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F. M. BENNETT
METHOD AND APPARATUS FOR DISPOSAL OF WASTE
LIQUID AND SOLID MATERIAL

3,405,409

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3 Sheets-Sheet 1

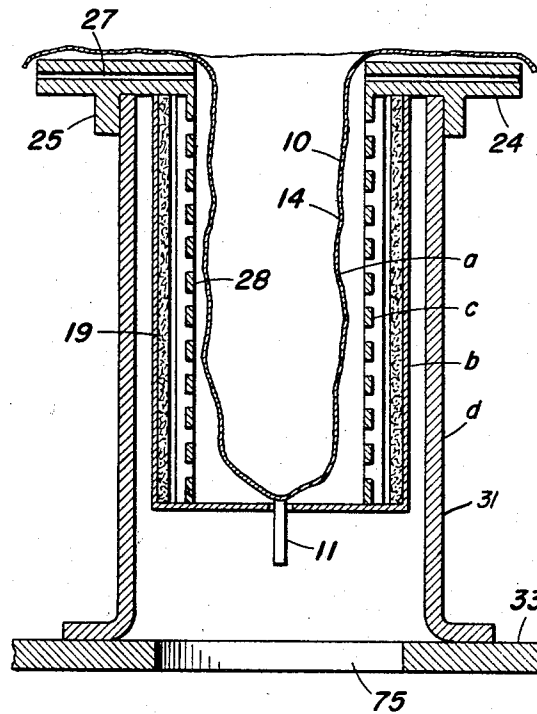
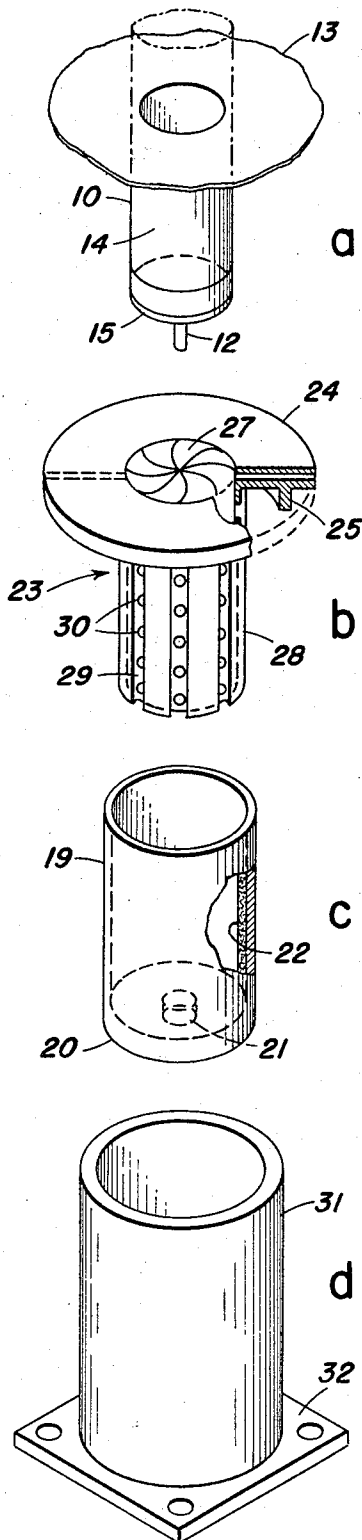


Fig. 2. Fig. 1.

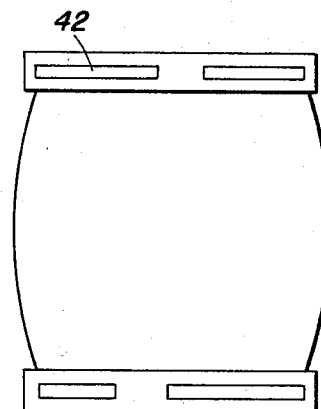


Fig. 3.

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Fig. 5.

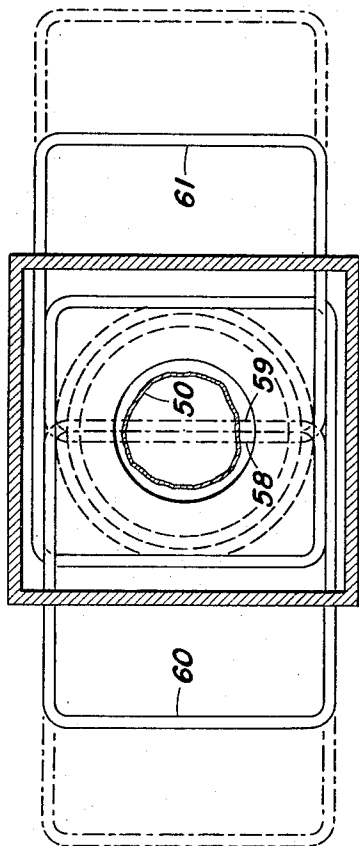
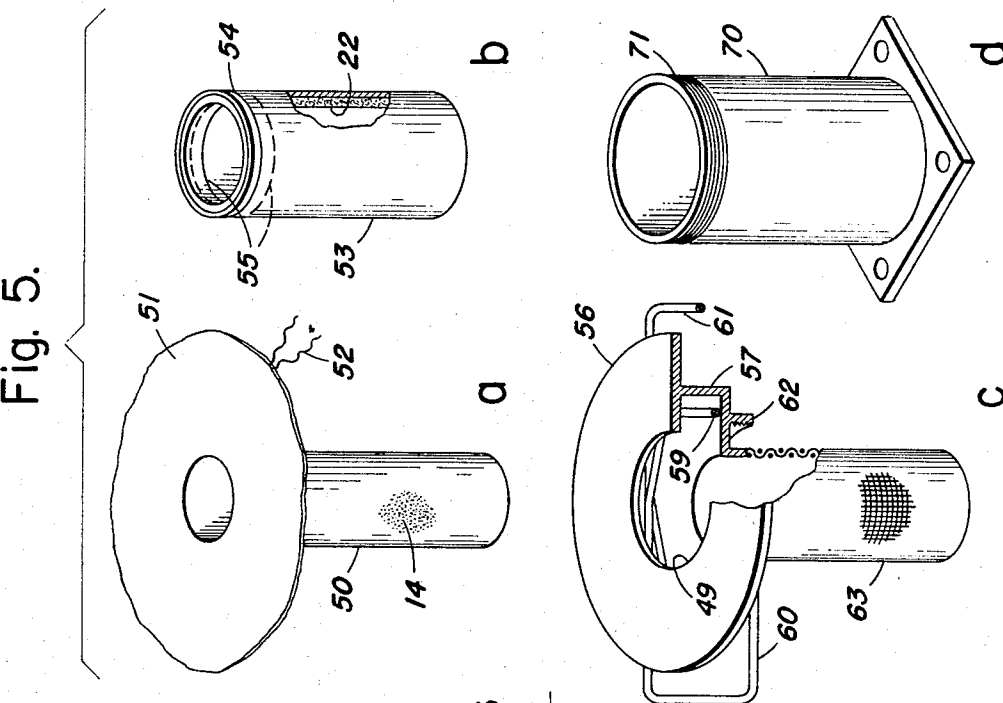


Fig. 6.

