United States Patent [19]

Kemper

[11] **3,922,730**

[45] **Dec. 2, 1975**

[54] **RECIRCULATING TOILET SYSTEM FOR USE IN AIRCRAFT OR THE LIKE**

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[73] Assignee: **Monogram Industries, Inc.,** Santa Monica, Calif.

[22] Filed: **Mar. 11, 1974**

[21] Appl. No.: **449,619**

[52] **U.S. Cl.** **4/10;** 4/77; 4/79; 4/115; 4/DIG. 11; 210/167

[51] **Int. Cl.²** **E03D 5/016**

[58] **Field of Search** ..... 4/1, 10, 11, 12, 17, 76, 4/79, 89, 90, 82, 115, 131, DIG. 3, DIG. 11, 77; 210/152, 167

[56] **References Cited**

UNITED STATES PATENTS

2,749,558	6/1956	Lent et al.	4/10
3,032,776	5/1962	Obert et al.	4/131 X
3,079,612	3/1963	Corliss	4/10
3,431,563	3/1969	Rascov	4/1
3,673,614	7/1972	Claunch	4/10
3,829,909	8/1974	Rod et al.	4/10
3,835,478	9/1974	Molus	4/11

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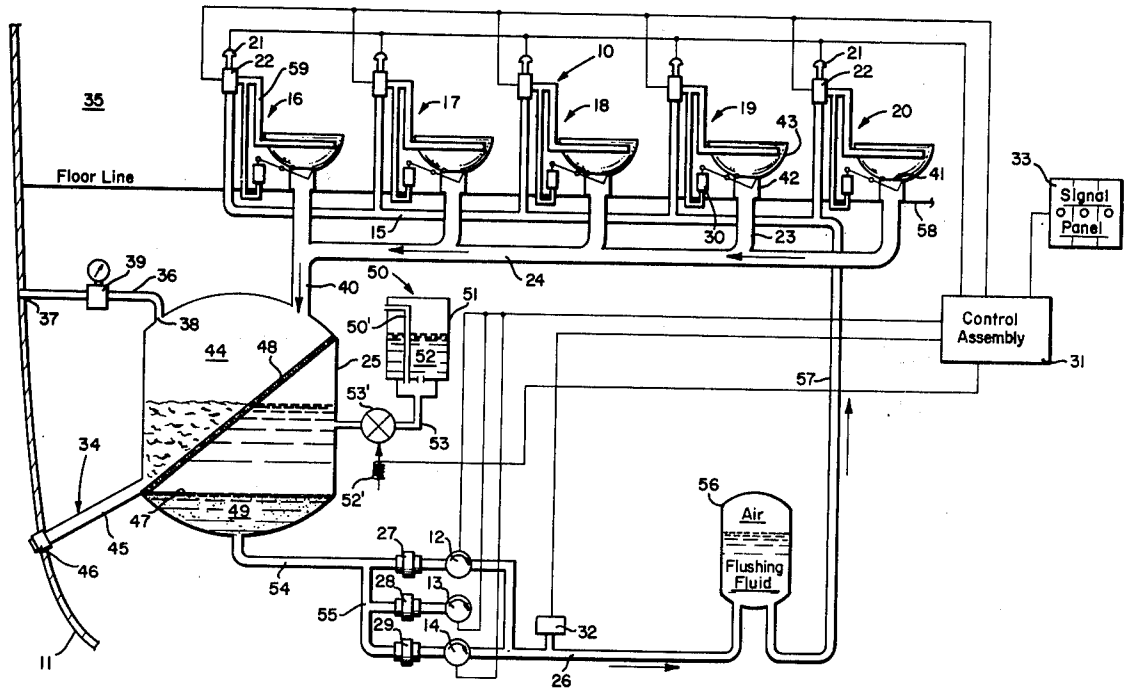
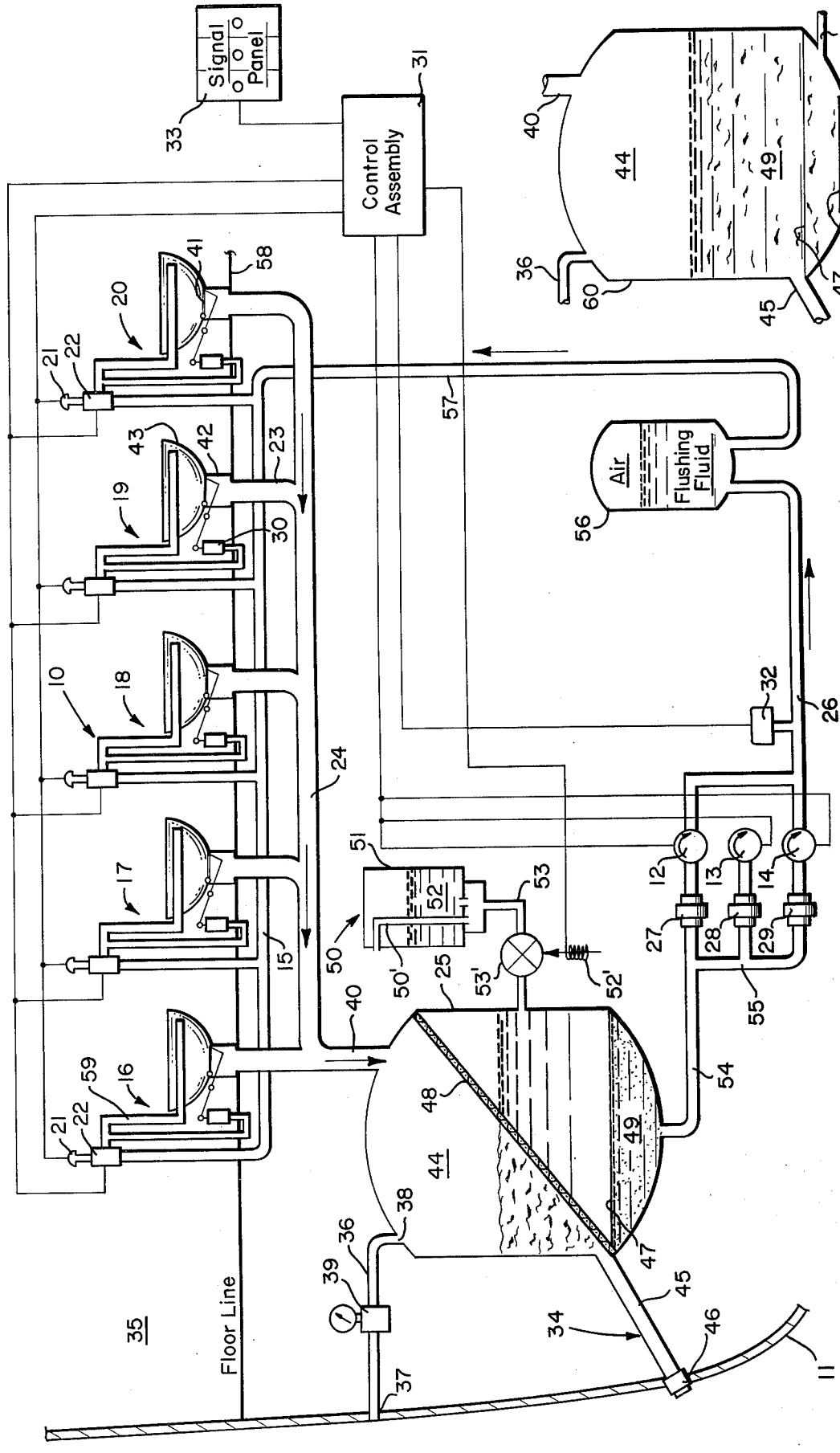
[57] **ABSTRACT**

A recirculating toilet system for use in an aircraft or the like having at least one toilet with a valve-controlled drain line and a waste tank connected to the drain line having a flushing fluid therein. A valve-controlled flushing line is in fluid communication with both the tank and the toilet and at least one pump is provided for pumping the flushing fluid from the tank to the toilet. Means are provided for forming a vacuum in the tank so that when the toilet is flushed, waste products are sucked into the tank while the toilet is flushed with the flushing fluid.

