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The schematic diagram illustrates a vacuum distillation system. At the top, a chamber (10) is shown with a conical bottom containing a stirrer assembly (48, 54, 56, 58). A motor (62) drives the stirrer. The chamber is connected to a Vacuum Distillation Unit (78) via a pipe (60). The unit includes a condenser (90) and collection vessels (88, 90). An Environment Control System (22) is connected to the chamber and the vacuum unit. Various valves (V) and pumps (P) are indicated throughout the system, along with electrical control components like a Sequence Timer (42) and switches (76, 28, 50, 34).

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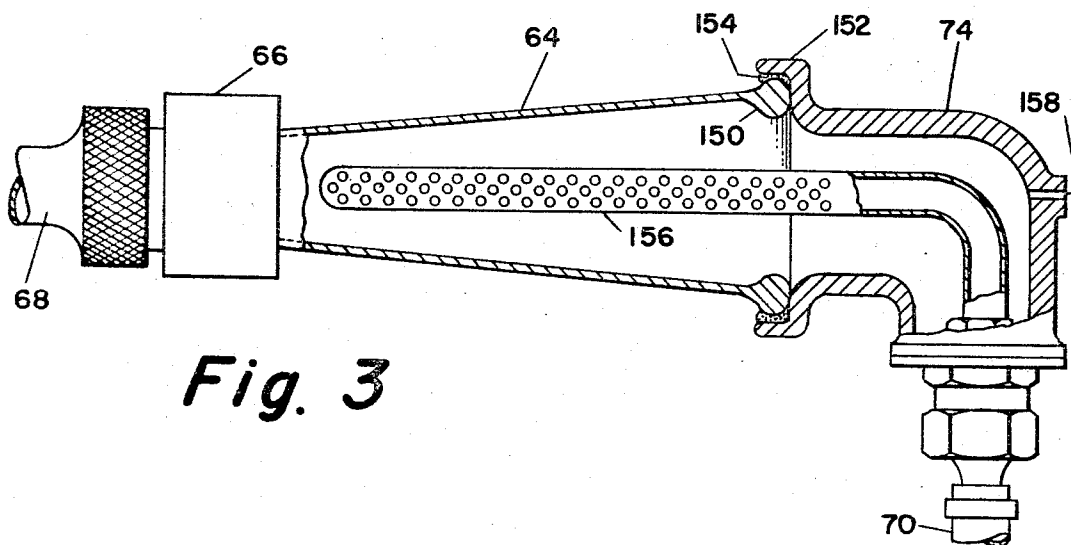


Fig. 3

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FLUSH TOILET FOR ZERO GRAVITY ENVIRONMENTS

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8 Claims. (Cl. 4-142)

This invention relates to apparatus for human waste collection and processing suitable for use in a zero gravity environment.

Manned space flights of extended duration make toilet facilities which are an integral part of the space vehicle system both psychologically desirable and economically feasible.

Previous arrangements for defecation have involved depositing the feces in a package or bag. Disinfectants must be mixed with the feces to kill bacteria which would otherwise produce gas. These operations have been performed manually and are psychologically objectionable.

The type of flush toilet used on earth is not suitable for use in space. In a zero gravity environment, a positive control must be exerted over the flushing medium and waste products to prevent these from entering the cabin.

It is, therefore, an object of this invention to provide a flush toilet suitable for use in a zero gravity environment.

It is also an object of this invention to provide auxiliary equipment to process human waste products in a sanitary and psychologically acceptable manner.

In a preferred form of the invention, a toilet is provided upon which a man can sit to defecate. An airtight seal between man and toilet is made to prevent odor from leaving the toilet. A current of air, supplied near the seal, directs both feces and odor to the toilet bowl outlet. A water jet is provided to cleanse the rectal area which is followed by a drying air jet. Water is used to wash the toilet bowl, and the liquids and feces removed through the bowl outlet are conveyed to a blender.

Micturition is provided for by a separate urinal which can be used in conjunction with or independently of the toilet. Flush water is provided for the urinal.

Urine and the feces-water mixture from the blender are pumped to a vacuum distillation unit. The distilled water from the vacuum distillation unit is then available for future flushing. The undistilled residue is retained in the still pot.

The invention will be better understood from the following description referring to the drawings in which:

FIGURE 1 is a schematic of a flush toilet and associated equipment according to the invention;

FIGURE 2 is a schematic of a sequence timer used to achieve a semiautomatic operation of the system; and

FIGURE 3 is a schematic of one embodiment of a urinal.

