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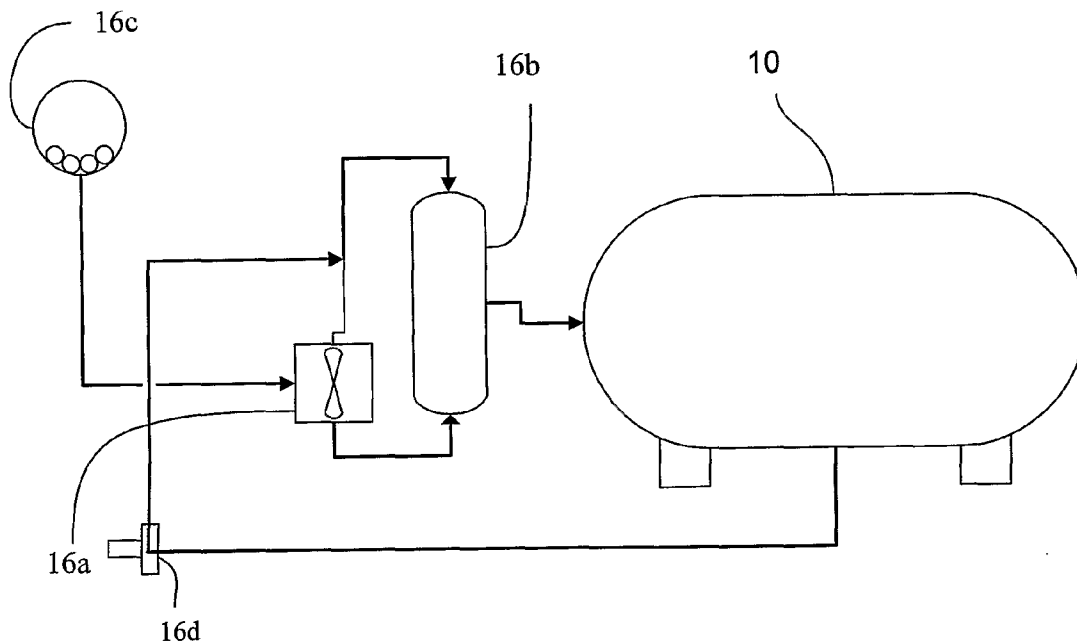
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(54) Title: COMPLETE WATER MANAGEMENT PROCESS AND SYSTEM



(57) Abstract: A complete water management system employing a plurality of tanks to control the use of potable, gray, and black water. The system is centrally controlled and continuously monitors the condition of all reservoirs, (i.e. the potable, the gray, and the black). The same controller also manages the treatment and interaction between the three reservoirs.

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COMPLETE WATER MANAGEMENT PROCESS AND SYSTEM

5 BACKGROUND OF THE INVENTION

Due to climate changes and increased demand, water shortages have become commonplace throughout the world. Even areas that have traditionally had adequate rainfall and water supplies are feeling the burden placed by the increasing demand for water. Increasing this burden is the misuse of the water that is available. For example, studies have shown that, in the U.S., as much as 80% of the potable water supplied to an average residence goes to uses that do not require potable water. This includes 40% going to toilet flushing and another 40% going to bathing. In fact, only 10% of an average residence's water use requires water meeting most public health requirements (this includes water used for drinking, food preparation, and food-prep material cleaning).

One method of lessening the demand on clean water supplies is to employ "gray-water" for those uses that do not require potable (such as toilet flushing and outdoor irrigation). As its name suggests, graywater is not as clean as potable water. Instead graywater lies on a continuum between potable water and black-water. The most common source for blackwater in the domestic setting is the toilet. However, any water that contains relatively high concentration levels of organic waste is considered blackwater. For this reason kitchen sinks, garbage disposals and dishwashers can be considered sources of blackwater. Graywater is generated from those residential water sources other than blackwater sources and can include bathing sources, bathroom sinks, washing machines (clothes).

Graywater treatment and recycling systems are not new. Graywater methods have been in use since the 1970s. Previously however, graywater has been suitable only for subsurface irrigation of non-edible landscape plants. Even with this limited scope of use the advantages are obvious. Any graywater used replaces, and conserves, potable water. The benefits cannot only be seen in the availability of potable water, but the decreased cost in a residential water budget.

Although graywater has the potential to carry pathogens, Blackwater is regarded as a much higher risk as it is a viable medium for waterborne diseases.

Blackwater also carries a high biodegradable organic carbon load that can adversely affect natural water bodies. The contaminant load of blackwater provides a ready food source for microorganisms that can deplete the oxygen from the water and cause an environmental disaster.

5 In addition to the carbon load of blackwater, there are concerns regarding the high levels of nitrogen, phosphorous, odor and particulate (solid) matter. For these reasons, the disposal of blackwater from mobile sources (*i.e.* RVs, boats, trains, cruiseships and planes) require approved collection facilities. Such facilities are often scarce and do not provide 24-hour service, increasing the risk of “the occasional”
10 transgressor disposing of the blackwater in an unauthorized fashion.

The traditional method for treating blackwater in residential buildings is the on-site treatment system, septic tank, or connecting directly to a municipal sewer line. Although these methods require little to no attention by the homeowner, they can cause significant problems when malfunctions occur. Additionally, the cost of the
15 municipality to treat the wastewater is passed to the consumer both in taxes as well as the cost (albeit reduced) for reclaimed water.

Therefore, what is needed is a complete wastewater management system than can produce a clear and disinfected product that can be readily used without fear of illness or the transmission of pathogens.

20

SUMMARY OF THE INVENTION

The instant invention provides a system whereby a user can satisfy all of his/her water consumption needs while minimizing waste of potable water.

25 The present invention includes a wastewater treatment system comprising generally of three (3) reservoirs. The first reservoir is a potable water subsystem in valved fluid communication with a potable water user source (sinks, baths, showers, etc.). The second reservoir is a gray water subsystem in valved fluid communication with a drain associated with at least one potable water user source and at least one toilet whereby water used by the potable water source passes to the gray water
30 subsystem and is used for toilet flushing. The third reservoir is a black water subsystem in valved fluid communication with at least one blackwater source whereby water passes to the black water subsystem upon use. The movement of

water through the system is controlled by a programmable logic controller (PLC). In one embodiment, a water filter is disposed between the gray water subsystem and potable water subsystem. The filter can be of any type, such as a reverse-osmosis filter.

5 In another embodiment, the graywater subsystem further comprises a water level sensor communicatively coupled to the PLC, an ORP sensor communicatively couple to the PLC for transmitting a signal responsive to the detection of a predetermined ORP level in the water, and a disinfection/oxidation loop. Water enters the disinfection/oxidation loop responsive to the detection of a predetermined ORP level
10 in the water. An oxidation source, such as an ozone generator, is placed in valved fluid communication with the disinfection/oxidation loop. This allows treatment of the water as it flows through the loop.

In another embodiment, the potable water subsystem further comprises a water level sensor, an ORP sensor communicatively coupled to the PLC for transmitting a
15 signal responsive to the detection of a predetermined ORP level in the water, and a disinfection/oxidation loop. Water enters the disinfection loop responsive to the detection of a predetermined ORP level in the water. As with the graywater subsystem, an oxidation source, such as an ozone generator, is in valved, fluid
communication with the disinfection loop.

20 In yet another embodiment, the blackwater subsystem further comprises a water level sensor, a temperature sensor, a heater, and a mixing/aeration loop. A settling unit is placed in valved fluid communication with the blackwater subsystem and graywater tank. The settling unit is chosen from the group consisting of a column and conical-bottom tank and further comprises a level sensor communicatively coupled to
25 the PLC.

In an alternate embodiment, the blackwater subsystem further comprises two (2) tanks, an oxic tank having a mixing/aeration loop and an anoxic tank having a mixing loop in valved fluid communication with the oxic tank. A settling unit is placed in valved fluid communication with the anoxic tank. As with the previous embodiment,
30 the settling unit is chosen from the group consisting of a column and conical-bottom tank and comprises a level sensor communicatively coupled to the PLC.

In yet another embodiment, a macerator pump is disposed between at least one blackwater source and the blackwater subsystem.