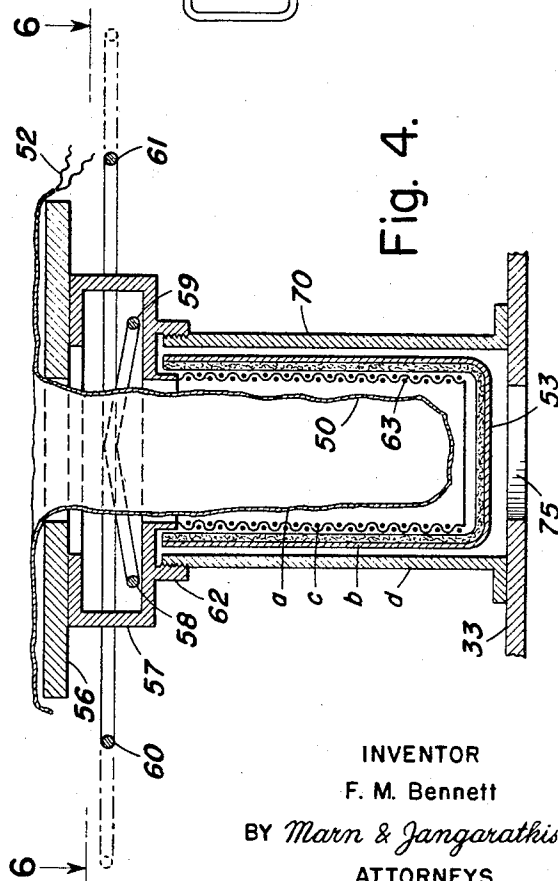


Fig. 4.

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Fig. 7.

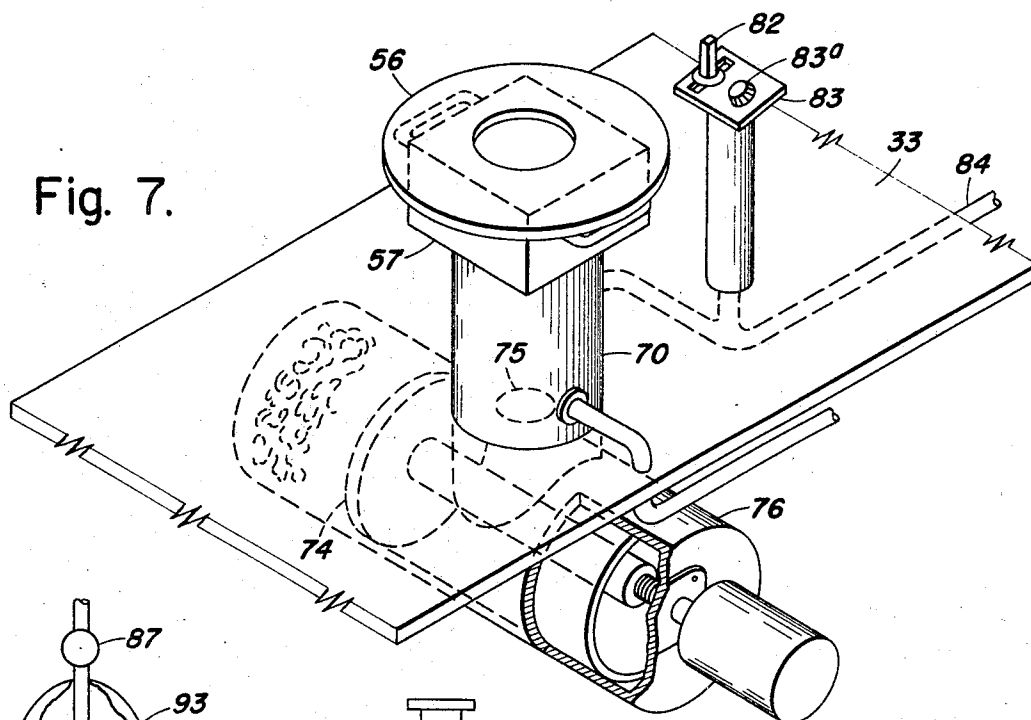
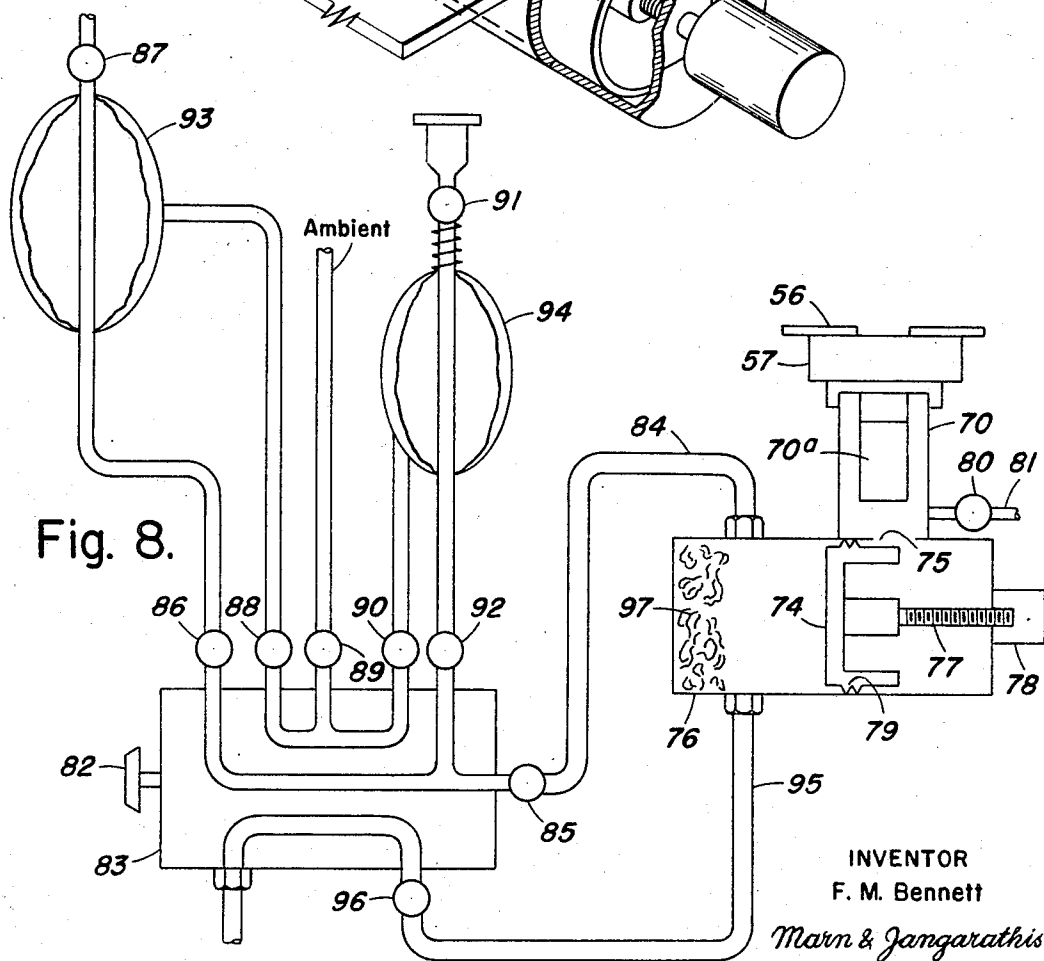


