UNCLASSIFIED

AD NUMBER
AD243608
LIMITATION CHANGES
TO: **Approved for public release; distribution is unlimited.**
FROM: **Distribution authorized to U.S. Gov't. agencies and their contractors; Administrative/Operational Use; MAY 1960. Other requests shall be referred to Aeronautical Systems Division, Wright-Patterson AFB, OH 45433.**
AUTHORITY
AMRL ltr, 29 Jul 1970

THIS PAGE IS UNCLASSIFIED

WADD TECHNICAL REPORT 60-290

WASTE COLLECTION UNIT FOR A SPACE VEHICLE

J. Des Jardins
J. D. Zeff
R. A. Bambenek

American Machine & Foundry Company

MAY 1960

Contract No. AF 33(616)-6132

WRIGHT AIR DEVELOPMENT DIVISION

WADD TECHNICAL REPORT 60-290

WASTE COLLECTION UNIT FOR A SPACE VEHICLE MR 1092

J. Des Jardins
J. D. Zeff
R. A. Bambenek

American Machine & Foundry Company

MAY 1960

Contract No. AF 33(616)-6132
Project No. 6373
Task No. 63122

AEROSPACE MEDICAL DIVISION
WRIGHT AIR DEVELOPMENT DIVISION
AIR RESEARCH AND DEVELOPMENT COMMAND
UNITED STATES AIR FORCE
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

400 – September 1960 – 1-28

FOREWORD

This report was prepared by the Mechanics Research Division of the American Machine & Foundry Company, Alexandria, Virginia under Contract AF 33(616)-6132, with the Aerospace Medical Division, Wright Air Development Division. The work reported herein was performed in support of Project No. 6373, "Equipment for Life Support in Flight Operations," Task No. 63122, "Refuse Management," with Messrs. Courtney A. Metzger and R. Bennett, Task Scientists, Survival and Crew Maintenance Section, Engineering and Development Branch, successively acting as contract monitors.

Recovery of drinking water from urine was also studied in support of the same Project and Task under Contract AF 33(616)-5783 with the American Machine & Foundry Company. This work is reported in WADC Technical Report 58-562 (parts I and II), Development of a Unit for Recovery of Water and Disposal or Storage of Solids from Human Wastes.

ABSTRACT

This study was conducted to develop a unit to collect and package human waste in a space vehicle designed for missions from three days to one year. Physiological processes of defecation and micturition described in the literature were reviewed, and waste collection systems used in related areas were surveyed. Molds of a human posterior and anal area were constructed and preliminary design of six feces collection systems were analyzed. The recommended waste collection system, as fabricated, incorporates a pneumatic system which controls the movement of waste material and obnoxious gases by positive pressure differences and/or frictional drag forces. The pneumatic system could be replaced by one which allows cabin gases and flatus to be discharged to outer space.

PUBLICATION REVIEW

Wayne H. McCandless

WAYNE H. McCANDLESS
Chief, Life Support Systems Laboratory
Aerospace Medical Division

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

SECTION 1

INTRODUCTION

Project Objectives

The objectives and scope of this project were established by the Aerospace Medical Division. Essentially, the scope of the work is to develop a unit for a space vehicle to collect and package human waste. After being packaged these wastes can then be processed, if required, to usable products.

The unit was specified to operate on missions of three days to one year and was required to be of minimum size and weight. The working parts of the unit were to be of noncorrosive materials and to be used only by male personnel. Other requirements of the waste collection unit are enumerated as follows:

1. Urine will be collected separately from the solids.

2. The design of the urine-collector will be such that it can be used either separately or in conjunction with the solid collector.

3. No additives or chemicals are to be used to preserve the wastes since these materials may interfere with the reprocessing of the wastes.

4. The unit shall be of sanitary design, so it can be easily disassembled and cleaned.

5. The unit shall be designed to operate efficiently without the use of power, water or additional equipment. All produced urine will be reclaimed for processing into drinking water and none will be used for sanitation or the operation of the unit.

6. The unit is to be designed to operate efficiently in a cabin pressure of approximately 0.5 to 1 atmosphere in a closed ecological system where a weightlessness condition exists.

7. The unit is to be designed so that the solid wastes can be packaged or sealed in a container for either storing for the duration of the mission or for processing sometime later.

8. Provision for odor control and elimination should be incorporated in the unit, so that the odors cannot be detected by the crewmembers.

An original objective of the program was to incorporate the waste collection unit in a standard aircraft seat. However, this objective was

---

Manuscript submitted by the authors for publication as a WADD Technical Report January 1960.

eliminated early in the program because manned flights into space, as envisioned, will begin with relatively small vehicles containing only one man, and will be planned for missions no longer than approximately one day, e.g., NASA's Project Mercury. For such a mission it will be necessary to collect and store urine, but not feces. Therefore, these initial missions do not require a complete waste collection unit. Since urine could be collected by a portable unit while the man occupied a standard aircraft seat, no modifications of the seat would be necessary.