BRIEF DESCRIPTION OF THE DRAWINGS

- 5 For a fuller understanding of the nature and objects of the invention, reference should be made to the following detailed description, taken in connection with the accompanying drawings, in which:

Fig.1 is a perspective view of the potable water tank.

Fig. 1A is a perspective view of the disinfection loop in the potable water subsystem.

- 10 Fig. 2 is a perspective view of the graywater tank.

Fig. 2A is a perspective view of the disinfection loop in the gray water subsystem.

Fig. 3 is a perspective view of the blackwater tank.

Fig. 3A is a perspective view of the mixing/aeration loop.

FIG. 3B is a perspective view of an alternate blackwater subsystem.

- 15 Fig. 4 is a perspective view of the settling column apparatus.

Fig. 5 is a diagrammatic view of the oxic biologic process whereby organic nitrogen and ammonia are converted to nitrite and nitrate.

Fig. 6 is a diagrammatic representation of the process whereby nitrate and nitrite are reduced to atmospheric nitrogen.

- 20 Fig. 7 is a diagrammatic representation of the total water management system.

DETAILED DESCRIPTION

- In the following detailed description of the preferred embodiments, reference is made to the accompanying drawings, which form a part hereof, and within which
25 are shown by way of illustration specific embodiments by which the invention may be practiced. It is to be understood that other embodiments may be utilized and structural changes may be made without departing from the scope of the invention.

Terms

- With regard to present disclosure above and below, the following terms are to be
30 understood as follows.

Graywater – as used herein refers to any water that has been used in the home, except water from toilets or sources which generate organic waste (*i.e.* garbage disposals).

5 Blackwater – as used herein refers, generally, to water generated in toilets and garbage disposals but can include any source which generates wastewater with a relatively high concentration of organic matter.

Primary Use – as used herein refers to water use which requires water to be potable quality. Examples include drinking water, food preparation and cleaning of items used for food preparation. Although some activities, such as laundry and the like, do not require potable quality water, they are often connected to potable water sources.

Secondary Use – as used herein refers to water use in which it is not necessary for the water to be potable as long as microbial and organic constituents are low, or non-existent. Examples include toilet flushing, irrigation and the like.

15 Tertiary Water Use – as used herein refers to uses such as recycling and purification. For example, a tertiary use of blackwater would be diversion to the settling column of the present invention.

Potable Water User Source – any source wherein the user would expect, or require, at the time of use that the water be potable. Examples include showers, tubs, sinks and faucets.

Graywater User Source – any source wherein the quality of water need not be potable as long as microbial and organic constituents are low, or nonexistent. Examples include clothes washers (TDS < 1,000 ppm), irrigation, toilet flushing.

25 Blackwater Generation Source – as used herein refers to any source of blackwater. Examples include toilets and garbage disposals.

Programmable Logic Controller (PLC) – as used herein refers to any device used to automate monitoring and control of the inventive system and process.

The system of the present invention comprises three water tanks (each with a water level sensor); a potable water tank, a graywater tank and a blackwater tank. The system also includes a programmable logic controller (PLC), oxidation reduction potential sensors (ORPs), an electric heater, a temperature sensor, a settling column, contact columns, an oxygen concentrator, an ozone generator, venturis, water pumps and a power source.

Potable Water Subsystem

Fig. 1 is a perspective view of one embodiment of the present invention. This portion of the system comprises potable water tank **10**. Potable water tank **10** is equipped with; level sensor **17**, vent **11**, ORP Sensor **14**, fresh water fill line **12**, egress line **18**, drain **15**, and treated-recycled water fill line **13**. A disinfection loop is represented as a whole by the numeral identifier **16**. Disinfection loop **16** (shown in Fig. 1A), further comprises venturi **16a**, contact column **16b**, ozone generator **16c**, and pump **16d**.

Potable water enters the potable water tank **10** through the fresh water fill line **12** from any source. Typically this source will be either a municipal water facility or a well. Water can be directly pumped from potable water tank **10** through egress line **18** to any user source in the residence. Most commonly these sources will include a shower/tub, dishwashers, clothes washers and sinks or faucets. Water level sensor **17** monitors the level of the water in potable water tank **10** and communicates the information to the programmable logic controller (not shown). Drain **15**, can drain to any suitable source and most commonly will lead to a municipal sewer line or septic tank. Since only potable water is kept in tank **10**, it is possible for the drain to lead to virtually any source which can accept water. Vent **11** provides a release for any gases which could potentially develop in tank **10** (*i.e.* in case of contamination). This safety feature also prevents the tank from rupturing due to pressure as well as venting ozone from the disinfection loop. The vent is equipped with an ozone destruct unit (not shown), which converts the vented ozone gas into elemental oxygen so there are no safety issues with ozone gas being released from the tank.

Oxidation reduction potential (ORP) sensor **14** resides within potable water tank **10** and is communicatively connected to the PLC. ORP is generally measured in millivolts (mV) and provides an extremely accurate measure of the quality of water within tank **10**. As its name suggests, ORP measures the oxidizing activity of the water. Although ORP offers many advantages over other “real time” monitoring methods, such as pH monitoring, any method capable of accurately determining the quality of water in tank **10** and communicating said information to the PLC may be utilized.

Water may also enter tank **10** from a water purification and filtration unit (discussed below), that may include reverse osmosis filtration (not shown in Fig. 1), through inlet **13**. Water residing in the tank can be further purified by passing through the disinfection loop **16**. When a target ORP level is detected by the ORP sensor, the PLC activates a pump **16d** which channels the water into disinfection loop **16**. Upon activation, ozone generator **16c** feeds ozone to venturi **16a** of the disinfection loop. The water then enters the contact column **16b** allowing the oxidation reaction to take place as the ozone gas is dissolved into the water. From contact column **16b**, the water then re-enters the potable water tank. As the oxidation reaction reaches a predetermined value, the disinfection process stops and the water circulation stops as well. In one embodiment, water is sent through the disinfection loop whenever the lower limit ORP setting is reached which ensures the contents of the tank stay free of microorganisms, for continuing consumption.

15 *Graywater Subsystem*

Fig. 2 is a perspective view of one embodiment of the graywater subsystem. The graywater subsystem comprises graywater tank **20**, which is similar to potable water tank **10**. Graywater water tank **20** is also equipped with; level sensor **27**, vent **21**, ORP sensor **24**, egress line **28**, drain **25**, and treated-recycled water fill line **23**. Graywater tank **20** receives water from a graywater inlet **22** or settling column/tank inlet **29** (settling column not shown in Fig. 2). Graywater sources feeding inlet **22** can be any potable water or graywater source, such as a bathroom sink or shower drain. A disinfection/oxidation loop is represented as a whole by the numeral identifier **26**. Disinfection loop **26** (shown in Fig. 2A), further comprises venturi **26a**, contact column **26b**, ozone generator **26c** and pump **26d**. Optionally, particulate filter **26e** can be installed in the disinfection/oxidation loop.

Disinfection/oxidation loop **26** of the graywater tank works in identical fashion to that of the disinfection loop of the potable water tank **10** (discussed *supra*). After water leaves the disinfection loop and reenters graywater tank **20**, it can then be pumped through egress line **28** for a suitable use (such as flushing or irrigation). Water leaving tank **20** via the egress line **28** can travel to a blackwater use source (i.e. toilet), however, water in line **28** can also be diverted to the blackwater tank **30** (not

shown in Fig. 2). Alternatively, the graywater can also be pumped out of drain 25 where it will either leave the system or enter filtration unit 50 (Fig. 7). If the water is diverted to filtration unit 70 it can be recycled to the potable water tank 10. Water passing through the filtration system, but not meeting predetermined standards of purity, can also re-enter the graywater tank 20 through the treated-recycled water fill line 23 or blackwater subsystem 30 via inlet 32. The tank is vented in the same manner as in the potable water tank, discussed above. Ozone gas is vented through an ozone destruct unit (not shown) so no ozone is released from the tank.