11 Claims, 3 Drawing Figures




Signal Panel
33
Control Assembly
31
Air
Flushing Fluid
56
Floor Line
35
10
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12
13
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18
19
20
21
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FIG. 1

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44
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60
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61

FIG. 2

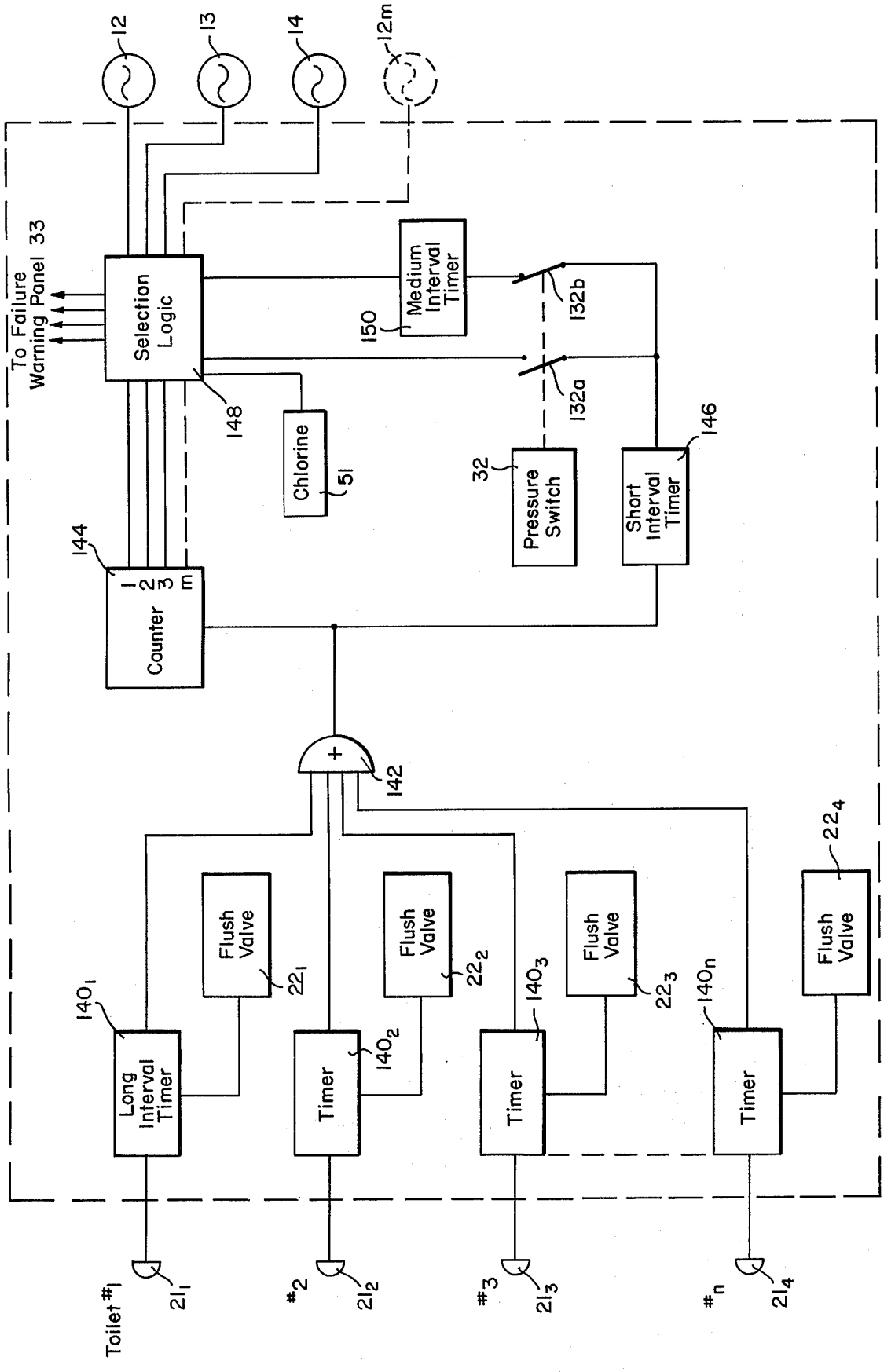
12
13
14
12m
To Failure Warning Panel 33
Selection Logic
148
Medium Interval Timer
150
132b
132a
Chlorine
51
32
Pressure Switch
Short Interval Timer
146
144
Counter
1
2
3
m
142
Flush Valve
22_1
22_2
22_3
22_4
140_1
140_2
140_3
140_n
Long Interval Timer
Timer
Timer
Timer
Toilet #1
#2
#3
#n
21_1
21_2
21_3
21_4