Fig. 8.



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METHOD AND APPARATUS FOR DISPOSAL OF WASTE LIQUID AND SOLID MATERIAL

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ABSTRACT OF THE DISCLOSURE

A method and apparatus of managing the disposal of waste liquids and solid material accumulated aboard a vehicle on a mission in space is provided. In accordance with one aspect of the inventive concept a heated chamber having piston means movable therein is utilized for continuously desiccating waste materials and a hollow stand is utilized for accumulating said material in a package, wherein said piston means blocks a first opening in said chamber during the packaging of said material and said piston means unblocks said first opening in said chamber for storage of said packaged material therein.

This invention relates to a method of and system for managing the disposal of waste liquid and solid material accumulated aboard a spacecraft on a mission and to a disposable receptacle for accumulating such material in small quantities and, more specifically, to an integrated and semi-automatic system for vacuum desiccating such material accumulated in an improved disposable receptacle in space.

The problem of collecting and handling waste liquid and solid material produced by humans aboard a spacecraft on a mission in one form is solved in my Patent No. 3,158,874, issued on Dec. 1, 1964. This included the particular aspect of zero gravity. It has been found that the problem of managing the collection and disposition of such waste liquid and solid material involves aspects of reliability and minimum weight and volume. This managing problem is also concerned with the questions of adequate capacity under emergency conditions, and of containing and controlling flatus, odorfacients, liquids and solids. It was also found that such managing system should be sterile or at least non-septic to avoid contamination of the spacecraft either during use or as a result of any condition that may arise during the storage of the accumulated waste. In addition, the system should be psychologically acceptable to the user, familiar and common to use as is possible, and require as little after-use contact with the waste liquid and solid material as is feasible.

The present invention is, therefore, concerned with a system for managing the collection and disposition of waste liquid and solid material produced by humans, aboard a spacecraft on a mission.

It is a principal object of the present invention to provide a reliable system for managing the collection and disposition of human waste on a spacecraft.

Another object is to provide a waste receptacle that is expeditiously usable and disposable.

It is a further object to provide a waste accumulator that is sterile to the user.

It is still another object to provide a human waste management system that is easily usable in zero gravity.

It is also another object to provide a human waste accumulator that is readily adaptable for rapidly successive uses by different persons under emergency conditions.

It is another object to provide a human waste management system that precludes contamination of a spacecraft.

It is another object to provide a human waste management system that processes expeditiously both liquid and solid human waste.

It is further an object to provide a human waste management system that is essentially mechanical in operation.

It is also an object to provide a human waste management system involving equipment having minimum weight and bulk.

It is still another object to provide a human waste accumulator that is expeditiously usable.

It is a further object to accumulate small amounts of human waste in discrete facile and sterile packages.

The present invention contemplates as one specific embodiment apparatus for accumulating and packaging small amounts of human waste liquid and solid material accumulated on a spacecraft on a mission in association with a frame structure of the type, for example, disclosed in my patent, supra. This apparatus comprises a hollow stand disposed normally on a suitable deck of the spacecraft and a seat assembly positioned on the free end of the stand, this assembly including a flat seat having a central opening, a perforated tube rigidly attached to one surface at the seat in coaxial relation therewith, a perforated first plastic bag sealed at one end and unsealed at the other and so disposed interiorly at the tube that the unsealed end is spread out over the usable surface of the seat. The perforated first bag is pervious to gas and substantially impervious to liquid and solid material, a second plastic bag opaque and impervious to liquid and solid material, the second bag sealed at one end and unsealed at the other, the second bag so disposed on the outer surface of the tube that the unsealed end lies in proximity of the seat. An absorbent liner charged with a bacteriostatic is positioned between the second bag and the tube, and movable means located adjacent to the seat and engaging an outer periphery of the first plastic bag thereat whereby the movable means is adjustable to one position by seat pressure to allow the unsealed end of the latter bag to open to receive a charge of waste liquid and solid material and to another position by a relaxation of seat pressure to close the unsealed end of the latter bag against the receipt of further charges of such material.

When the first plastic bag is loaded with waste material to the desired amount, the portion of this bag covering the seat is withdrawn therefrom and knotted or otherwise suitably tied off. The closed first bag is then dropped into the second plastic bag and the latter bag, together with the tied-off first bag and absorbent lines, is withdrawn from the perforated tube. As the second bag is provided with a pressure-sensitive substance on the portion adjacent to the unsealed end, finger pressure applied thereto serves to seal it off with the first bag contained therewithin. A zipper provides a mechanical closure for the second bag and maintenance of the pressure-tight seal affected with the pressure-sensitive substance. A limited amount of waste liquid and solid material is now packaged in a disposable receptacle.