10 *Blackwater Subsystem*

Fig. 3 is a perspective view of one embodiment of the blackwater system which comprises blackwater subsystem 30. Blackwater subsystem 30 is also equipped with; water egress line 33, water source inlet 32, a level sensor 37, a temperature sensor 34, an electric heater 39, and a drain 35. Blackwater subsystem 30 receives water from all blackwater user sources in the system through source inlet 32. This also includes water coming from graywater tank 20 that is diverted to blackwater subsystem 30. Water also enters the tank from the filtration unit through inlet 32. In one embodiment the blackwater in blackwater subsystem 30 is not discharged unless the tank requires maintenance. Instead, the water in blackwater subsystem 30 is circulated through the tank via a mixing/aeration loop 36 (Fig 3A). The mixing/aeration loop 36 consists of venturi 36a, solenoid valve 36b and pump 36c. While in mixing/aeration loop 36, the water is treated with bacteria and solenoid valve 36b is opened or closed by the PLC depending upon whether the mixing process is oxic or anoxic. The temperature in the blackwater subsystem is monitored by temperature sensor 34 which is communicatively coupled to the PLC.

As the water in blackwater subsystem 30 is treated, it is periodically cycled to settling unit 40 (i.e. column, vertical, or conical tank) via conduit 34 as shown in Figs. 4 and 7. Settling unit 40 is equipped with level sensor 47, which stops the cycling when the unit is full. The activated sludge settles to the bottom of settling unit 40 and a purified layer, or supernate, is formed above the sludge layer. The supernate is then transferred to graywater tank 20 via inlet 29 (Fig. 2) where the oxidation process and the disinfection process are coupled in graywater tank 20's oxidation/disinfection

loop. This supernatant layer from settling unit 40 is the only water which leaves blackwater subsystem 30. All other water is recycled from settling unit 40 to blackwater subsystem 30 via conduit 38 which connects to inlet 32. The frequency of the filling and draining of settling unit 40 is controlled by the PLC.

5 In an alternative embodiment, shown in Fig. 3B, two tanks are used to create the blackwater subsystem. In this embodiment, an oxic 30a and anoxic tank 30b are kept in valved fluid communication. In this manner, the bacteria can be kept in an optimum environment and are not harmed as the environment of a single tank is changed from oxic to anoxic.

10

Bacterial Treatment of Wastewater

Generally, the biological treatment of the wastewater is achieved in two (2) steps. In the first step (Oxic Step) the wastewater begins in a storage tank and enters a mixing loop, where it is mixed with air, or oxygen, thus ensuring that the bacteria remain in contact with the column of wastewater. A mixing loop can be any device that allows the introduction of a gas, here oxygen or air, and provides for the gas to be dissolved in water. Examples include a venturi followed by a static mixer or a simple bubble-diffuser and contact column or merely turbulent flow created upon re-entry into the holding tank 30. The water then re-enters the holding tank

20 The process whereby the organic nitrogen present in the wastewater is converted into nitrite and nitrate is delineated in Fig. 5. Organic nitrogen combines with hydrogen to form ammonia and ammonium ions. These two elements are in constant flux, and continue to change states. In the presence of water beneficial bacteria, such as *Nitrosomonas*, convert the ammonia and ammonium ions to Nitrites (NO₂). Finally, another strain of bacteria, such as *Nitrobacter*, converts the Nitrite (NO₂) to Nitrate (NO₃).

The second step (Anoxic Step) is a continuation of the biological filtration and is achieved anaerobically. The wastewater is passed through the same mixing loop but without exposure to oxygen. It is in this step that the denitrifying bacteria reduces nitrate-nitrogen produced in the oxic phase into nitrogen and nitrogen-oxide gases, which are released from the wastewater. After passing through the mixing loop the wastewater re-enters the holding tank.

30

The anoxic phase is illustrated in **Fig. 6**. Nitrate and nitrite, through microbial action, react with a reductase (any catalyst which will begin the reaction) to nitric oxide (NO). Subsequently the nitric oxide is converted to nitrous oxide (N₂O), 30, and is finally reduced to atmospheric nitrogen (N₂).

5

The Combined Systems

A schematic view of one embodiment comprising a water treatment system is provided in **Fig. 7**. Here it can be seen that potable water from tank **10** is consumed at a user source and then plumbed to graywater tank **20**. Where the potable water is consumed at a blackwater user source (here a kitchen sink), the water is transferred to blackwater subsystem **30**

To maximize efficiency of the system, a minimal amount of particulate matter is transferred to graywater tank **20**. Once in graywater tank **20** the water enters oxidation/disinfection loop **26**. Although this embodiment uses ozone, any oxidant is acceptable if used in sufficient amounts to achieve the intended result and does not leave any contaminating residue after oxidation. In this embodiment ozone (O₃) from ozone generator **26c** is fed into venturi **26a** (**Fig. 2A**). The water then enters contact column **26b** wherein the oxidation reaction occurs. From contact column **26b**, the water re-enters graywater tank **20**. ORP value is constantly monitored by the PLC. As the oxidation reaches completion and the ORP reaches a predetermined value, the oxidation process stops and water circulation through loop **26** is ceased. In alternate embodiments the water is exposed to the oxidation process at least once every 24 hours regardless of the ORP levels.

Blackwater is, logically, plumbed to blackwater subsystem **30**. It is important to note that blackwater generated at sources such as kitchen sinks originates as potable water, whereas blackwater from toilets originated as graywater from graywater tank **20**. Blackwater generated from the toilet passes through a macerator pump **60** (**Fig. 7**) before entering blackwater subsystem **30**. The macerator pump serves to crush and break the solids of the wastewater into smaller particles. The biological processes occurring in blackwater subsystem **30** remove odor from the blackwater and drastically reduces the biochemical oxygen demand (BOD). BOD is a measure of the quantity of oxygen consumed by microorganisms during the

decomposition of organic matter. BOD is the most commonly used parameter for determining the oxygen demand on the receiving water of a municipal or industrial discharge. BOD is used to evaluate the efficiency of treatment processes, and is an indirect measure of biodegradable organic compounds in water.

5 Odor, BOD, as well as the nutrients and solids in the blackwater are reduced by the sequencing computer program, run in the PLC, which alternates the environmental conditions of the blackwater subsystem (such as oxic and anoxic conditions). The nutrients of concern in domestic wastewater are nitrogen and phosphorous. The removal of these nutrients greatly depends on their chemical
10 speciation, which is dependant on the environmental conditions (oxic versus an-oxic).

 The mixing of the bacteria in blackwater tsubsystem **30** is critical to the success of the biological process. Referring now to FIG. 3(A), blackwater subsystem **30** is equipped with a mixing/aeration loop **36**. Mixing/aeration loop **36** is comprised
15 of pump **36d** that forces the blackwater through venturi **36a** and back into blackwater subsystem **30**. The venturi is used to introduce air containing oxygen) to the blackwater. Any means of introducing oxygen (O_2) is acceptable, whether it is pure oxygen or ambient air containing sufficient oxygen. In one embodiment solenoid valve **36b** is attached tventuri **36a**. If oxic conditions are desired, the PLC will open
20 valve **36b**, thus allowing air to be introduced into the blackwater flow. If an-oxic conditions are desired, valve **36b** will close and no air will be introduced. Even during anoxic conditions, however, the bacteria (or activated sludge) are mixed with the blackwater.

 In an alternative embodiment two tanks are used to create the blackwater
25 subsystem. In this embodiment, an oxic **30a** and anoxic tank **30b** are kept in valved fluid communication. In this manner, the facultative bacteria can be kept in an optimum environment and are not harmed as the environment of a single tank is changed from oxic to anoxic. Responding to a predetermined BOD value, water is transferred between the anoxic and oxic tanks. Mixing/aeration loop **36** is kept in
30 valved fluid communication oxic tank **30a** whereas the mixing loop attached to the anoxic tank **30b** (not shown) does not, as its name suggests, provide access to oxygen. This design insures that, even in the anoxic tank where oxygen is not introduced, that

the facultative bacteria are mixed with the blackwater. Anoxic tank **30b** is kept in valved fluid communication with settling unit **40**.