FIG.3

RECIRCULATING TOILET SYSTEM FOR USE IN AIRCRAFT OR THE LIKE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to a recirculating toilet system; and, more particularly, to a recirculating toilet system for use in an aircraft or the like.

2. Description of the Prior Art

Self-contained, recirculating toilet systems are currently being used on large aircrafts. Such systems generally comprise a plurality of substantially independent, recirculating toilet systems, each with its own filter and pump assembly and storage tank.

Such prior art systems have varying disadvantages, a discussion of which is presented in application Ser. No. 243,897, entitled MULTIPLE RECIRCULATING TOILET, filed by James M. Kemper on Apr. 13, 1972, and commonly assigned to Monogram Industries.

It is noted, however, that none of these prior art systems take advantage of the differential pressure created across the cabin of all recent commercial aircraft. Further, the piping from the toilets to the sewage tank in such prior art systems are relatively high in inside diameter in order to permit the sewage from the toilets to flow by gravity to the sewage tank. This results in a considerable cost and weight problem. Finally, odors are present in these prior art systems and the technology heretofore in this art did not remove all of the objectionable odors from the lavatories in which the toilets are installed.

SUMMARY OF THE INVENTION

It is an object of this invention to provide an improved recirculating toilet system for use in an aircraft or the like.

It is a further object of this invention to provide such a recirculating toilet system which removes substantially all objectionable odors from the lavatory in which the toilets of such system are installed.

It is still another object of this invention to provide a recirculating toilet system for use on an aircraft which removes human waste products from the toilets of such system without the use of gravity.

These and other objects are preferably accomplished by providing a recirculating toilet system having at least one toilet with a valve-controlled drain line and a waste tank connected to the drain line having a flushing fluid therein. A valve-controlled flushing line is in fluid communication with both the tank and the toilet and at least one pump is provided for pumping the flushing fluid from the tank to the toilet. Means are provided for forming a vacuum in the tank so that, when the toilet is flushed, waste products are sucked into the tank while the toilet is flushed with the flushing fluid.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a vertical, partly diagrammatic, view of a recirculating toilet system in accordance with the teachings of my invention;

FIG. 2 is a view of a portion of FIG. 1 showing a modification thereof; and

FIG. 3 is a block diagram, partly schematic, of the control system for the toilet system of FIG. 1.

DESCRIPTION OF THE PRIOR ART

Referring now to the drawing, a recirculating system

10 in accordance with the teachings of my invention is shown. This system 10 is particularly designed to be used in an aircraft or the like and thus a portion of the skin or body shell 11 of an airplane is shown. A plurality of substantially identical pumps 12 through 14 (three being shown) are shown as connected in parallel to a single flush manifold 15 which serves several, substantially identical toilet assemblies 16 through 20 (five being shown).

A push-button switch 21 is provided for each of the toilet assemblies 16 through 20, which controls a flush valve 22 operatively engaging the flush manifold 15 to initiate a flushing cycle. A waste return line 23 couples each toilet assembly 16 through 20 to a waste manifold 24 leading to a single holding tank 25.

Pumps 12 through 14 are commonly connected to a pressure sensing line 26, of a smaller internal diameter than flush manifold 15, which is adequate to signal pressure in the line 26 associated with the motor of each pump 12 through 14, respectively. Each of the toilet assemblies 16 through 20 is coupled to flush manifold 15 through the solenoid flush valve 22 which may be operated by an electrical control assembly 31 which will be discussed further hereinbelow. A pressure switch 32 in pressure sensing line 26 applies an electrical signal output to the control assembly 31.