However, when experience in manned space flight is acquired, longer missions can be achieved and larger vehicles and crews will be required. Then, a complete waste collection unit will be essential for missions that are longer than three days, requiring more than one crewmember. However, for such missions, a weight and volume savings can be realized if only one waste collection unit is provided. This unit could be built into one of the crewmember's seats or be located separately. If it is built into one of the seats, it would be necessary for two men to change seats when a crewmember other than the occupant of the waste collection seat found it necessary to defecate. Such a maneuver may not be feasible with a two- or three-man crew.

Procedure

The study was divided into four phases: background study, design analysis, detailed design of the recommended unit, and the fabrication program.

The background study was devoted to a literature and industry survey and included the following subjects:

1. Physiological processes pertaining to defecation and micturition
2. Waste collection systems used in long-range military aircraft and collection devices utilized in hospitals
3. Anatomy of the anal area.

Contemporary knowledge of elimination processes in the absence of gravitational forces was sought, but none was found. The results of the background study are presented in the next section.

For the design analysis, three basic techniques for the collection of feces were formulated and analyzed by means of theoretical considerations. The most feasible technique was further analyzed by considering four possible design versions. The recommended system was thus obtained and is described in Section 4 of this report.

Fabrication details and photographs of the final assembly are presented in Section 5.

SECTION 2

BACKGROUND STUDY

Physiological Processes

To design a waste collection system that will function properly in the absence of gravitational forces, it is necessary to understand the manner in which urine, feces and flatus are discharged from the body under these conditions. Unfortunately, no known studies of these processes have been performed, because sufficiently long periods of time in a weightless state have not been attainable (ref. 1). It is, therefore, necessary to understand the elimination process under the influence of gravity and deduce the effect of weightlessness. The processes of micturition and defecation are described as follows:

Micturition (ref. 2) - The physiological processes involved in micturition are enumerated in stepwise fashion as follows:

1. The urge to micturate generally arises when 400 ml of urine have collected in the bladder.

2. There is a voluntary removal of restraint, releasing the reflexes of micturition. These reflexes involve the contraction of the bladder and the release of the sphincters.

3. In the case of the contents of the bladder being small in volume, the reflex processes of evacuation may be set in motion by the voluntary contraction of the abdominal muscles by which the pressure in the bladder is increased and the sphincter action reflexly inhibited.

During micturition, urine can be evacuated with considerable force, since the internal absolute pressure within the bladder can be as high as 130 cm of water (ref. 3).

Defecation (ref. 3) - Referring to the semidiagrammatic view of the large intestine in figure 1, the process of defecation is explained in stepwise fashion.

1. The feces are usually stored in the pelvic colon until defecation takes place.

2. When the obstacle of the pelvirectal sphincter is overcome by mass peristalsis, and the feces distend the rectum (a pressure of 30 to 40 mm Hg is sufficient), a perineal sensation is felt which awakens the urge to defecate.

3. Defecation is a reflex. Distention or stimulation of the rectum by movement of the feces within it or the anal canal provokes reflexly a strong wave of mass peristalsis, contraction of the rectum, and relaxation of the internal and external anal sphincters, thus emptying the large intestine from the transverse colon down.