It will be seen that the objects set forth above, and those made apparent from the foregoing description, are efficiently attained and since certain changes may be
5 made in the above construction without departing from the scope of the invention, it is intended that all matters contained in the foregoing description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention herein described, and all statements
10 of the scope of the invention which, as a matter of language, might be said to fall therebetween. Now that the invention has been described,

What is claimed is:

1. A wastewater treatment system comprising:
 - 5 a potable water subsystem in valved fluid communication with a potable water user source;
 - a gray water subsystem in valved fluid communication with a drain associated with at least one potable water user source and at least one toilet whereby water used by the potable water source
 - 10 passes to the gray water subsystem and is used for toilet flushing;
 - a black water subsystem in valved fluid communication with at least one blackwater source whereby water passes to the black water subsystem upon use.
2. The wastewater treatment system of claim 1 wherein the system is installed on
- 15 a vehicle selected from the group consisting of RVs, boats, trains, cruiseships and planes.
3. The wastewater treatment system of claim 1 wherein movement of water is controlled by a programmable logic controller (PLC).
4. The wastewater treatment system of claim 1 wherein a water filter is disposed
- 20 between the gray water subsystem and potable water subsystem.
5. The wastewater treatment system of claim 4 wherein the water filter is a reverse-osmosis filter.
6. The wastewater treatment system of claim 1 further comprising an oxidation source.
- 25 7. The wastewater treatment system of claim 6 wherein the oxidation source is an ozone generator.
8. The wastewater treatment system of claim 3 wherein the graywater subsystem further comprises:
 - a water level sensor communicatively coupled to the PLC;
 - 30 an ORP sensor communicatively couple to the PLC for transmitting a signal responsive to the detection of a predetermined ORP level in the water; and

a disinfection/oxidation loop.

9. The wastewater treatment system of claim 8 wherein water enters the disinfection/oxidation loop responsive to the detection of a predetermined ORP level in the water.

5 10. The wastewater treatment system of claim 8 further comprising an oxidation source.

11. The wastewater treatment system of claim 10 wherein the oxidation source is an ozone generator.

12. The wastewater treatment system of claim 10 wherein the oxidation source is in valved fluid communication with the disinfection/oxidation loop.

13. The wastewater treatment system of claim 3 wherein the potable water subsystem further comprises:

a water level sensor;

15 an ORP sensor communicatively coupled to the PLC for transmitting a signal responsive to the detection of a predetermined ORP level in the water; and

a disinfection/oxidation loop.

14. The wastewater treatment system of claim 13 wherein water enters the disinfection loop responsive to the detection of a predetermined ORP level in the water.

15. The wastewater treatment system of claim 13 further comprising an oxidation source.

16. The wastewater treatment system of claim 15 wherein the oxidation is an ozone generator.

17. The wastewater treatment system of claim 15 wherein the oxidation source is in valved, fluid communication with the disinfection loop.

18. The wastewater treatment system of claim 3 wherein the blackwater subsystem further comprises:

a water level sensor;

30 a temperature sensor;

a heater; and

a mixing/aeration loop.

19. The wastewater treatment system of claim 18 further comprising a settling unit in valved fluid communication with the blackwater subsystem and graywater subsystem.
20. The wastewater treatment system of claim 19 wherein the settling unit is
5 chosen from the group consisting of a column and conical-bottom tank.
21. The wastewater system of claim 19 wherein the settling unit further comprises a level sensor communicatively coupled to the PLC.
22. The wastewater treatment system of claim 3 wherein the blackwater subsystem further comprises:
- 10 an oxic tank having a mixing/aeration loop; and
 an anoxic tank having a mixing loop in valved fluid communication with the oxic tank.
23. The wastewater treatment system of claim 22 further comprising a settling unit in valved fluid communication with the anoxic tank.
- 15 24. The wastewater treatment system of claim 23 wherein the settling unit is chosen from the group consisting of a column and conical-bottom tank.
25. The wastewater system of claim 23 wherein the settling unit further comprises a level sensor communicatively coupled to the PLC.
26. The wastewater system of claim 1 wherein a macerator pump is disposed
20 between at least one blackwater source and the blackwater subsystem.