Pumps 12 through 14 may be any suitable pumps, such as pumps having a pumping capacity of twenty gallons per minute and as disclosed in my aforementioned copending application Ser. No. 243,897. Thus, as disclosed in that application, in the event of failure of any of the pumps 12 through 14, a failure warning indicator panel 33 may be provided at a remote location and operatively connected to control assembly 31 so that repair crews may be alerted to repair or replace the failed pump. Conventional one-way check valves 27 through 29 may be associated with each pump 12 through 14.

As particularly contemplated within the present invention, waste removal means are provided for removing waste from toilet assemblies 16 through 20. In the exemplary embodiment, such waste removal means, indicated generally at 34, includes the inner pressurized area 35 of the aircraft itself which may be referred to as the cabin of the aircraft. Thus, all present day commercial aircraft ordinarily fly at about 12,000 feet or more and have a pressurized cabin which is higher in pressure than the pressure outside of the aircraft. Thus, the cabin may be kept at a sea level pressure, such as 18 inches of mercury. A vacuum regulator may be used to automatically create a vacuum within tank 25. That is, in addition to area 35, waste removal means 34 includes a vacuum line 36 extending to an opening 37 formed in the shell 11 of the aircraft and in communication with an opening 38 at generally the top of holding tank 25. A vacuum regulator 39 is operatively disposed in line 36 between openings 37 and 38 to maintain the interior 44 of tank 25 under vacuum.

It can be seen that waste manifold 24 is in fluid communication with both waste return lines 23 from toilet assemblies 16 through 20 and a holding tank line 40 leading into holding tank 25 at substantially the upper end thereof.

It can also be seen that a solenoid drain valve 30 is operatively connected to a diaphragm actuated flapper seal 41 adapted to selectively open and close the dis-

charge portion 42 of the bowl 43 of each toilet assembly 16 through 20.

In this manner, the interior 44 of holding tank 25 is kept under vacuum. A drain or pumpout line 45 may be in fluid communication with a portion of holding tank 25 substantially above the lowermost end thereof along line 47 but below generally the midpoint thereof. This pumpout line 45 extends to a port 46 in shell 11 so that waste solids may be removed, when desired, from the interior 44 of tank 25.

The interior 44 of tank 25 may also be diagonally divided by a screen 48, which may be of stainless steel, and have a mesh sufficient to prevent the passage therethrough of undesirable foreign matter, such as metal particles or the like, from assemblies 16 through 20 so as to prevent damage to pumps 12 through 14. It can be seen in FIG. 1 that the interior 44 of tank 25 includes a bottom section 49 below line 47. As particularly contemplated within the present invention, means are provided for killing any bacteria in the fluid returned from tank 25 and maintaining this fluid clear. In the exemplary embodiment, such means, indicated generally at 50, includes an injector 51 adapted to contain therein a predetermined quantity of chlorine 52 adapted to kill bacteria in the mixture of liquid waste and flushing fluid before the bacteria has a chance to be absorbed by the flushing fluid. This keeps the flushing fluid clear when it settles in the bottom of tank 25. Thus, injector 51 may include an injection line 53 opening into the fluid in tank 25 disposed above line 47. A suitable valve 53' controlled by a solenoid 52', may be provided in line 53 for controlling the injection of chlorine from injector 51 into tank 25. Solenoid 52' may be operatively connected to control assembly 31 and controlled therefrom to release a predetermined amount, such as 30 ml, each time a toilet assembly is flushed as will be further discussed hereinbelow. A vent 50' may be provided in injector 51. A drain line 54 extends from fluid communication with the lowermost portion of the bottom section 49 of tank 25 and to a pump manifold 55 in fluid communication with pumps 12 through 14.

A surge tank 56 which is always kept under pressure by means of pumps 12 through 14 is disposed in system 10 in fluid communication with both pressure sensing line 26 and a flush line 57 leading to manifold 15. This tank 56 may have a capacity of about 3 gallons if each pump 12 through 14 is of a 20 gallons per minute capacity. The outlets or discharge portions 42 of bowls 43 are mounted within the floor 58 of the aircraft.

