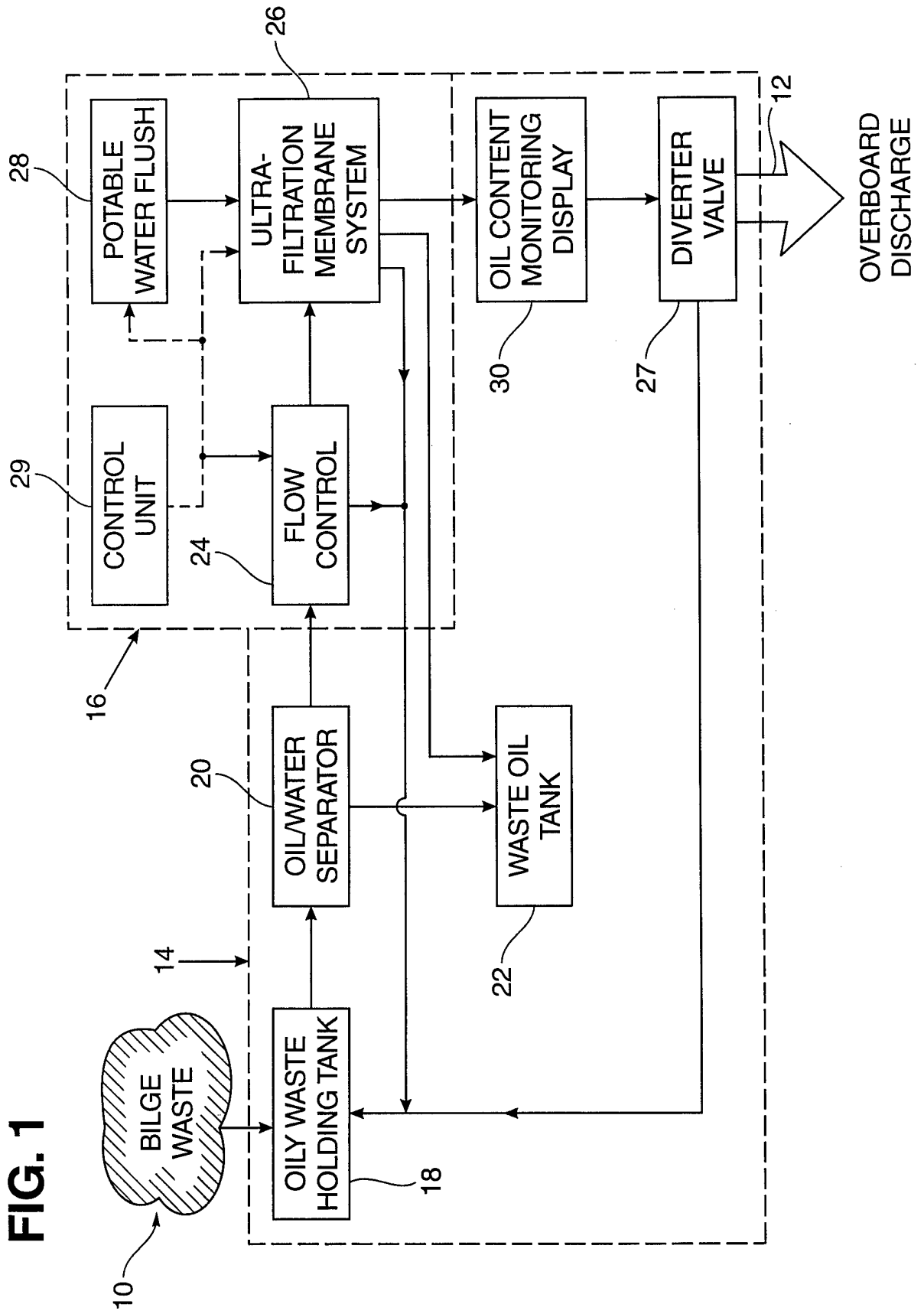
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2 OILY WASTE WATER TREATMENT SYSTEM

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4 ABSTRACT OF THE DISCLOSURE