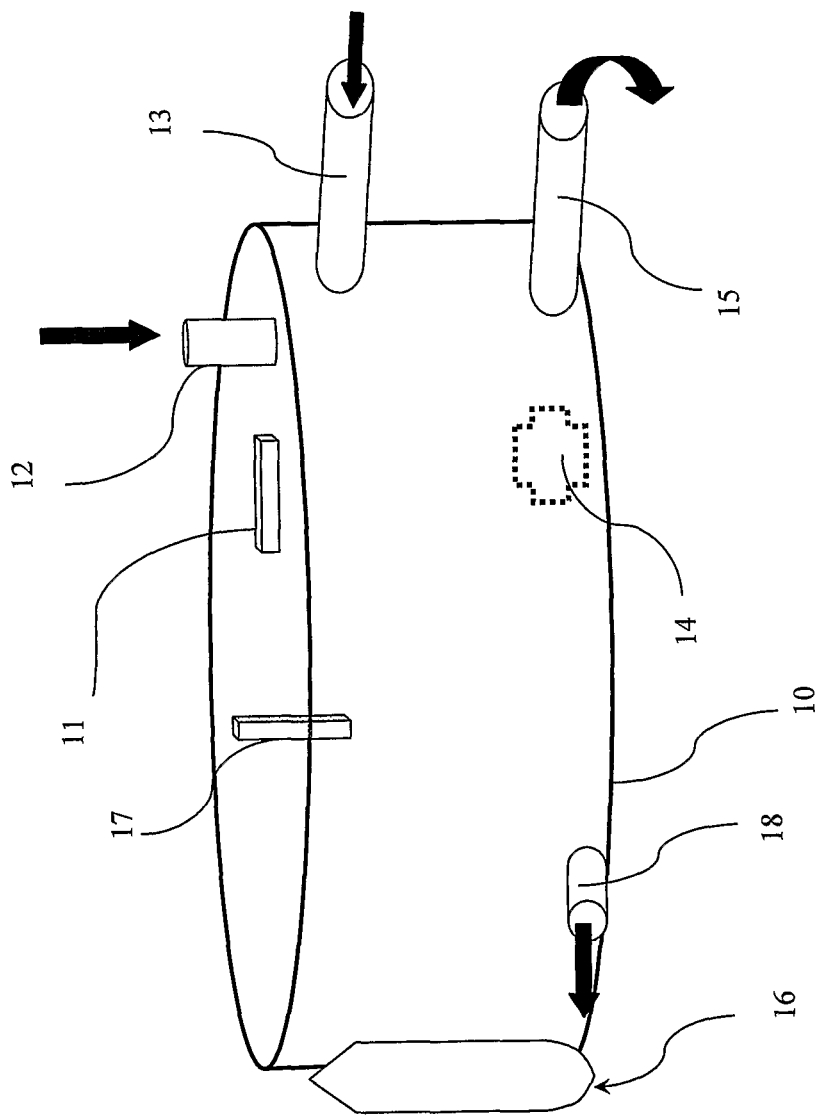


FIG. 1

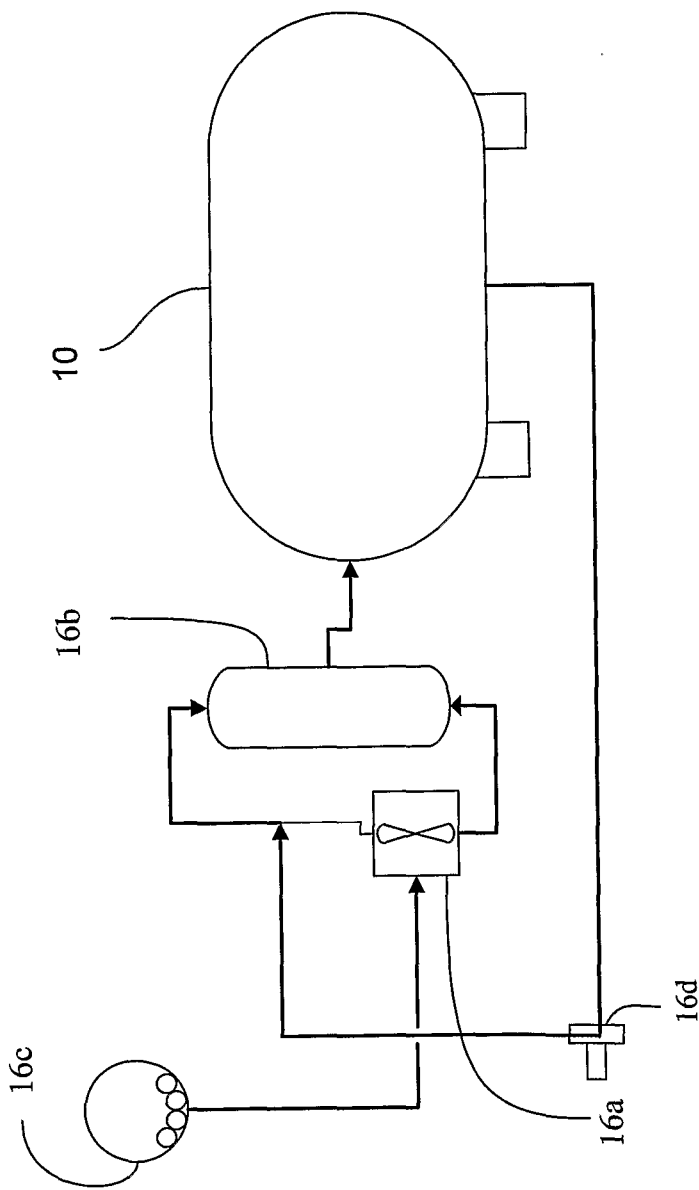


FIG. 1A