In a modification of the first and second plastic bags, the first bag is provided with a tab externally to the center of the sealed end thereof while the one end of the second bag is formed with a central slit through which the tab on the bottom of the first bag projects. The two bags are mounted on the perforated tube and perform the functions hereinbefore described. The tab provides a firm finger grip whereby the two bags are expeditiously demounted from the perforated tube. This modification utilizes mechanical clips built into the opposite ends of the second bag for effecting a mechanical closure thereof, and omits the use of the pressure-sensitive substance on the second bag. The modified package of waste liquid and solid material is now available for disposal.

The present invention also contemplates a system for managing the disposal of the above-noted packages of human waste liquid and solid material, and comprises a hollow desiccating chamber suitably heated and provided with an opening at each of its two opposite ends, one of the openings being aligned with the hollow stand supporting the seat assembly, and the other of the openings selectively connectable to one of several containers of different types of waste liquids via a valving arrangement. The hollow stand includes a valve for connecting the interior thereof to an air system of the spacecraft to dispose of unpleasant odors occurring during the accumulation of the waste liquid and solid material in the single porous plastic bag. Another valve also connects the interior of the desiccating chamber to a vacuum system included in the spacecraft for disposing of vapors and other products of desiccation produced in the desiccating chamber. Each package of waste material, after it is formed, is dropped into the hollow stand for desiccation in the desiccating chamber in a manner that is presently explained.

A piston located at the end of the desiccating chamber having the opening aligned with the hollow chamber is so normally positioned as to block off this opening during the period of the accumulation of the waste material in the two plastic bags. When, however, a package of such material is disposed in the hollow stand as just mentioned, the piston is retracted to uncover such opening thereby permitting the package to fall into the desiccating chamber for storage thereat, and is thereafter retracted to its initial position of blocking the opening to the hollow stand. This stand is now equipped with another porous plastic bag to commence the accumulating of another package of waste liquid and solid material. The valving arrangement connecting the other opening of the desiccating chamber to the several containers of different waste liquid is selectively adjustable to dump the different types of waste liquid from the several containers, one at a time, into the desiccating chamber as desired.

A feature of the present invention is that the process of desiccation is taking place at all times. Another feature is that the eyes of the user of the accumulator of the waste liquid and solid material are spared from the sight of the material in the inner bag and that the user is spared the direct handling thereof. Still another feature is that the waste liquids are enclosed within the respective containers at all times. A further feature is that the accumulator of waste solid material is personal to the user. An additional feature is that the package containing the waste liquid and solid material is expendable. Another feature is that gases attending the accumulation of waste solid material are instantaneously removed from the local environment. Still another feature is that the inner plastic bag constituting the final package in this embodiment is permeable to gases but not to solids. Another feature is a mechanical closure responsive to seat pressure for opening and closing the inner bags to charges of waste liquid and solid material. Still another feature is that the accumulator and disposal of waste liquid and solid material are expeditiously operable under zero gravity conditions.

The invention will be readily understood from the following description when it is taken together with the accompanying drawings in which:

FIG. 1 is a cross-sectional view of an assembly of one embodiment of the invention;

FIG. 2 is a perspective view of several discrete members usable in FIG. 1;

FIG. 3 is an elevational view of a disposable package obtainable with the arrangement of FIG. 1;

FIG. 4 is a cross-sectional view of an assembly of a modification of the invention in FIGS. 1, 2 and 3;

FIG. 5 is a perspective view of several discrete members usable in FIG. 4;

FIG. 6 is a plane view taken along line 6—6 in FIG. 4; FIG. 7 is a perspective view of an assembly of apparatus for another embodiment of the invention; and

FIG. 8 is a mechanical schematic diagram of the apparatus usable in FIG. 7.

It is understood that the same reference numerals are employed to characterize identical components appearing in the several figures of the drawings.

A cylindrical bag 10 in FIGS. 1 and 2a comprises a clear plastic material having end 11 sealed and provided with an elongated tab 12 for a purpose that is subsequently mentioned. The opposite end 13 of the bag is unsealed. The periphery of the bag is perforated with a plurality of microholes or openings 14 having, for example, 0.003 inch diameters distributed approximately to the number of 800 per square inch, commencing at a point about two inches below the sealed end and terminating several inches below the unsealed end. When this bag is installed as depicted in FIG. 1, it allows the passage of gas through its perforated area which is, however, substantially impervious to the passage of liquid therethrough due to surface tension effects of the liquid. The unsealed end 13 of the bag performs a function that is later mentioned with regard to waste assembly of FIG. 1. Bottom 15 of the bag is both non-porous and impervious to preclude the escapements of gas and/or liquid in the event of an accidental rupture, except when the bag is included in the assembly of FIG. 1 as subsequently noted.

A cylindrical bag 19 in FIGS. 1 and 2c is heat sealed flat across bottom 20 except for a slit 21 extending a length of the order of one inch at the center of this bottom. The bag is colored blue, for example, to render it opaque, and is impervious to both gas and liquid. The interior surface of the bag is provided with an absorbent, quilted cotton liner 22, FIG. 2c, about one-quarter inch thick. This liner is charged with a suitable bacteriostatic of the sulfo chemical family. An odor masking aldehyde and a deliquescent salt may be added to the liner as required. After the bag is used in a manner hereinafter explained with regard to waste assembly of FIG. 1, the liner serves to minimize the generation of unpleasant odors.

Seat assembly 23 in FIGS. 1 and 2b comprise a metallic seat 24 which may be provided with a contour or planar upper surface as desired. A metallic collar 25 formed integral with an underface of the seat serves a purpose that is later pointed out. A rigid plastic tube 28 in FIGS. 1 and 2b has one end fixedly secured to an undersurface of seat 24 in a perpendicular position relative thereto so that the seat opening aligns with the plastic tube opening. The opposite end of the tube is open. An outer surface of the tube is formed with a plurality of longitudinal grooves 29 formed in spaced relation thereon. A plurality of radial holes 30 is also formed in the tube so that the holes connect the interior of the tube with the grooves. An iris-type valve 27 of common structure is included in the seat.