Referring to FIGURE 1, hopper or toilet bowl 10 is provided with a seat portion 12. Lid 14 may be fitted to provide a substantially airtight seal for the toilet bowl when closed. A circular opening in seat portion 12 is equipped with a multiplicity of air bleed ports 16. These ports 16 are connected to an annular manifold 18 supplied with air from the cabin through conduit 20.

In operation, a pressure lower than that in the cabin is continuously maintained in the system to prevent any odors from passing into the cabin. This lower pressure is achieved by connecting the apparatus of this invention to the intake side of the environment control system 22. This system is not a part of this invention, but would be included in any manned space vehicle of a size to warrant the flush toilet of this invention. The environment control system removes any odors, maintains the desired atmos-

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pheric composition and regulates atmospheric temperature and humidity. Tube 24 connected to the intake side of system 22 is equipped with normally open solenoid valve 26 to regulate the air flow to a low volume when the flush toilet is not in use.

To use the flush toilet, lid 14 is raised and switch 28 is closed to open solenoid valve 30 in tube 32 and cause an increase in the air flow. Tube 32 provides an alternate passage between the apparatus of this invention and the intake side of the environment control system 22. A high volume air flow through air bleed ports 16 is initiated by opening valve 30. Closing switch 28 also causes valve 26 to close, thereby preventing any solid or liquid matter from bypassing the processing portion of the system.

The user positions himself on seat portion 12 with the system pressure aiding in achieving a seal. When defecation is completed, the user remains seated and closes switch 34 opening normally closed solenoid valve 36 in tube 38. From cleansing water nozzle 40 a jet of body temperature water is directed at the rectal area for approximately one minute. Sequence timer 42 shuts off the water jet by closing valve 36 and then opens normally closed solenoid valve 44 in tube 46, directing warm air at the rectal area from nozzle 48 for approximately three minutes.

The user then leaves seat portion 12, closes lid 14, and closes switch 50 to actuate the flushing sequence. Normally closed solenoid valve 51 in tube 53 is opened causing flush water to spray from wide angle nozzle 52 to wash down the bowl inner surfaces for about thirty seconds. The increased air flow initiated by closing switch 28 continues through the entire process described and remains on for about one minute to dry the inside of bowl 10. At the end of this time, sequence timer 42 closes valve 30 and opens valve 26 resuming low volume air flow through the system. Drying of bowl 10 may be facilitated by coating the interior with a hydrophobic material such as "Teflon."

Subsequent work has revealed that flushing and water cleansing can be performed simultaneously with the user performing the function of lid 14.

It should be noted that while only single nozzles for cleansing, drying and flushing are shown, multiple nozzles may be desired to increase effectiveness.

The increased air flow initiated in using the toilet carries flush and cleansing water as well as feces toward the bowl outlet 54. Positioned immediately adjacent to outlet 54 is blender 56. Blender 56 churns feces and water into a liquid sludge which is moved by pump 58 through tube 60. Blender 56 and pump 58 are both driven by motor 62. Motor 62 is started when switch 28 is closed and remains on until the flushing sequence is completed.

A separate urinal 64 is provided for male users which can be used at the same time the toilet is used or independently. Urinal 64 is connected by quick disconnect joint 66 and tube 68 to pump 58.

Quick disconnect joint 66 is designed to be connected to a space suit fitting to accommodate a suited user, or it can be connected as shown in FIGURE 1. Use of the urinal also requires closing switch 28 to cause the increased air flow and start motor 62 as previously described.

A separate flush system is provided for urinal 64 and tube 68. Tube 70 is fitted with solenoid valve 72 and head 74 which is connected to urinal 64 when the latter is not in use. Closing switch 76 opens solenoid valve 72 and provides a flush of water. Sequence timer 42 turns off valve 72 after about 15 seconds.

Vacuum distillation unit 78 receives the matter which is passed through tube 60 by pump 58. A vacuum distillation unit suitable for this purpose is disclosed in U.S. Patent 3,127,243, by J. J. Konikoff. The patented unit

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provides for the production of potable water by not only distilling the waste materials, but also oxidizing those contaminants contained in the vapors.