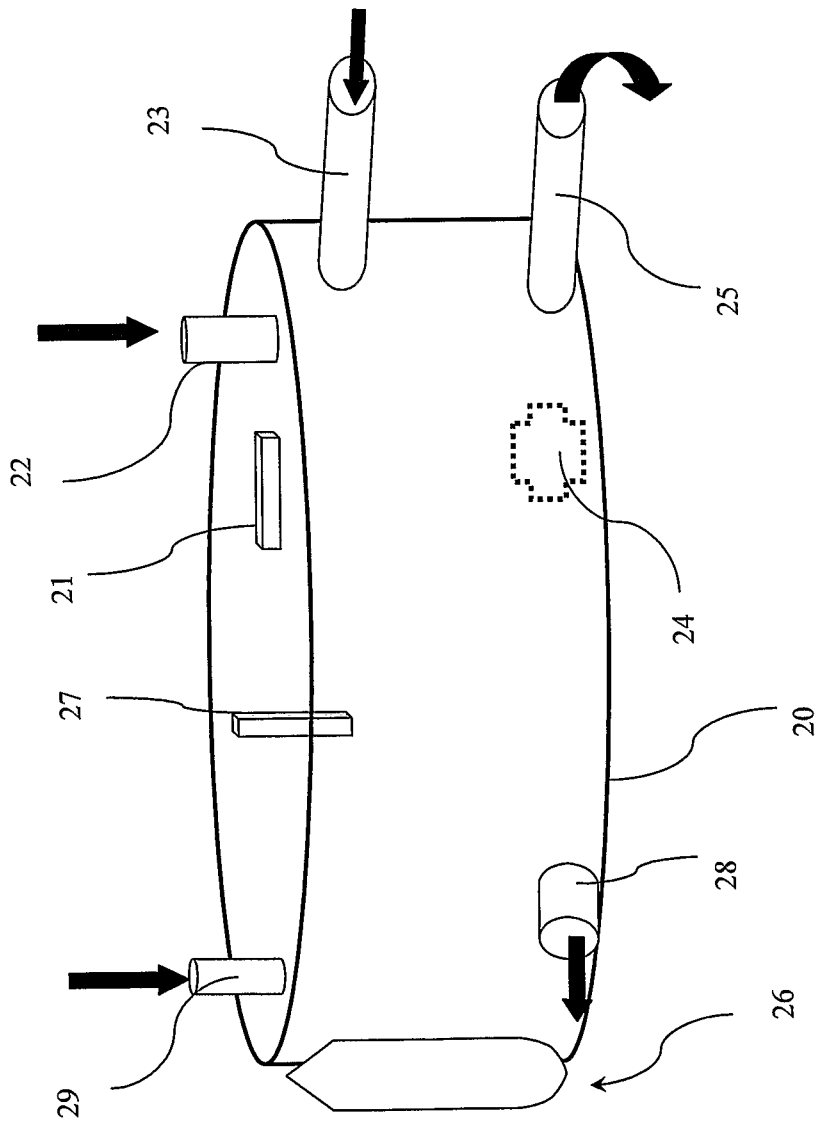


FIG. 2

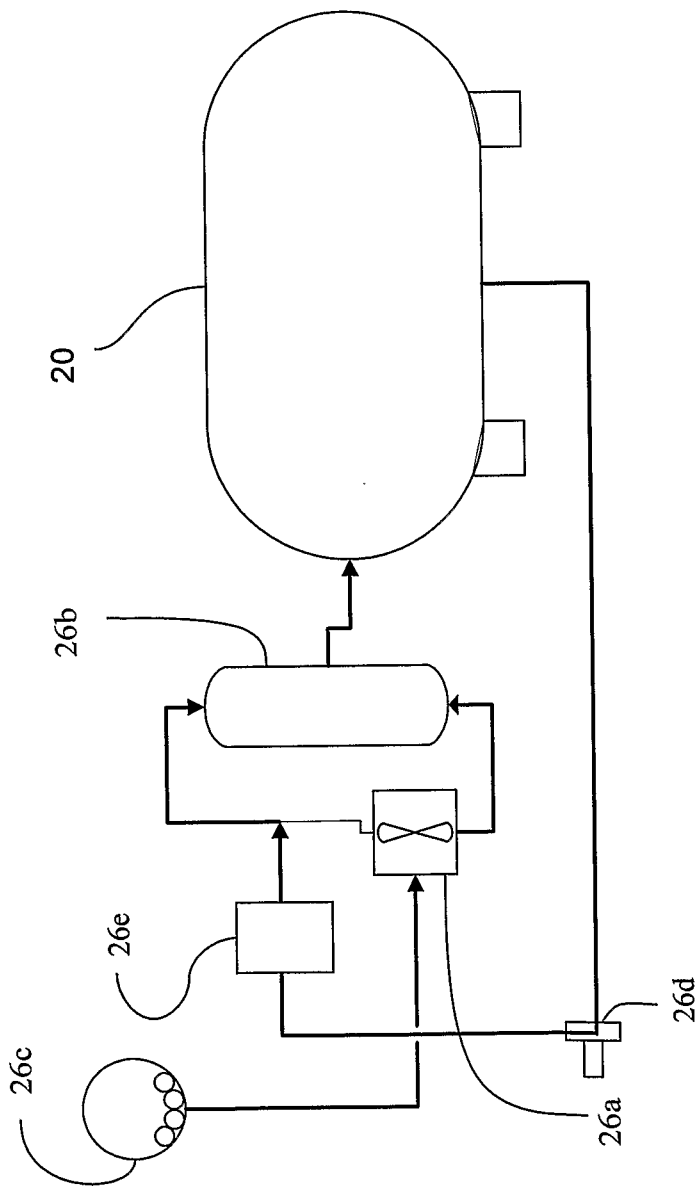
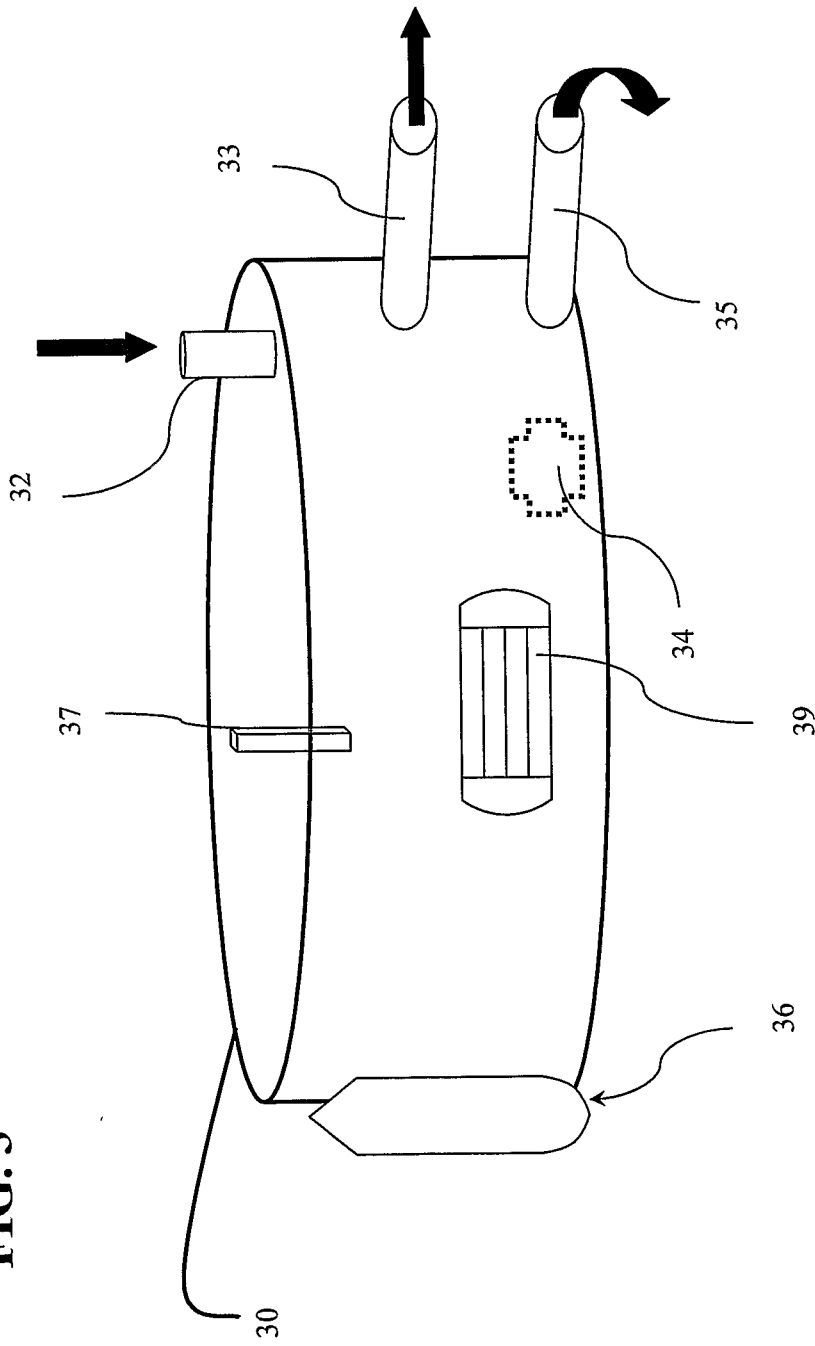