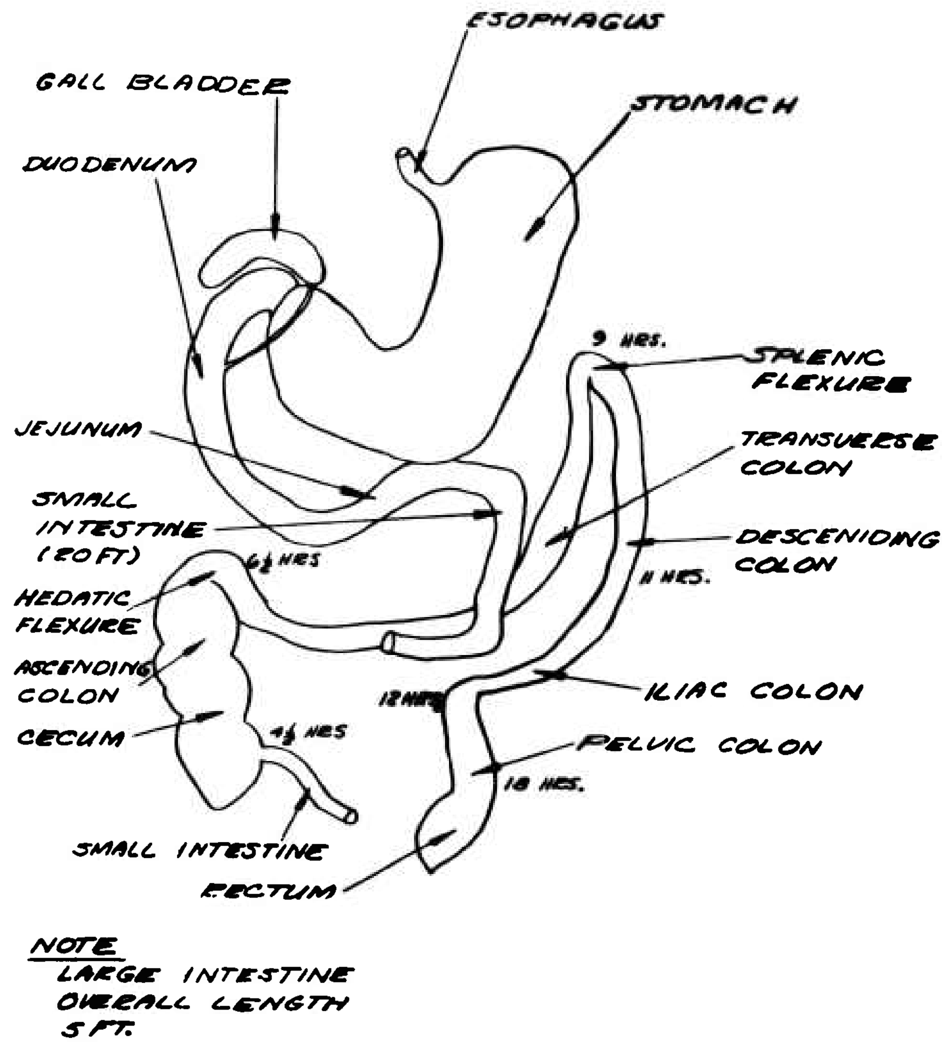

Figure 1. Digestive and Elimination System

4. The emptying of the large intestine is helped by the simultaneous contraction of the diaphragm and of the abdominal muscles, which increased abdominal pressure, and that of the levatores ani and other perineal muscles which sustain the perineum and help to evacuate the last remaining portions of the rectal contents.

5. The average man eliminates 100 - 150 gm of feces per day containing 20 - 25 gm of dry material.

6. The average adult on a normal diet discharges approximately 1 liter of flatus per day (ref. 4).

Conclusions - The processes of defecation and micturition are basically dependent upon muscular action or peristalsis rather than external forces such as gravity. It can therefore be deduced that the absence of gravitational forces will not alter the basic elimination processes and a waste collection system designed on this premise will function in an effective manner.

Waste Collection System

An industry and literature survey was performed to determine if waste collection equipment used in other fields might be adapted for use in a space vehicle. The main sources of information were aircraft companies, U.S. Air Force personnel, and hospital supply companies.

Aircraft Systems - In long range military aircraft, urine is collected in waste tubes or urine bottles (ref. 5). These devices contain a cup-shaped penis receptacle which is connected by means of a tube to either a centrally located storage container or airlock exit from the aircraft. These systems are unreliable when not kept clean since solids from urine deposit and block the passage of urine, thus causing the backflow of urine. These systems could not be adapted to a space vehicle because they do not provide a leak-proof seal around the penis. Past experience with these systems indicates that even under the influence of gravity, a positive pressure difference must be maintained in order to prevent the backflow of urine.

Long-range military aircraft, such as the B-47 and B-52 do not have any provisions for collection of feces. Commercial aircraft contain chemical toilets or electrical incinerator toilets. Such systems are not compatible with the established requirements.

Sickroom Devices (ref. 6,7) - The only sickroom device which might be adapted is the belt-type urinal used for bedridden patients (fig. 2). It is formed of rubber and has a penis receptacle containing a diaphragm for preventing backflow of urine while the patient is lying in a supine position. This seal technique is reliable and could be adapted to the waste collection unit.

Conclusions - The only contemporary waste collection device which can be adapted to a space vehicle is the penis receptacle of a belt-type urinal used for bedridden patients. Such a receptacle when used in conjunction with a system which provides a positive pressure differential could provide a reliable urine collection unit.

Anatomy

To control the movement of urine, feces, and flatus after discharge from the body requires the use of a suitable seal between the respective discharge areas and the collection unit. For the collection of urine, the aforementioned penis receptacle and seal diaphragm satisfy this requirement, and detailed studies of the anatomy of the penis were not necessary. However, for the anal area, no such seal designs were available. To study the topographic anatomy of this area, suitable molds were prepared using a human subject.