The potable water produced by the vacuum distillation unit will be more than needed for flushing and cleansing purposes of this system since in addition to the flushing and cleansing water, water is contained in the feces and urine. Water removed from distillation unit 78 through tube 80 may be removed from the system through tube 82 by manipulation of valve 84, or distributed for flushing and cleansing purposes. Secondary pump 86 may be provided to supply additional hydraulic head.

Cooling water for the condenser of vacuum distillation unit 78 is supplied through tube 88 and removed via tube 90. Depending on the temperature at which the equipment operates, additional heating or cooling of the potable water may be required. Vacuum distillation is performed at lower temperatures than required for boiling at atmospheric pressures on earth which may eliminate the need for heat exchangers. No heat exchangers have been included in the drawings for this reason.

Referring now to FIGURE 2, sequence timer 42 will be further described. Contained in sequence timer 42 (indicated by broken lines in FIGURE 2) are the elements which permit semiautomatic operation of the apparatus of this invention. It should be evident that such operation is not necessary since the valves could be manipulated manually.

Momentary contact switch 28 is closed by the user when either the flush toilet or the urinal is to be used. A latching relay represented by coil 100 and switch 102 is operated completing circuits between battery 104 and normally open solenoid valve 26 to close this valve, battery 104 and normally closed solenoid valve 30 to open this valve, and battery 104 and motor 62 to start the motor.

Cleansing of the rectal area is initiated by closing momentary contact switch 34, causing operation of a latching relay represented by coil 106 and switch 108. A circuit is thereby closed between battery 110 and timer 112.

Timer 112 and the other timers used in sequence timer 42 start a preset time interval when first initiated. At the end of this interval two switches in the timer will be operated. These internal switches can be connected to external circuits. A suitable type of timer for this purpose is type 440P, made by the Cramer Division of Gianini Controls in Centerbrook, Connecticut.

Timer 112 causes normally closed solenoid valve 36 to open for the preset period, and at the end of the period closes valve 36 and completes the circuit between battery 110 and timer 114.

Timer 114 causes normally closed solenoid valve 44 to open for the preset period, and at the end of the period closes valve 44 and completes the circuit to coil 116, which opens switch 108.

The toilet flushing sequence is initiated by closing momentary contact switch 50. A latching relay represented by coil 118 and switch 120 is operated completing the circuit between battery 122 and timer 124.

Timer 124 causes normally closed solenoid valve 51 to open for the preset period, and at the end of the period closes valve 51 and completes the circuit between battery 122 and timer 126. At the end of the preset period of timer 126 (during which only the high volume air flow is passing through the system), timer 126 completes the circuit to coil 128 causing switch 120 of the toilet flushing circuit to open, and completes the circuit to coil 130 causing switch 102 to open. Opening switch 102 opens normally open valve 26, closes normally closed valve 30, and shuts off motor 62.

When the urinal has been used, momentary contact switch 76 is closed for the urinal flush. A latching relay represented by coil 132 and switch 134 is operated completing the circuit between battery 136 and timer 138.

It is to be noted that an additional circuit is com-

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pleted via conductor 140 between battery 136 and valve 26, valve 30 and motor 62. When the urinal is used simultaneously with the flush toilet, both the urinal flush and the toilet flush must be operated. Completion of the toilet flush, as described above, shuts off motor 62 and operates valves 26 and 30. If the urinal flush is not yet completed, the urinal flush water must be pumped away. By the circuit from battery 136 to motor 62 and valves 26 and 30, these are maintained in the proper condition. In a similar manner, conductor 142 provides a circuit between battery 122 and motor 62, etc. Completion of the urinal flush prior to the toilet flush will, therefore, not shut off motor 62.

Timer 138 causes normally closed solenoid valve 72 to open for the preset period, and at the end of this period closes valve 72 and completes a circuit from battery 136 to timer 144. At the end of the preset period of timer 144, circuits are completed to coils 146 and 130 opening switches 134 and 102, respectively.

The arrangement of the sequence timer shown in FIGURE 2 is for convenience. Normally a single battery or other power supply would be used in lieu of the multiple batteries shown. Also other timers are available which will operate more than two circuits at different periods. The arrangement shown permits a simpler description of how and when the various valves can be operated, but is only an example.

In FIGURE 3, the details of urinal 64, quick disconnect joint 66 and head 74 are shown. Urinal 64 is equipped with ferrous ring 150 permitting easy connection to magnetic rim 152 of head 74. Gasket 154 provides a water tight connection.