FIG. 2A

FIG. 3



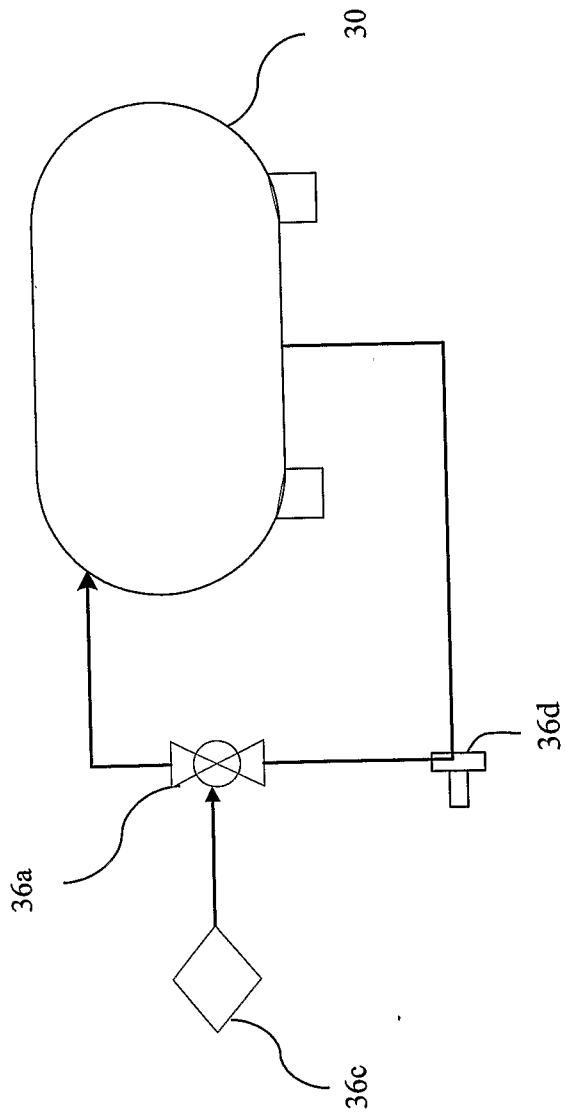


FIG. 3A

FIG. 3B

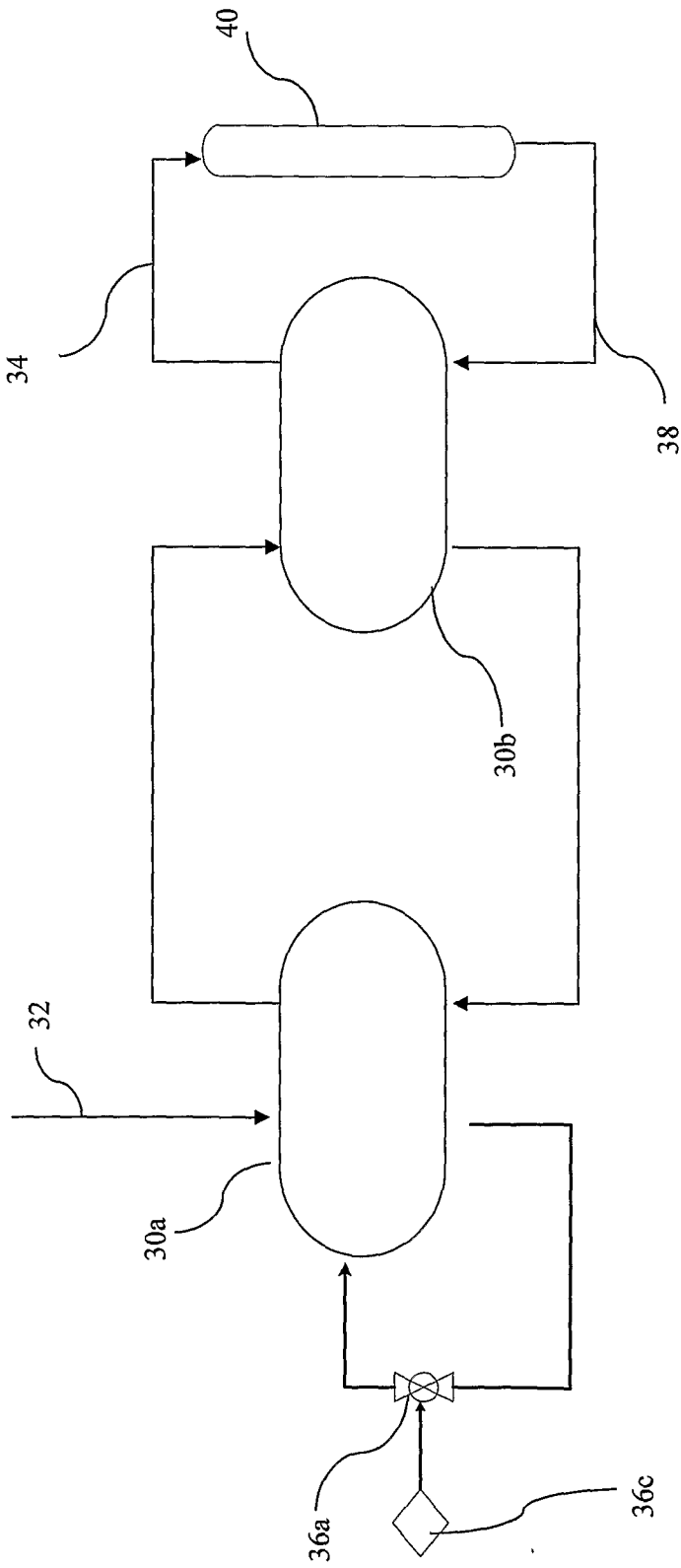
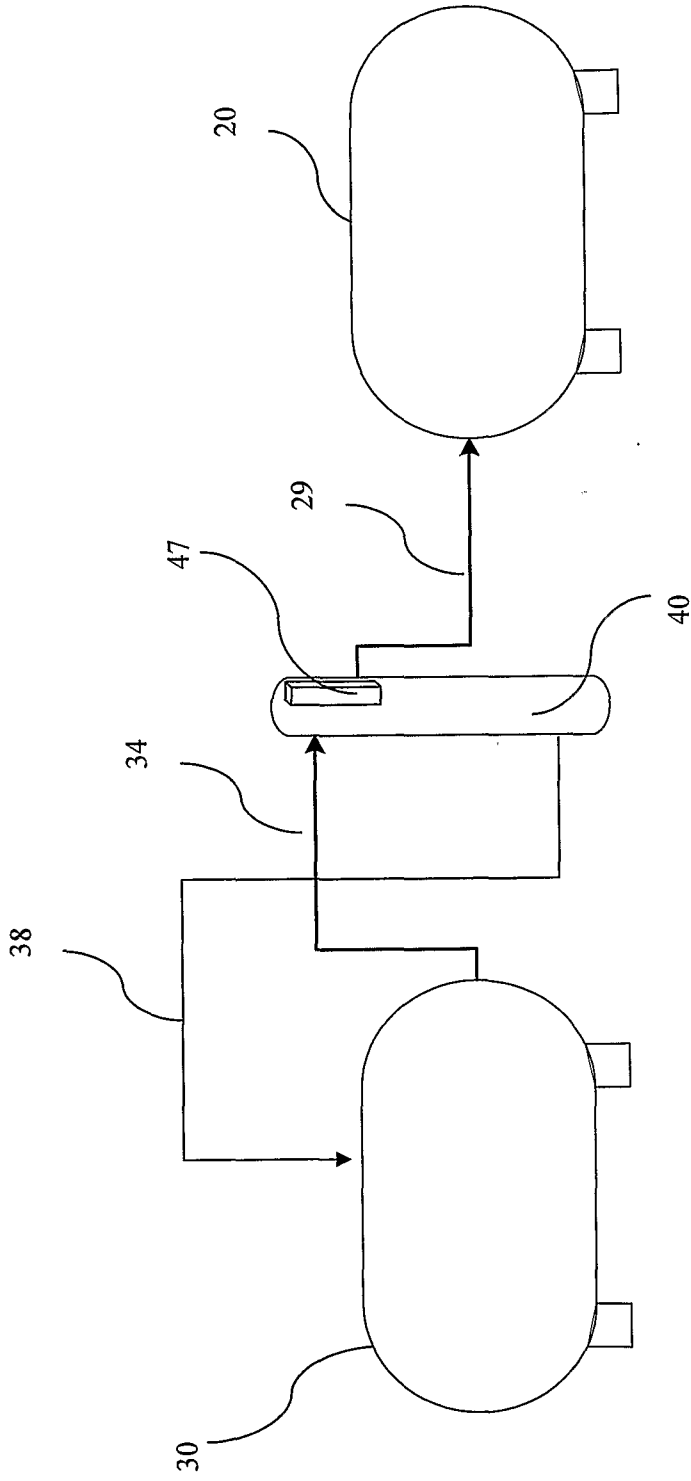