A hollow stand 31 in FIGS. 1 and 2d has a lower end rigidly secured to a flat member 32 which may be bolted to a preselected surface 33, FIG. 1, of a spacecraft, and an upper end open. This surface may connect in one instance with an intake part of the spacecraft circulation device and/or an atmosphere control as hereinafter explained. Obviously, the stand is normally positioned relative to its mounting surface.

The waste receptacle of FIG. 1 is assembled in the following manner. For this purpose, let it be assumed that the several components of the receptacle are resting in the respective positions shown in FIG. 2 except stand 31 in FIG. 2d is now normally secured to the preselected surface of the spacecraft. The seat assembly in FIG. 2b is taken into one hand and inner bag 10 is projected into tube 28 with the other hand so that the unsealed end of the bag extends outside the seat and the sealed end lies adjacent to but inside the opening of

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the tube. For this purpose, it is understood that a slight pressure exerted on the upper surface of the seat opens the iris valve to permit the extension of the open bag end therethrough to the seat. At this time, the unsealed end of the bag is spread over the entire surface of the seat, and the remainder of the bag lies limply within the tube. When the seat pressure is relaxed, the iris valve is closed to engage the outer periphery of the bag in the vicinity of the seat.

Outer bag 19 is now forced to its full extent onto the free end of tube 28 whereby the sealed end of the bag is caused to assume a somewhat rounded configuration and to open slit 21 formed therein. This enables tab 12 on the bottom of inner bag 10 to be drawn through slit 21. It is now obvious that the absorbent liner 22 on the inner surface of bag 19 is disposed between the latter bag and the outer surface of tube 28 in direct contact with the walls of the longitudinal grooves formed thereon. It is thus apparent that grooves 29 may be disposed of in a manner other than longitudinal on the outer surface of tube 28; it is only important that such grooves enable the absorbent liner to communicate via the connecting holes with the interior of this tube.

The assembly including the seat, porous tube and two bags and liner is installed on stand 31 by inserting the assembled porous tube and two bags thereinto and snapping collar 25 onto the top of the stand. This forms a seal between the seat and the interior of the stand. All air-flow is now through the microholes of the inner bag which is thereby forced smoothly and tightly against the inner surface of the porous pipe where it remains through repetitive openings and closings of the iris valve by repeated usages of the seat. This assembly is shown in FIG. 1 with the iris valve open except the limp inner bag is more pressed against the inner surface of the porous tube as just explained.

An alternate form of valve for closing the upper end of inner bag 10 shown in FIG. 3 comprises a pair of oppositely disposed jaws as hereinafter discussed with regard to FIGS. 4, 5 and 6.

The operation of the disposable receptacle in FIGS. 1 and 2 takes place in the following manner. The iris valve, for example, remains closed until it is opened by the pressure of a user occupying the seat and positioning himself in the zero g-field by grasping the handgrips disclosed in my patent, supra. The closest valve for the inner bag is essential to the control of waste solid, for example, which may be deposited therein in two or more voluminous and relatively high velocity charges. The valve permits rapid opening and momentary closing between successive charges by the user appropriately adjusting his pressure on the seat. The one liter of air flowing into the inner bag, as aforementioned, exerts only a small force on the waste, solid or liquid contained therein.

A waste charge striking the bottom of the inner bag rebounds with approximately twenty percent of its initial velocity, and if it is not contained within the bag, may be projected thereon into the immediate environment. The iris valve in response to a momentary closing serves as a baffle to deflect any waste that may tend in a path of projection out of the inner bag. The closed valve dissipates the kinetic energy in the waste charge via a series of bounces thereof, thereby retaining a complete enforcement of the waste charge within the inner bag.

When the inner bag is loaded to the desired extent and the user has vacated the seat, the iris valve closes to seal off the waste material in the inner bag. Then the user removes the upper portion of the inner bag covering the seat and twists it and puts a knot into it. Thereafter, the user drops the knotted inner bag into the outer bag. The seat, together with the porous tube and inner and outer bags, is removed from the stand. The user holding the seat in one hand grasps the tab on the bottom of the inner bag and pulls the seat and porous

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tube away from the inner and outer bags. At this time, the knotted inner bag is entirely contained within the outer bag 19 which is sealed, rolled up at its opposite ends and clamped with the self-contained metallic tabs 42, as illustrated in FIG. 3. This places the outer bag in condition for storage. It is apparent that at no time does the user see the waste material in the inner bag and that there is no need to touch such waste. This is so since the outer bag is opaque and thereby tends to provide the user with some psychological advantage during a flight in space.

The assembled outer bag may be stored in a suitable or a special manner as hereinafter described. The bacteriostatic contained in the absorbent liner placed in the inside of the outer bag prevents bacteria-generated flatulence. Enzymatic decomposition of the waste is retarded because of the liquid removal property of the absorbent liner. The semi-dry waste contained in the inner bag tends to generate some carbon monoxide and dioxide gases which are adequately restrained in the outer bag. The waste disposal apparatus itself does not add any bothersome amount of weight to the spacecraft in flight, and in one example, has a weight of approximately 3.7 pounds. Each disposable set of inner and outer bags weighs about 0.15 pound and the gross weight of all such sets for a 45-day flight in space is of the order of 12.2 pounds.

A modified assembly of the disposable waste bags is illustrated in FIGS. 4, 5 and 6. Inner bag 50 in FIG. 5a comprises a bag of polyethylene plastic sealed at its bottom and unsealed at its top; it is provided with a plurality of microholes 14 throughout its entire peripheral area except for a portion several inches from the unsealed top in the manner of bag 10 in FIG. 2a. The microholes permit freer passage of gas therethrough but substantially block the passages of liquids due to surface tension effects thereof. The top of the bag is provided with a flat-ring-shape integral seat member 51, FIG. 5a, of polyethylene plastic which includes a shirring string 52 attached to the top thereof. An outer bag 53 in FIG. 5b is similar to outer bag 19 in FIG. 2b and includes liner 22 thereof, except the former is entirely sealed at its bottom and at its unsealed top includes a zipper 54 and two removable labyrinth seal cover tapes 55 oppositely disposed on the inside of the bag adjacent to the zipper. Pressure-sensitive material is positioned underneath the tapes for a purpose that is later explained. The bottoms of both the inner and outer bags may comprise an integral structure, if it is so desired.