In operation, it can be seen that system 10 is designed to take advantage of the differential pressure across the cabin of the aircraft in which it is installed. The pressure within area 35 of the aircraft is greater than the pressure outside of the aircraft. The sewage or holding tank 25 is thus exposed to the atmosphere outside of the aircraft by means of vacuum line 36, regulator 39 regulating the vacuum formed in the interior 44 of tank 25 as discussed hereinabove.

In a normal prior art waste disposal system, the waste products from bowls 43 must flow by gravity to tank 25. In this system 10, as each flush valve 30 is activated to open its respective seal 41, the combination of the pressure in the aircraft cabin and the vacuum in the tank 25 results in a tremendous suction taking place, which draws the waste products within bowl 43 through discharge portion 43, into manifold 24 and then into holding tank 25. This tremendous suction also sucks and thereby removes all undesirable odors in the lavatory in which toilet assemblies 16 through 20 are installed.

Since suction rather than gravity is used to empty bowls 43, the piping from bowls 43 to tank 25 may be significantly less in internal diameter than known prior art piping, as for example, piping having an internal diameter of about 1½ inches compared to prior art piping having an internal diameter of about 4 inches. This results in considerable cost and weight savings. Also, when flush valves 30 close seals 41, since tank 25 is in communication with the outside of the aircraft, no undesirable odors can enter the lavatory wherein assemblies 16 through 20 are installed.

Tank 25 is initially charged with a suitable flushing fluid that is not soluble in waste products, in this embodiment of the invention, a flushing fluid having a specific gravity at 20° C. higher than the specific gravity of the waste products, i.e. higher than 1.0. Thus, as shown in FIG. 1, bottom section 49 of tank 25 holds the flushing fluid therein and this fluid covers substantially the bottom of tank 25 to a preferable depth of about four inches.

Also, as shown, screen 48 filters out foreign matter onto one side of the interior 44 of tank 25 and the waste products (e.g., urine, human waste solids, and the flushing fluid) on the other. The mixture of solids, urine and flushing fluid settles so that the flushing fluid is below the urine due to its higher specific gravity. Of course, port 46 permits tank 25 to be cleaned out when desired.

Thus, when a flush cycle is to be initiated at a toilet assembly, the appropriate push button switch 21 is activated signalling the control assembly 31. As discussed in my co-pending application Ser. No. 243,897, one of the pumps 12 through 14 is then selected and power is applied to its motor. If operable, the selected pump will begin pumping. The fluid is pumped into line 26 and enters surge tank 56 which feeds fluid therefrom through flush line 57 leading to flush manifold 15. The fluid pressure in manifold 15 will rise. The solenoid flush valve 22 corresponding to the selected push button switch 21 is also energized to open.

Thus, as the fluid pressure line 26, flush manifold 15 and flush line 57 increases, pressure switch 32 is operated signalling to control assembly 31 that the pressure has reached a predetermined minimum. The fluid is then applied to the appropriate toilet assembly 16 through 20 through the open flush valve 22 and into a flushing pipe or line 59 opening into the top of each bowl 43 to thereby flush the interior of the bowl.

The pressure sensing switch 32 operates the motor in the selected pump to maintain the pressure in the flush manifold 15 below a preselected maximum.

Control assembly 31 may include a timing circuit therein — to be discussed further hereinbelow — to maintain the flush valve 22 open for a timed flushing interval. At the expiration of that interval, the flush valve 22 is closed and the pump motor of the selected pump is de-energized. The operation of the various pumps if one or more fails to operate or if a second button switch 21 is activated is described in detail in my co-pending application Ser. No. 243,897, the pertinent subject matter therein being incorporated herein by reference.

Drain valves **30** are operatively connected to flushing line **59** and are opened upon the opening of flush valve **22** to thereby open flapper seals **41.** Since the interior **44** of tank **25** is under vacuum as heretofore described, the waste products within bowls **43** are immediately sucked into tank **25** to again initiate the discharge portion of system **10.**

Although a flushing fluid having a specific gravity greater than **1.0** has been disclosed, water, which has a specific gravity of **1.0,** may be used as the flushing medium. This is shown in FIG. **2** wherein like numerals refer to like parts of FIG. **1.** Thus, tank **60** is identical to tank **25** except that a screen **61** may be disposed in bottom section **49** and above the inlet of drain line **54** to screen the solids out of the mixture of urine, water and solids.