5 The effluent outflow from a shipboard oil/water separator is further reduced in oil content  
6 by passage through ultrafiltration membranes as an added downstream treatment prior to  
7 overboard discharge. Effluent from the oil/water separator is buffered by delivery through a feed  
8 pump and use of a recirculation pump through which such downstream ultrafiltration treatment is  
9 subject to conditional flow control as well as periodic backflush cleansing of the filter  
10 membranes.  
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**FIG. 1**



**FIG. 2**

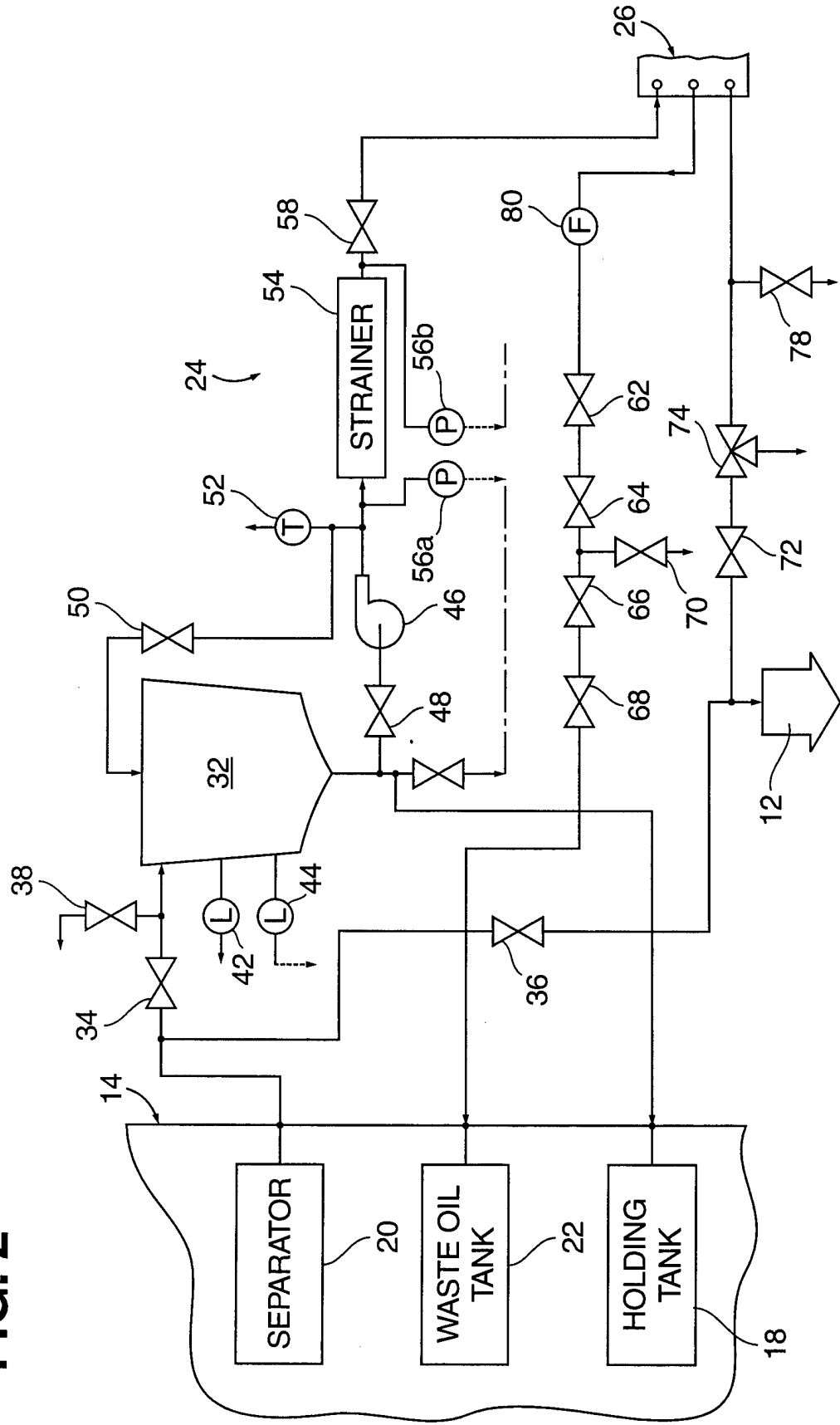
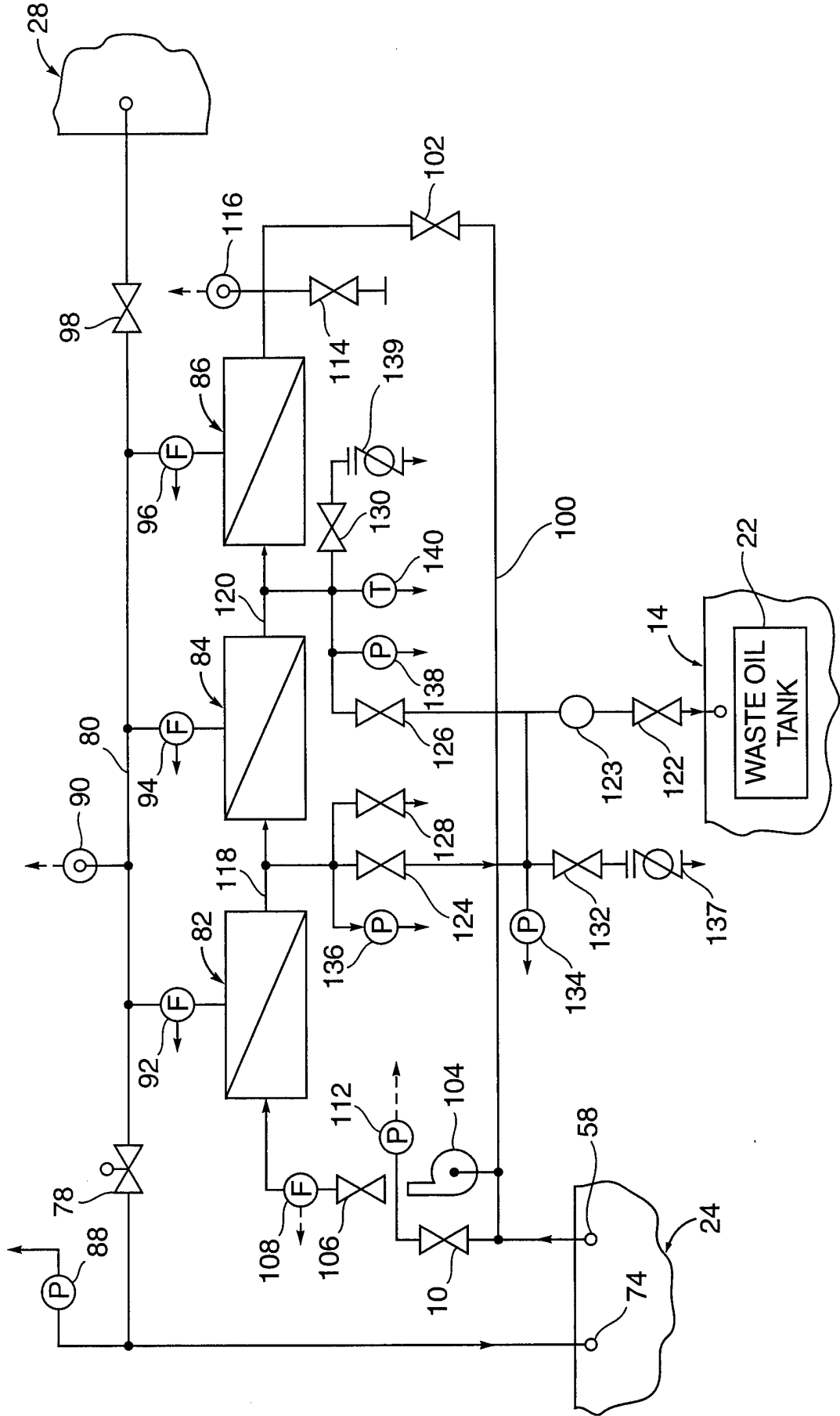


FIG. 3



**FIG. 4**