Seat 56 in FIG. 5c comprises a clear, solid circular sheet of suitable plastic having a central opening 49 and mounted on top of a hollow rectangular metallic box 57 housing a valve including oppositely disposed jaws 58 and 59 spring-loaded in a familiar manner, not shown, and actuated by handles 60 and 61, respectively, for a purpose that is subsequently mentioned. A circular collar 62 is fixedly secured to an underfold of the box in coaxial relation with the seat and is provided with an internal thread, not shown, for a purpose later mentioned. A fine mesh tubular screen 63 disposed inside the collar and spaced therefrom is firmly fastened to the underface of the bag in coaxial relation with the seat and collar. Jaws 58 and 59 shown in abutting relation by the full lines in FIGS. 5a and 6 are movable to a retracted position as represented by the broken lines in FIG. 6.

It is understood that jaws 58 and 59 depicted in FIG. 4 are spring biased so as to control the retracted position of the jaws in response to the presence of an exerted seat pressure, such spring bias normally adjusting the jaws to the abutting position in the absence of such seat pressure. It is apparent that a valve structure employing the opposing jaws in FIGS. 4, 5 and 6 may also be used as a substitute for the iris valve 27 in FIG. 2c.

Hollow stand 70 in FIG. 5d is similar to stand 31 in FIG. 2d except an upper portion of the former is provided

with an external thread 71 for accommodating the internal thread of collar 62 in FIGS. 4 and 5c for a purpose which is presently discussed. Stand 70 is also normally mounted relative to spacecraft surface 33.

The assembly of the disposable waste receptacle in FIGS. 4, 5 and 6 takes place in the following manner. For this purpose, it is assumed that the several components of the receptacle are lying in the respective positions shown in FIG. 5 except stand 70 is now normally mounted on the preselected surface of the spacecraft. Seat assembly in FIG. 5c is held in one hand of an assembler or under one arm while the inner and outer bags are opened and the outer bag is unzipped. Then, screen 63 is interposed between the inner and outer bags by the use of both hands as required. Liner 22 is now positioned between the outer bag and the screen. Care is exercised at this time to ensure that liner 22 is not damaged and labyrinth seal tapes are not dislodged from the upper inner end of the outer bag. The inner bag is lying limp inside the hollow screen, and the zipper on the upper end of the outer bag is disposed above the thread on stand 70.

Next, the seat assembly, including the seat, screen and two bags thereon, is installed on stand 70 by disposing the screen and two bags thereunto and screening the thread of collar 62 onto the thread of the stand. Either one of handles 60 and 61 in FIGS. 4 and 5c is pulled out by one hand of the assembler to retract the opposing jaws attached thereto, while his other hand reaches down through the seat opening to extract the inner bag from the interior of the screen cautiously freeing it from any entanglement with the screen, if it is necessary, in order to avoid any damage to the inner bag. The inner bag is pulled out through the seat opening until its seat member 51 is positioned above the seat. The handle that is pulled out is now released to permit the opposing jaws to engage the peripheral portion of the inner bag adjacent to the seat, thereby effectively closing the upper end thereof as illustrated in FIG. 6.

The seat member is spread out over seat 56 and attached thereto, if it is necessary, by drawing on the shirring string 52, FIGS. 4 and 5a. The inner bag is caused to fit tightly onto the inner surface of the screen in FIG. 4 in response to vacuum pressure available to stand 70 in a manner that is hereinafter pointed out. The disposable waste receptacle is now tight fitting and mechanically closed, and available for receiving waste liquid and/or solid material. The disposable waste assembly in FIG. 4 is used to accumulate waste in the respect mentioned above with regard to the waste disposable assembly in FIG. 1, except the opposing jaws 58 and 59 in the former are now abutting as shown in FIG. 6 for this purpose. Vacuum pressure causes an air flow that snaps open the upper end of the inner bag when the opposing handles are activated to retract the opposing jaws from the inner bag, as subsequently mentioned.

When the inner bag is loaded to the desired amount, seat member 51 is removed from seat 56, relaxing the draw on seat 51, as necessary. This end of the inner bag is twisted and tied with the string in a suitable manner, taking care that the free length of the string is minimal. This is done to avoid fouling the closure of the zipper on the outer bag in the operation which is presently explained. With the opposing jaws now disposed in their retracted position, the tied-off inner bag is pushed down into the outer bag.

Next, collar 62 is unscrewed from stand 70 and the entire seat assembly, including the screen and inner and outer bags removed therefrom. Holding the seat portion in one hand, the other hand grasps the end of the outer bag and pulls the outer bag off the tubular screen, using a suitable twisting motion to free the zipper. The inner bag pulls free with and is contained within the outer bag. At this point, the seat assembly minus the two bags is loosely positioned on but not screwed onto the stand.

The two labyrinth seal cover tapes are removed from

the opposite insides of the zipper end of the outer bag and placed inside thereof. This exposes the opposing bands of pressure-sensitive material, and these bands are finger-pressed together to form a final seal. Care is exercised here to line up the top ends of the outer bag before pressing the sealing surfaces together so that the zipper positions are operatively aligned for the final operation. As the outer bag is now closed on its original crease lines, the zipper is closed and the disposable waste accumulator is ready for storage. It has been found that the final package is leak-proof for pressure differentials of 10 p.s.i. The zippered bag is now dropped into stand 70. The weights of the waste disposal apparatus and the bag therefor in FIG. 4 are approximately that given above for the corresponding apparatus and bags in FIG. 1.

A system for managing the storage of waste receptacles of the type shown in FIGS. 1 and 4 is disclosed in FIGS. 7 and 8. FIG. 7 illustrates stand 70 mounted normally on preselected spacecraft surface 33 and having its open upper end surmounted with box 57 and seat 56 including tubular screen 63 enclosed with outer and inner bags 53 and 50, respectively, as illustrated in the assembly shown in FIG. 4. For the purpose of the explanation at this moment, it is immaterial that opposing jaws 58 and 59 are shown in their abutting position.

As the following explanation is concerned only with the system for managing the storage of the liquid and/or solid waste accumulated in the outer and inner bag assemblies illustrated in FIGS. 1 and 4 and finally contained in the sealed outer bag as hereinbefore described, it is understood such explanation is hereinafter directed only to the storage of the zipper-sealed outer bag dropped into stand 70 in FIG. 4 as just mentioned, and that it applies equally as well to the storage of the sealed outer bag shown in FIG. 3 and dropped into stand 31 as previously mentioned.