FIG. 4



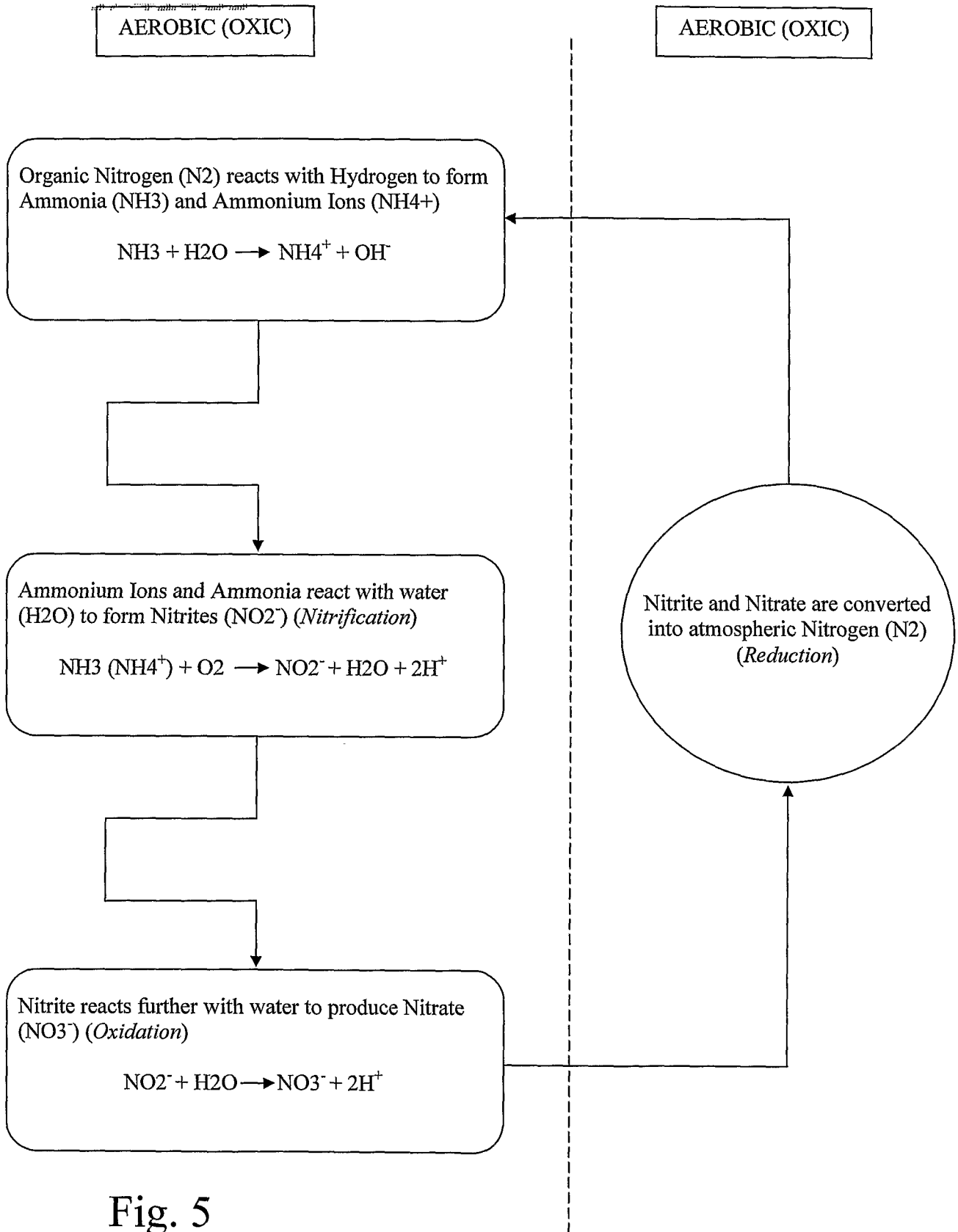


Fig. 5

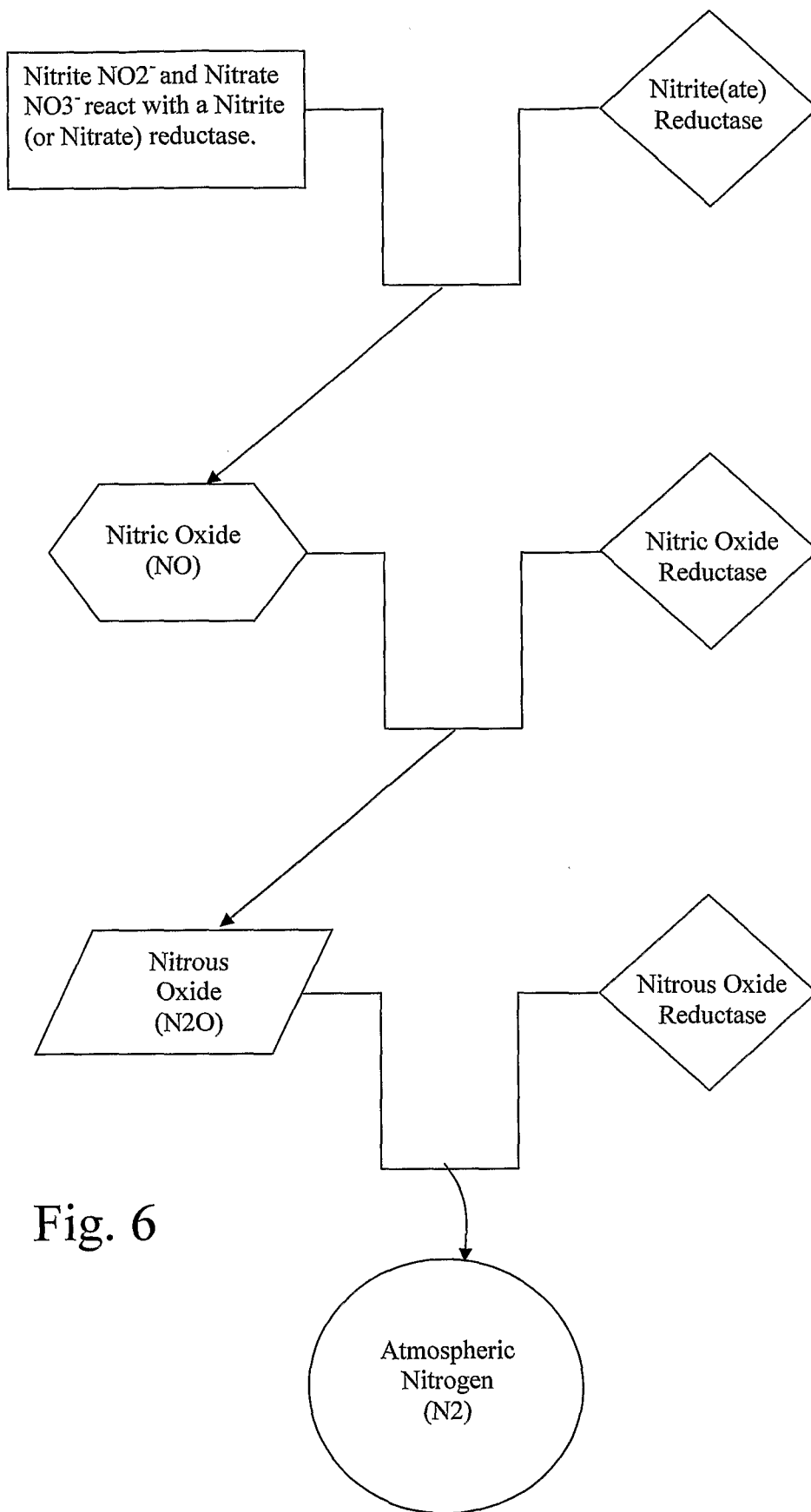
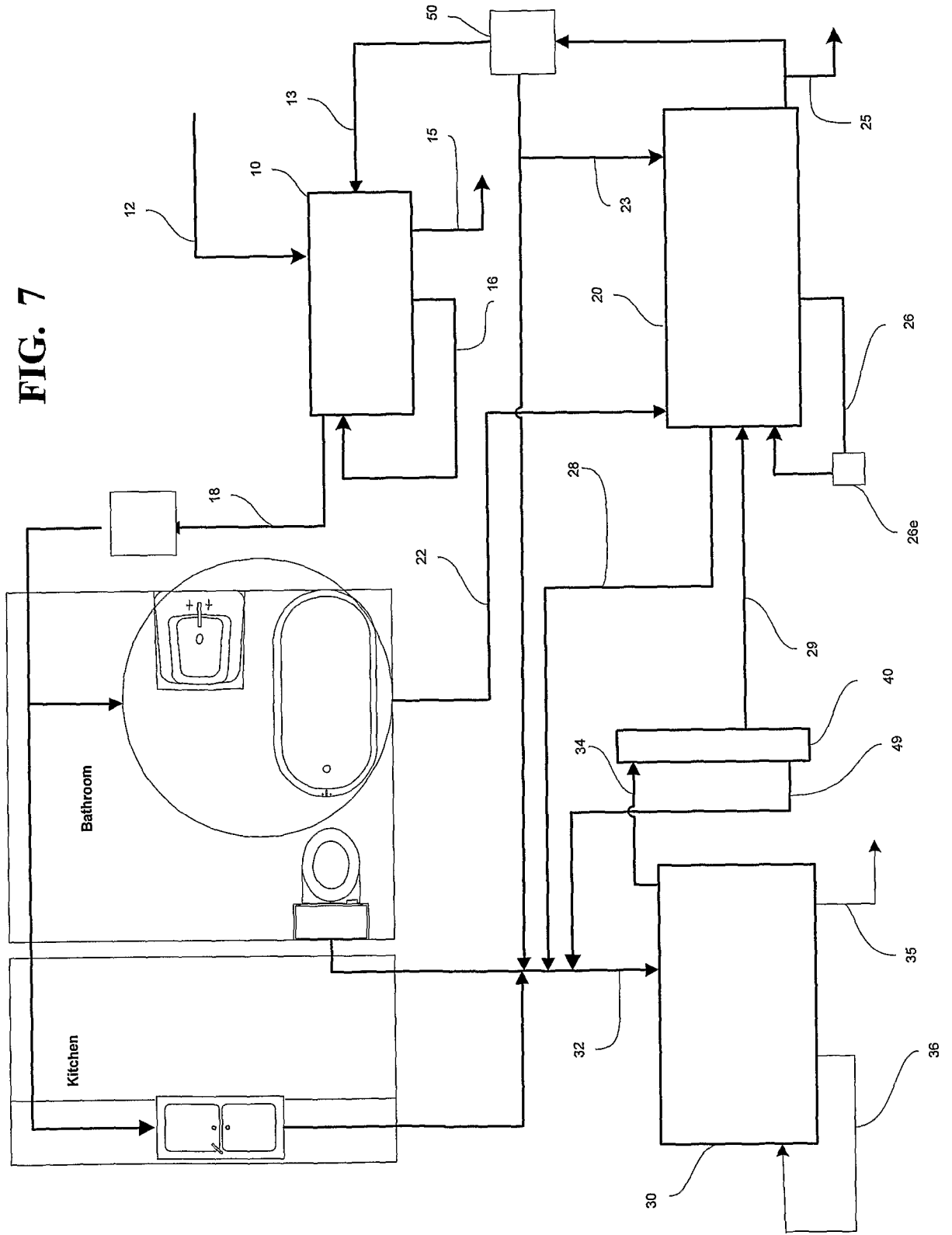


Fig. 6

FIG. 7



INTERNATIONAL SEARCH REPORT

International application No.

PCT/US06/41453

A. CLASSIFICATION OF SUBJECT MATTER

IPC: **B01D 35/14**(2006.01)

USPC: 210/86,202,241,192,96.1,151,103,149

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)
U.S. : 210/86,202,241,192,96.1,151,103,149

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)
Please See Continuation Sheet

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 6,383,369 A (ELSTON) 26 September 2001 (26.09.2001), see whole document.	1-6 ----- 7-26
Y	US 5,006,232 A (LIDGITT et al) 09 April 1991 (09.04.1991), see whole document.	19-26
Y	US 3,701,428 A (LESH) 31 October 1972 (31.10.1972), see whole document.	18
Y	US 6,398,959 A (TERAN et al) 04 June 2002 (04.06.2002), see whole document.	7-17

Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents:

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

15 June 2007 (15.06.2007)

Date of mailing of the international search report

28 JUN 2007

Name and mailing address of the ISA/US

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Jean Proctor
Paralegal Specialist

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US06/41453

Continuation of B. FIELDS SEARCHED Item 3:

EAST

search terms: blackwater greywater graywater rainwater potable ozone ozonation