If water is used as the flushing fluid, a predetermined amount of chlorine is preferably injected along with the water since water will absorb bacteria and oil will not. That is if an oil is used as the heavier than water flushing fluid, it is well known that bacteria will not grow in oil. If water is used as the flushing fluid, chlorine is injected along with the water to kill any bacteria therein. The filtering medium will remove any solid material and thus purify the urine in the urine-water mixture.

A control circuit for operating system **10** of FIGS. **1** and **2** is shown schematically in FIG. **3.** FIG. **3** has been generalized to cover a system having N toilet assemblies and M pumps. This is indicated by applying to the reference numerals of the several switches **21** a subscript **1** through *n*. Similarly, the flush valves **22** are also suitably subscripted **1** through *n*.

Connected to each push button **21,** is a relatively long, interval timer circuit **140.** The long timer circuit **140** is intended to be energized for a predetermined, adjustable time interval and provides a continous output during the timed interval. One output of the timer circuit **140** is applied to energize the flush valve **22** and a second output is applied through an or circuit **142,** which applies its output to a counter **144** and to a second, relatively short, interval timer **146.**

The or circuit **142** receives substantially similar inputs from each of the long interval timers **140** and provides a single output to the remaining elements of the control circuit **31.**

The counter **144** may be a ring counter or any other conventional, addressing circuit which sequentially selects, in turn, M different output lines, all of which are applied to a selection logic circuit **148** which ultimately determines which of the M pumps **12, 13, 14** and **12*m*** to energize.

The output of the short interval timer **146** is applied on a first line through a normally closed set of switch contacts **132*a*** to the selection logic circuit **148,** and, on a second line through a second set of normally closed switch contacts **132*b***, to a "medium" interval timer **150.** The output of the medium interval timer is also applied to the selection logic block **148.**

The normally closed switch contacts **132*a*** and **132*b*** are directly controlled by the pressure switch **32** which, in this embodiment, is arranged to maintain switches **132*a*** and **132*b*** in the closed configuration so long as the pressure detected is less than a preset magnitude. When the prssure exceeds the limit, the two switches **132*a*** and **132*b*** are opened, interrupting both circuits to the selection logic circuit **148.**

As is well known in the design and construction of data processing equipment, the operation of the control circuit **31** may be represented by a series of logical equations which define the conditions under which an output is provided. Once these equations have been formulated, it is then routine to design the appropriate structural elements that operate in accordance with these logical equations.

In operation, it will be seen that as a push button **21** is actuated, the relatively long timer **140** is energized, which times the flush cycle. A counting impulse is applied to the counter **144** to select one of the pumps. The selection is signalled on the appropriate output line to the selection logic block **148,** which immediately energizes the selected pump, injects chlorine from injector **51** into tank **25,** and removes flushing fluid from tank **25** and pumps it through reservoir **56.**

The relatively short interval timer **146** is energized for an interval which is believed adequate to permit the selected pump to come to full pressure in the line. The pressure switch **32** switch contacts **132*a*** and **132*b*** will be opened by the pressure increase and at the time that a signal output is provided by the short interval timer **146,** the circuit will be open.

If the pressure in the line is not adequate to open switch contacts **132*a***, 132*b*, then a signal is applied by the timer **140** to the selection logic **148** and to the medium length timer **150.** The selection logic **148** then energizes a second motor. If the pressure in the line is still insufficient to open the switch contacts **132*a***, 132*b*, then the output of the medium interval timer **150,** when applied to the selection logic **148,** energizes the third motor of the group through the circuitry of the selection logic **148.**

During a flush cycle, if the pressure drops sufficiently to reclose the switch contacts **132*a***, 132*b*, a second pump is immediately energized, and if pressure is not restored within the interval timed by the second timer **150,** a third pump is energized.