The lowermost end of hollow stand 70 is aligned with an opening 75 located at the righthand end of desiccating chamber 76 which is heated in a suitable manner such, for example, as by a heat exchanger, not shown, designed to cool the electronic gear or spacecraft, electric and/or solar apparatus and the like. As such heat is continuously applied to the chamber, it is understood that the desiccation process therein is in operation at all times. The chamber includes a piston 74 connected to one end of a worm gear 77 which terminates on its opposite end in an actuator 78 controlled in a manner that is later mentioned. The piston includes an elastomer "O" ring 79 or other suitable ring for maintaining an air-tight seal between the piston and inner surface of the chamber. The interior of stand 70 is connected via electrically operated valve 80 and conduit 81 to an environmental control system (ECS unit), not shown, which causes an air flow through the inner bag 50 at the rate of one cubic foot per minute. This inflates the inner bag in the assembly of FIG. 4 where the opposing jaws are operated to the retracted position shown therein, as previously noted. Valve 80 is operated by mode-selector control 82 mounted on control panel 83 in FIG. 7.

The desiccating chamber in FIGS. 7 and 8 is connected via conduit 84 to a master valve 85 which is connected in an obvious manner with valves 86, 87, 88, 89, 90, 91 and 92 for controlling liquid flow into the desiccating chamber as indicated in the table shown below. Envelopes 93 and 94 are accumulators for atmospheric waste water and urine, respectively. Conduit 95 and valve 96 discharge gas and vapor from the interior of the desiccating chamber to a vacuum included in the spacecraft. Selector lever 82 mounted on control panel 83 provides the following operational modes. In this connection, it is understood that the several valves are electrically operated although hand or pneumatic operation would work equally as well.

Mode:	Valves open
(1) Urine accumulator	----- 91, 89, 90
(2) Waste water accumulator	- 87, 88, 89

Mode:	Valves open
(3) Urine dump -----	89, 90, 92, 85, 96
(4) Water dump -----	86, 88, 89, 85, 96
(5) Solid collection (stand 70)	80
(6) Desiccation -----	96
(7) Solid collection dump ----	None

A typical operating cycle of the waste management system proceeds in the following manner. For the operation of mode 5, for example, valve 96 is opened to the vacuum, piston 76 closes opening 75 to stand 70, and valve 80 is open to the ECS unit in the spacecraft during the collection of solids in the plastic bags in stand 70 as explained above. Opening of valve 80 permits unpleasant odors to be conducted away from the solids accumulator stand. When the outer bag is zipper-sealed and dropped into stand 70 in FIG. 8, as mentioned above, it is stored in the desiccating chamber in accordance with the following procedure. Valves 80 and 96 are closed in response to an appropriate adjustment of hand control 82, and hand control 83a is operated to activate actuator 78 whereby piston 76 is retracted to the right hand of the desiccating chamber for registering stand opening 75 with the interior thereof.

This permits the zippered outer bag 70a to drop from the interior of the stand into the desiccating chamber. As an alternate procedure, valve 96 is opened to permit an on-rush of air into the desiccating chamber in response to the effect of the vacuum whereby bag 70a is flushed from the interior of stand 70 into the chamber. Hand control 83a is again operated to move the piston against the zippered bag in a lefthand direction in the desiccating chamber whereby the latter bag is stored in the lefthand end thereof together with the one or more bags 97 already stored therein. Thereafter, the piston is again moved to the position shown in FIG. 8, thereby blocking opening 75 and seat 56 is again assembled with the inner and outer bags and absorbent liner as illustrated in FIG. 4. Valves 80 and 96 are reopened. At this time, it is recalled that the absorbent liner 22 in outer bag 53 in FIG. 5 functions in the manner and for the purpose previously mentioned with regard to that of liner 22 in the disposable receptacle, FIG. 1. During this time, it is also recalled that the desiccating chamber is continuously heated to advance the process of desiccation therein.

It is found that approximately two cubic feet of atmosphere are lost each time the desiccating chamber is opened to store another zippered waste bag therein. Under normal operating conditions, this loss is estimated at approximately 240 cubic feet for a 45-day, three-man mission of the spacecraft, or about 12 pounds of atmosphere at the anticipated cabin pressure. Each opening and closing cycle of the desiccating chamber is found to require about 80 watt seconds of power for an 8-second cycling period. The complete management system weighs about 50 pounds including storages for a 135 man-day mission.

It is obvious that the arrangement of FIGS. 7 and 8 may be further selectively operated in the modes given in the foregoing table for accumulating and dumping waste liquids into the desiccating chamber.

It is understood that the invention herein is described in specific respects for the purpose of this description. It is to be further understood that such respects are merely illustrative of the application of the principles of the invention. Numerous other arrangements may be devised by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. In a spacecraft having a heated chamber and apparatus for accumulating waste liquid and solid material in discrete packages in space, the method of managing the disposal of said packages of waste liquid and solid material in said chamber in space, which comprises continuously desiccating waste liquid and solid material in said chamber, accumulating said waste liquid and solid in discrete packages in said apparatus while said waste

liquid and solid material are continuously desiccated in said chamber, and transferring said packages of waste liquid and solid material one at a time from said apparatus into said chamber for desiccating therein while said waste liquid and solid material in said chamber are continuously desiccated therein.

2. In the spacecraft according to claim 1, the method which includes the additional step of withdrawing from said chamber vapor and solid particles resulting from the desiccation of said packages of said waste liquid and solid material therein.

3. In the spacecraft according to claim 2, the method which includes the further steps of accumulating discrete amounts of other waste liquids on said spacecraft in space, and selectively introducing additional amounts of said other waste liquids into said chamber for desiccation therein while said packages of said waste liquid and solid material in said chamber are continuously desiccated therein except when said discrete packages of said waste liquid and solid material are being transferred one at a time from said apparatus into said chamber.

4. In a vehicle including a desiccating chamber and apparatus for accumulating discrete packages of waste liquid and solid material aboard while on a mission in space, the method of managing the disposal of said packages of waste liquid and solid material in said chamber in space, which comprises continuously desiccating said waste liquid and solid material in said chamber, accumulating said waste liquid and solid material in discrete packages in said apparatus while said desiccation of said waste liquid and solid material is continued in said chamber, transferring said packages of said waste liquid and solid material one at a time from said apparatus into said chamber for desiccation therein while said desiccation of said waste liquid is continued in said chamber, and withdrawing from said chamber vapor and solid particles resulting from the desiccation of said waste liquid and solid material therein while said desiccating of said waste liquid and solid material is continued in said chamber.