Spray nozzle 156 is provided with flush water from tube 70, and is designed to flush the entire inner surface of urinal 64. Drying of the urinal is accomplished by air bleed 158 in head 74 and can be facilitated by coating the inner surface of urinal 64 with a hydrophobic material such as "Teflon."

While a particular embodiment of a flush toilet for zero gravity environments has been illustrated and described, it will be obvious that changes and modifications can be made without departing from the spirit of the invention and the scope of the appended claims.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A flush toilet suitable for use in a zero gravity environment comprising:

- a hopper for receiving feces,
- means for flushing said hopper with a liquid,
- means for cleansing the rectal area of a user with a liquid,
- means for drying the rectal area of a user, and
- means for conveying feces and cleansing and flushing liquid from said hopper without the assistance of gravity.

2. A flush toilet as defined in claim 1 further comprising:

- a urinal,
- means for flushing said urinal with a liquid, and
- means for conveying urine and flushing liquid from said urinal without the assistance of gravity.

3. A flush toilet suitable for use in a zero gravity environment comprising:

- a hopper for receiving feces,
- means for flushing said hopper with water,
- means for cleansing the rectal area of a user with water,
- means for drying the rectal area of a user with air,
- means for recovering water from said feces and flush and cleansing water, and
- means for conveying feces and flush and cleansing water from said hopper to said means for recovering water without the assistance of gravity.

4. A flush toilet suitable for use in a zero gravity environment comprising:

- a hopper for receiving feces,

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means for flushing said hopper with water,
means for cleansing the rectal area of a user with water,

means for drying the rectal area of a user with air, a urinal,

means for flushing said urinal with water,
means for recovering water from said feces and flush and cleansing water and urine, and

means for conveying feces and flush and cleansing water from said hopper and urine and flush water from said urinal to said means for recovering water without the assistance of gravity.

5. A flush toilet suitable for use in a zero gravity environment comprising:

a seat portion for a user,

a hopper for receiving feces positioned below said seat portion,

means for flushing said hopper with water,
means for cleansing the rectal area of a user with water,

means for drying the rectal area of a user with air, a vacuum water distillation unit, and

means for inducing a flow of air from said hopper to said vacuum distillation unit to convey feces and water towards said vacuum distillation unit without the assistance of gravity.

6. A flush toilet suitable for use in a zero gravity environment comprising:

a seat portion for a user,

a hopper for receiving feces positioned below said seat portion,

means for flushing said hopper with water,
means for cleansing the rectal area of a user with water,

means for drying the rectal area of a user with air, a urinal,

means for flushing said urinal with water,

a vacuum water distillation unit, and

means for inducing a flow of air from said hopper to said vacuum distillation unit to convey feces and water towards said vacuum distillation unit and from said urinal to said vacuum distillation unit to convey urine and water towards said vacuum distillation unit without the assistance of gravity.

7. A flush toilet suitable for use in a zero gravity environment comprising:

a seat portion for a user,

a hopper for receiving feces positioned adjacent to said seat portion,

means for admitting air to said hopper at a point other than the hopper opening,

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means for flushing said hopper with water,
means for cleansing the rectal area of a user with water,

means for drying the rectal area of a user with air, a blender for churning feces and water into a liquid sludge connected to the outlet of said hopper,

means for inducing a flow of air from said hopper to said blender to convey feces and water to said blender without the assistance of gravity,

a vacuum water distillation unit, and
a pump for pumping the liquid sludge from said blender to said vacuum water distillation unit.

8. A flush toilet suitable for use in a zero gravity environment comprising:

a seat portion for a user,

a hopper for receiving feces positioned adjacent to said seat portion,

means for admitting air to said hopper at a point other than the hopper opening,

means for flushing said hopper with water,
means for cleansing the rectal area of a user with water,

means for drying the rectal area of a user with air, a blender for churning feces and water into a liquid sludge connected to the outlet of said hopper,

a urinal,

means for flushing said urinal with water,

a conduit connecting said urinal with the outlet of said blender,

means for inducing a flow of air from said hopper to said blender to convey feces and water to said

blender and from said urinal to the outlet of said blender to convey urine and water to the outlet of

said blender without the assistance of gravity,

a vacuum water distillation unit, and

a pump for pumping the liquid sludge from said blender and the urine and water from the outlet of said blender to said vacuum distillation unit.

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