It is not believed essential to describe the detailed logic required to select the appropriate failure warning lights in panel **33.** It will be obvious to those skilled in the art that the circumstances dictating the lighting of the failure lamps can be easily expressed in logical terms which can be simply mechanized.

The successive energization of more than one push button **21** will not affect the state of the counter **144** so long as a pump is running. However, as soon as the latest flush cycle is concluded, and the pumps deenergized, the next energization of a push button **21** will advance the counter **144.**

It can be seen that I have described a recirculating toilet system which is particularlay suited to take advantage of the pressurized cabin of an aircraft or the like. This system removes all odors from the lavatory in which the toilets of the system are installed when flushing such toilets with a flushing fluid.

I claim as my invention

1. A recirculating toilet system for use in a pressurized cabin of an aircraft or the like comprising:

at least one toilet assembly disposed in said cabin having a valve-controlled drain line;

a waste tank under vacuum operatively connected to said drain line having a pressure in its interior at a lesser pressure than the exterior pressure at the toilet assembly;

vacuum controlling means associated with said tank for controlling the vacuum within the interior of the tank;

a valve-controlled flushing line communicating with both the interior of said tank and said toilet assembly; and

at least one pump disposed in said flushing line having an inlet in fluid communication with the interior of said tank and an outlet in fluid communication with said toilet assembly.

2. The system of claim **1** wherein a pressurized surge tank having a portion of a flushing fluid therein is in selective fluid communication with the outlet of said pump.

3. The system of claim **2** including pressure response means associated with said pump and said surge tank adapted to respond to fluid pressure in said system to maintain a predetermined pressure at said toilet assembly.

4. The system of claim **1** wherein a plurality of toilet assemblies and pumps are provided, each of said pumps being controllable volume pumps and means associated with each of said pumps adapted to respond to fluid pressure in the system to maintain a predetermined system pressure, said pumps being connected to parallel to supply fluid to the toilet system, fluid pressure sensing means connected to the toilet system for providing a first signal when sensed fluid pressure is less than a predetermined magnitude;

control means, connected to said pumps and said pressure sensing means, operable in response to applied first signals for energizing one of said pumps for increasing the flow of fluid into the toilet system;

a switch at each of the toilet assemblies connected to said control means, said control means being responsive to switch actuations for energizing one of said pumps, said control means being further operable in response to said first signals for energizing the other of said pumps.

5. In the system of claim **1** wherein a flushing fluid having a specific gravity greater than the specific gravity of water is disposed in said waste tank.

6. In the system of claim **1** wherein a predetermined amount of flushing fluid having a specific gravity lesser than the specific gravity of water is disposed in said waste tank.

7. In the system of claim **1** wherein said waste tank communicates with the exterior of said aircraft and said vacuum controlling means is associated with the communication between said waste tank and the exterior of said aircraft.

8. A method for flushing a toilet in a pressurized aircraft or the like wherein said toilet is installed in the interior of said aircraft and includes a valve-controlled drain line, a waste tank in fluid communication with the drain line, a valve-controlled flushing line communicating with both the interior of said tank and said toilet and at least one pump disposed in said flushing line having an inlet in fluid communication with the interior of said tank and an outlet in fluid communication with said toilet, the method which comprises the step of:

communicating the interior of said tank with the atmosphere outside of said aircraft;

controlling the communication between the interior of said tank and the exterior of said aircraft to create a vacuum within said tank at a pressure lesser than the exterior pressure at said aircraft;

activating the valve of said flushing line to flush said toilet with a flushing fluid; and

sucking any waste products and flushing fluid in said toilet out of said toilet and into said tank due to the differential pressure between the exterior of said toilet and the interior of said tank thereby also removing any undesirable odors in the portion of said aircraft where said toilet is installed.

9. The method of claim **8** further including the step of maintaining a predetermined fluid pressure within said flushing line.

10. In the system of claim **8** including the step of initially placing a predetermined amount of flushing fluid having a specific gravity greater than the specific gravity of water in said waste tank.

11. In the system of claim **8** including the step of initially placing a predetermined amount of flushing fluid having a specific gravity lesser than the specific gravity of water in said waste tank.

* * * * *