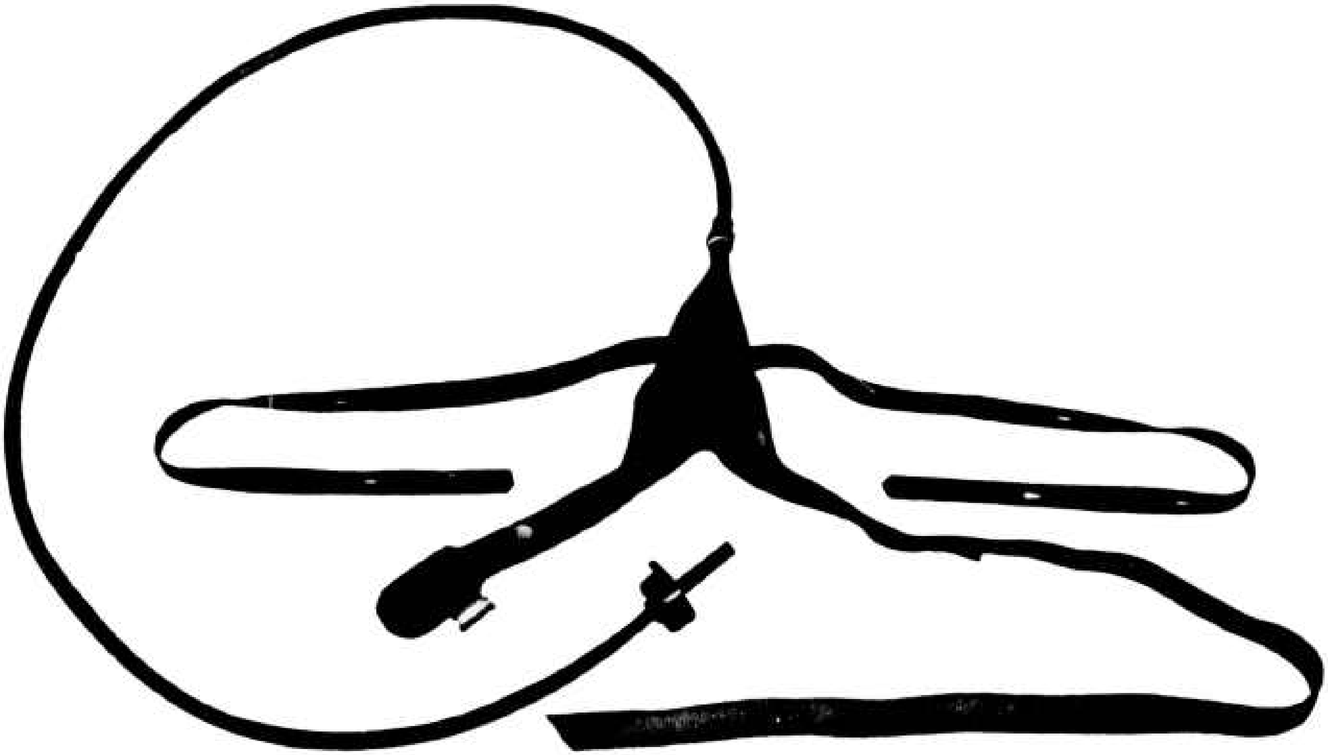

Figure 2. Male Urinal

To form the molds, the subject was shaven around the anus, and two molding techniques were utilized. First, to obtain a negative mold of the anal area, 50 pounds of molding plaster was mixed with water, placed in a polyethylene wash basin and then covered with a 2-mil-thick film of vinyl plastic. The basin was then placed on the floor next to a wall, and the subject squatted so as to impress the anal area and part of his posterior in the plaster-water mixture. The subject remained in this position for approximately 15 minutes, at which time the mixture had become tepid. The resultant negative mold and a wax positive mold are illustrated in figure 3. The positive mold illustrates the complicated topography of the anal area.

For the second molding technique, the subject was prone on a table, face down, with his feet on the floor. The subject's posterior and anal area were coated with a thin film of petroleum jelly and then covered with small patches of cotton gauze. A plaster-water mixture was then applied. The subject remained in this position for approximately 15 minutes, at which time the mixture had become tepid. Figure 4 illustrates the negative mold and a positive mold made from dental wax. This molding technique did not clearly indicate the complete anal perimeter, especially near the scrotum; because the steep angle, with respect to the horizontal, made it difficult to retain the mixture-covered gauze on the subject while in the specified position. However, the mold did indicate the topography of the buttocks and their relation to the anus.