5. In a vehicle including a heated chamber, apparatus for accumulating waste liquid and solid material in discrete packages, and a plurality of containers of other waste liquids of different types, said waste liquid and solid material and other waste liquids of different types accumulated aboard said vehicle while on a mission in space, the method of managing the disposal of said packages of said liquid and solid material and said other waste liquid in said chamber in space, which comprises accumulating said other waste liquids of different types in said containers, each container having one of said other different liquids, selectively transferring said other liquids of different types one at a time into said chamber from time to time, continuously desiccating said other different liquids in said chamber into a vapor, accumulating said liquid and solid material in discrete packages in said apparatus while said other different liquids are being desiccated in said chamber, transferring said packages one at a time from said apparatus into said chamber for desiccation into vapor and solid particles thereon while said other different waste liquids are being desiccated in said chamber, and withdrawing said vapor and solid particles from said chamber from time to time.

6. A system of managing the disposal of waste liquid and solid material accumulated aboard a spacecraft on a mission in space, comprising in combination means including a hollow stand for accumulating said liquid and solid material in a package, a heated chamber for continuously desiccating waste liquid and solid material therein, said chamber having an opening located at one end thereof and aligned with said hollow stand, and piston means movable in said chamber to block said opening at said one end thereof during the packaging of said liquid and solid material in said hollow stand, said piston means further movable in said chamber to unblock said opening at said one end thereof from dumping said package from

said hollow stand into said chamber, said piston means additionally movable in said chamber for storing said last mentioned package at an end of said chamber opposite to said one end thereof.

7. The system according to claim 6 which includes valve means connected to said opposite end of said chamber for withdrawing therefrom vapor and solid particles resulting from the desiccation of said package of waste liquid and solid material in said chamber.

8. A system for managing the disposal of waste liquids of different types accumulated aboard a spacecraft on a mission in space, comprising in combination a plurality of containers for accumulating said waste liquids of different types, each container having at least two openings, one through which one of said different liquids is loaded therein and the other through which said last-mentioned one different liquid is dumped therefrom, enclosed means for continuously desiccating waste liquid therein and including an opening, first valve means interconnecting said containers other openings and said desiccating means opening for selectively transferring desired amounts of said different types of waste liquid one at a time from said respective containers into said desiccating means, and second valve means connected to said desiccating means for withdrawing therefrom vapor resulting from the desiccation of said different waste liquids therein.

9. A system for managing the disposal of waste liquids and solid material accumulated aboard a dirigible vehicle on a mission in space, comprising in combination means including a hollow stand for accumulating waste liquid and solid material in discrete packages one at a time, a plurality of containers for accumulating waste liquids of different types, each of said containers having one opening for loading of one of said different liquids thereunto and the other through which said last mentioned one different liquid is withdrawn therefrom, a heated chamber for continuously desiccating said waste liquids and packages therein, said chamber including at least two openings, one of which is located at one end in alignment with said stand and the other located at the opposite end and connectable with said other openings of said containers, means movable in said chamber to block said one opening thereof during the accumulation of said waste liquid and solid material in said discrete packages, said movable means further movable in said chamber to unblock said one opening thereof for transferring said discrete packages one at a time from said hollow stand into said chamber, said movable means additionally movable in said chamber for storing said packages at an end of said chamber opposite to said one end thereof, means for selectively connecting said chamber sleeve opening with said other openings of said containers one at a time for transferring desired amounts of said different waste liquids one at a time from the respective containers into said chamber, and means connected to said chamber for withdrawing from said chamber vapor resulting from the desiccation of said waste liquid and solid material therein.

10. An accumulator of waste liquid and solid material produced aboard a vehicle on a mission in space, comprising in combination a hollow stand having one end attached to a deck of said vehicle and open at its opposite end, a set formed with an axial opening corresponding with that of said stand, a tubular member formed with a plurality of holes, one end of said member secured to said seat in coaxial relation therewith, a first tubular bag unsealed at one end and sealed at the other, said bag formed with a plurality of microholes pervious to gas and substantially impervious to said waste liquid and solid material, said bag disposed interiorly of said member with its sealed end at the free end thereof and its unsealed end projecting exteriorly of said member and disposed over

said seat, a second tubular bag sealed at one end and unsealed at the opposite end and impervious to gas and said waste liquid and solid material, said second bag disposed on the outside surface of said member with its unsealed end adjacent to said seat and its sealed end enclosing said free end of said member, a liquid absorbent liner disposed between said second bag and member, said seat, member, first and second bags and liner disposed in the free end of said stand, and adjustable means mounted on said seat to engage the outer surface of said first bag in proximity of said seat opening, said last mentioned means adjustable to one position to allow said unsealed end of said first bag to remain open to receive a charge of said waste liquid and solid material therein, said last mentioned means adjustable to another position to close the unsealed end of said first bag to the reception of a further charge of said waste liquid and solid material therein.

11. An accumulator of waste liquid and solid material produced aboard a vehicle on a mission in a spacecraft, comprising in combination a seat having a central opening, a porous tubular member secured to a surface of said seat in coaxial relation therewith, a first bag sealed at one end and unsealed at the other, said first bag disposed inside said member so that said unsealed end of said bag is spread out over said seat, said first bag pervious to gases and substantially impervious to said liquid and solid material, a second bag sealed at one end and unsealed at the other, said second bag impervious to said waste liquid and solid material, said second bag disposed on the outside of said member with its unsealed end adjacent to said seat and its sealed end enclosing the free end of said member, and a liquid absorbent liner disposed between said second bag and said member.

12. The accumulator according to claim 11 in which the sealed end of said first bag includes a tab projecting externally coaxially therewith, and said one end of said second bag is provided with a central slit whereby said tab projects through said slit for expeditiously demounting said first and second bags from said member.

13. The accumulator according to claim 10 in which said adjustable means comprises an iris valve contractable to constitute said one position for allowing said unsealed end of said first bag to remain open and expansible to constitute said other position for closing said unsealed end of said first bag.

14. The accumulator according to claim 10 in which said adjustable means comprises a pair of opposing jaws retracted to constitute said one position for allowing said unsealed end of said first bag to remain open abutting to constitute said other position for closing said unsealed end of said first bag.

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