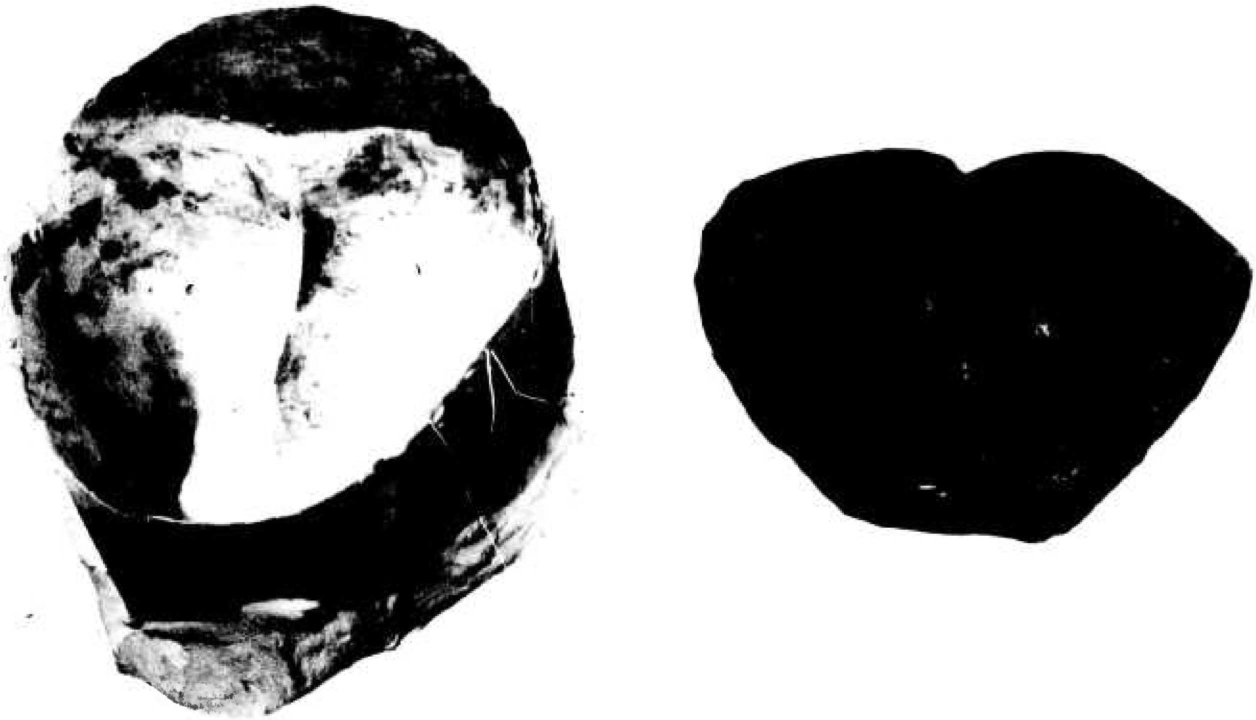

Figure 3. Mold of Anal Area

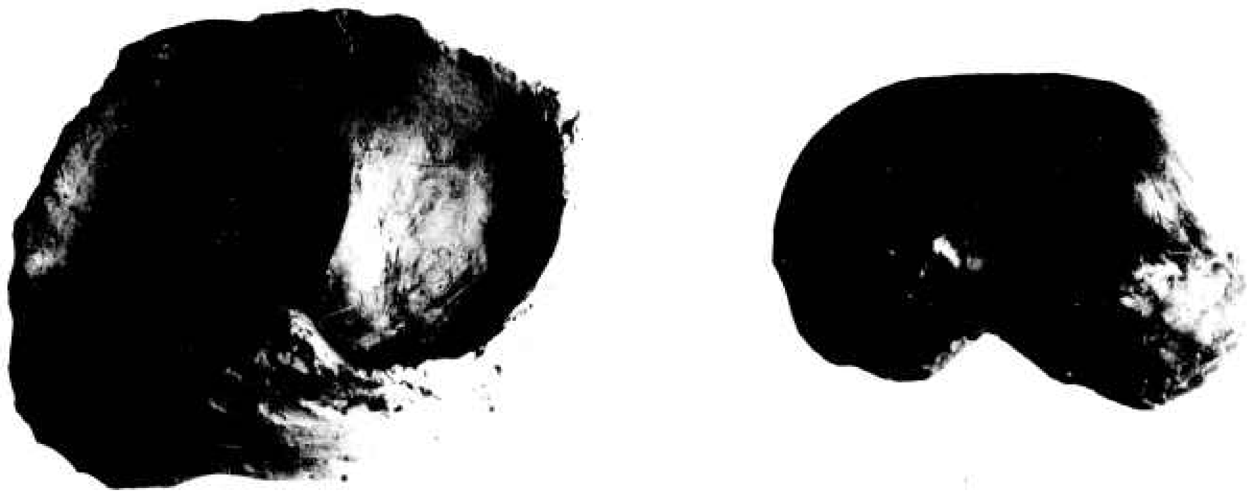

Figure 4. Mold of Human Posterior

The subject used for these molds had the following physical dimensions:

Height:	5 feet 8 inches
Weight:	160 pounds
Waist:	34 inches
Leg:	29 inches

SECTION 3

DESIGN ANALYSIS

Feces Collection Techniques

A number of waste collection techniques designed to operate in the absence of gravity were investigated: (1) a material to absorb the feces and flatus, (2) a collector inserted into the anus, and (3) a container whose interior is at a lower pressure than its surroundings. These various techniques and detailed descriptions of their operation are enumerated as follows:

Magnetized Absorbent Clay Collector - To operate the system illustrated in figure 5, the man removes caps from the seat and container, connects pressure and vacuum lines to the container and inserts the container into the seat. He then straps himself into the seat, with his anus positioned over the container, and operates the hand pump. A partial vacuum in the container seals the perineal area to the top of the container, which follows the contour of the perineum. The excess air from the collector is exhausted to the cabin by means of a relief valve. This excess air travels from the container through the deodorizer, the entrainment separator, and finally to the hand pump to the relief valve.

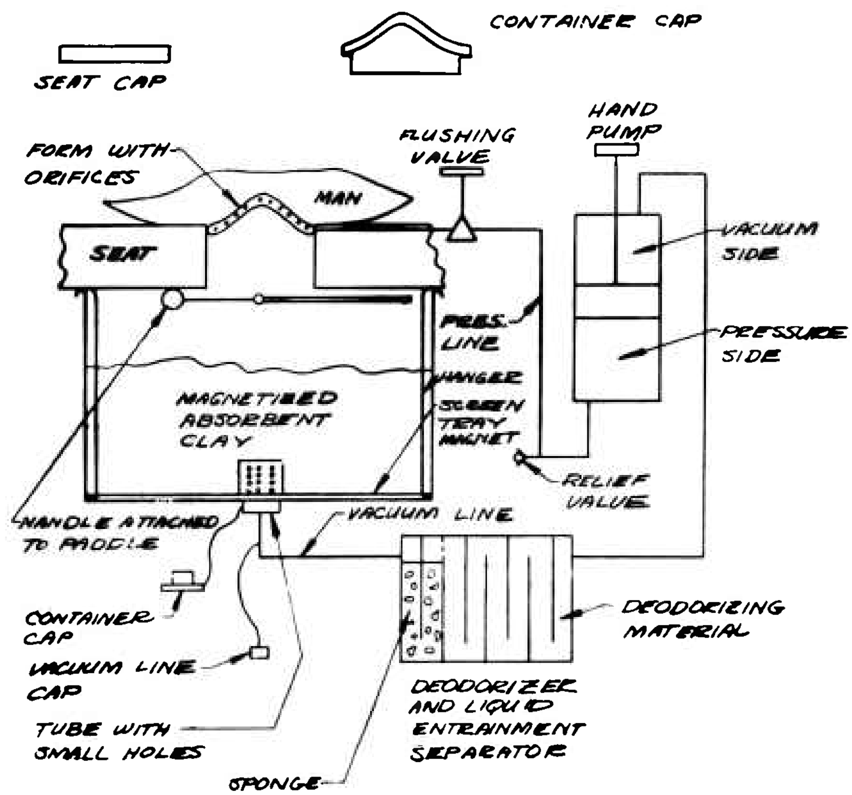

Figure 5. Reusable Magnetized Absorbent Clay Feces Collection System

The user then forms a cavity in the magnetized clay by means of the paddle. The surface of the clay is not prepared for receiving the feces.

During defecation, the pump is operated as required to maintain the partial vacuum. When defecation is complete, the flushing valve is opened and the hand pump operated. The air and gases from the container are then circulated through the tube, vacuum line, deodorizer, pump, pressure line, the sealing form, and back into the container. Pumping is continued until the odor is removed from the gases and the jets of air from the small orifices in the sealing form have forced the feces into the depression in the surface of the clay. The user then removes himself, wipes his anal perimeter and flushes the paper into the clay by means of the hand pump. The operation is completed by capping the container, disconnecting the pressure and vacuum lines, removing the container and capping the seat. The clay then absorbs the water from the feces leaving behind a dry residue coated by the magnetic clay.

When the container is full, it is possible to remove the dried feces and paper by lifting out the screen tray. The clay will sift through the screen and cling to the magnet, leaving the feces and paper on the tray.

Absorbent clay is now used for household pets (e.g., "Kitty Litter" for cats).

An experiment was performed by MRD to determine if this clay could be used without a pneumatic system. To perform the experiment, the subject squatted and sat on a shallow pan which contained the clay. When defecation began, it was noted that the clay caused resistance to discharge of the feces. Consequently, defecation could not be accomplished in a normal manner. Therefore, it was concluded that to use the clay, it would be necessary to position the anus a sufficient distance above the surface of the clay and guide the feces into a depression.

Since guidance of the feces would be required for this collection technique, it was concluded that no distinct advantage could be gained in a system using magnetic clay.

The Anal Insert Collector - From the previous technique we deduced that the feces must be guided from the anus into a retention device. Therefore, we investigated a means by which a conduit could be inserted into the anus, thus providing guidance and preventing flatus from escaping into the cabin atmosphere. Figure 6 illustrates the basic components of such a collection technique.

With the unit shown in figure 6, the user removes caps from seat and container, inserts the container from under the seat, and connects the pressure line to the container. He straps himself into the seat with his anus positioned over the container and inserts it into his anus from under the seat. The man is now prepared to defecate.

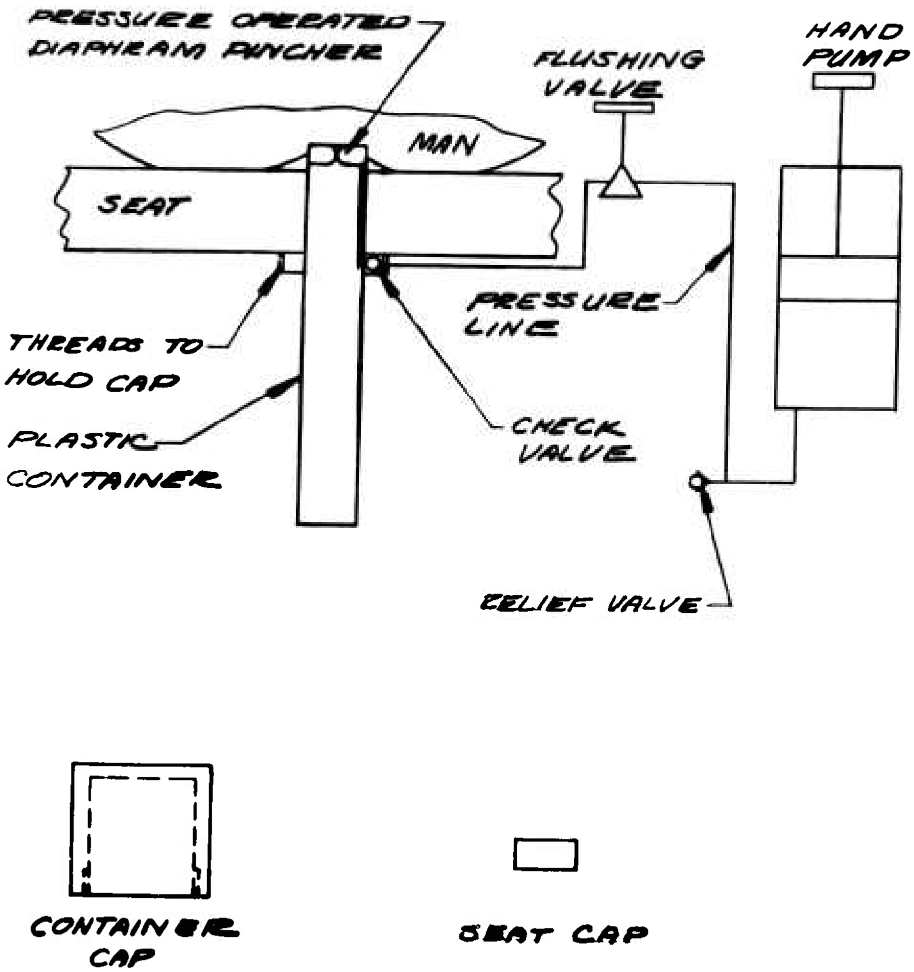

Figure 6. Insert into Anus Pneumatic Feces Collection System

After defecation, the flushing valve is opened and the hand pump is operated, expanding the pressure-operated diaphragm pincher which closes the container and separates the feces from the man. The relief valve in the pressure line acts as a safety valve to prevent over-pressurization and rupture of the diaphragm. The pressure line is then disconnected and the air within the diaphragm is contained by means of the check valve. The container is then removed from the seat, capped, and the seat cap replaced to complete the operation.

This method requires the least amount of equipment and space, but physiologically the system was found to be impractical. Holding the container within the rectum was impossible, since the perineal sphincter muscles must expel any insert along with the feces during the act of defecation. Also, to make the rigid container disposable would require large storage volume.

Operation by Outside Vacuum - Guidance of the feces from the anus into the collection device can be accomplished by means of aerodynamic drag forces. To produce these forces it is necessary to pass a gas over the feces in the direction of movement desired. Controlled gas motion requires a pressure differential. Since the cabin atmosphere is at a higher pressure than the external pressure, the required gas motion could be induced by venting a portion of the cabin gas through the collection system to the external environment. Figure 7 illustrates a feces collection system which vents cabin gas to this environment.

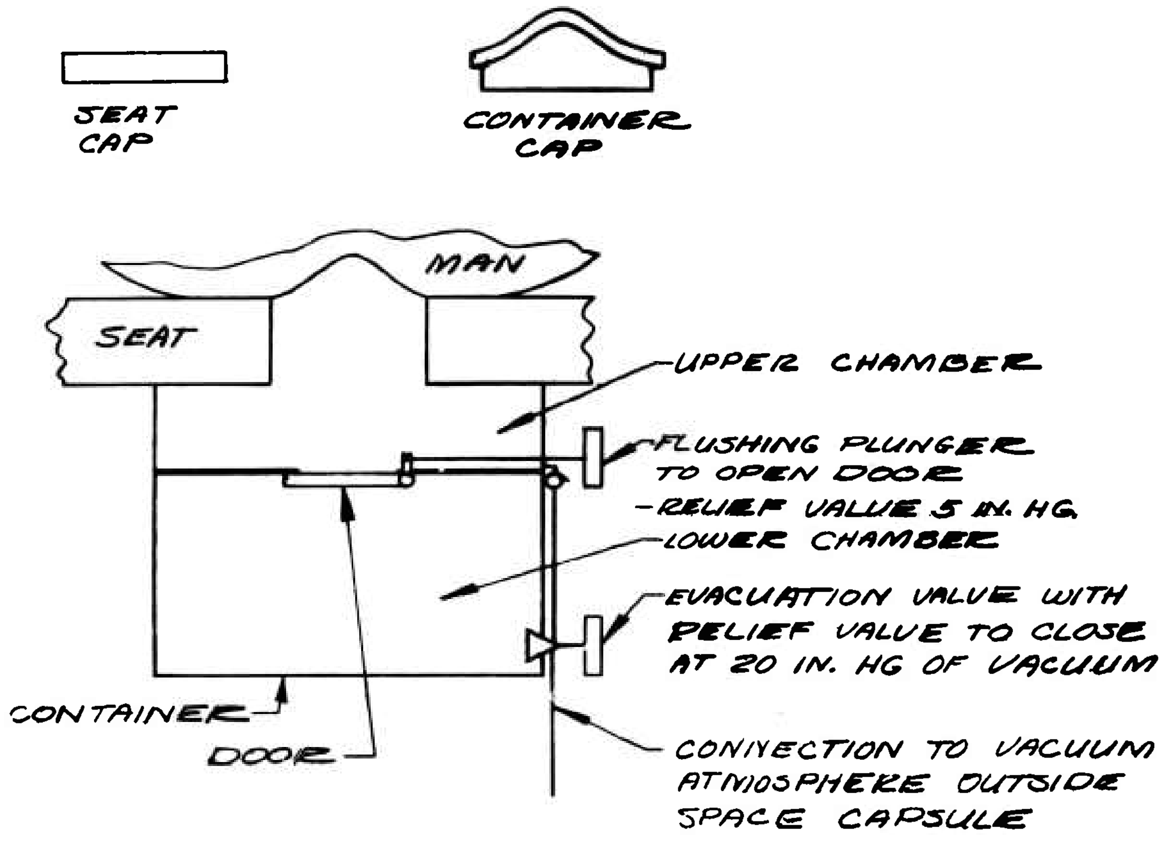

Figure 7. Feces Collection System Operated By Outside Vacuum

In figure 7, the man removes the seat and container caps and inserts the container from under the seat. He straps himself into the seat with his anus positioned over the container opening and opens the evacuation valve. The upper and lower chambers are evacuated to different pressure levels; e.g., 20 inches Hg and 5 inches Hg absolute, respectively, at which time their respective relief valves operate to prevent further evacuation. Evacuation creates a seal between the man's perineum and the top of the container.

During defecation the feces are discharged into the upper chamber where they will merely "float."

After defecation, the door between the two chambers is opened by operating the flushing plunger. The gas, feces, and flatus in the upper chamber flow into the lower chamber. The operation is completed by capping the container, disconnecting the vacuum line, removing the container, and capping the seat.

This method of feces collection would produce sufficient guidance of feces between the anus and lower chamber where it could be stored. This system would also prevent flatus from escaping into the cabin. The undesirable features found in the application of this technique are as follows:

1. Feces which contact the walls of the upper chamber would contaminate those surfaces. Thus, to maintain sanitary conditions, the crewmembers would be required to clean the upper chamber frequently.

2. To partially evacuate the entire lower chamber (storage volume) for every defecation would require the venting of relatively large amounts of cabin gas every time a crewmember defecated.

Collapsible Container Collector - It was determined that aerodynamic drag forces could also be induced by means of an expanding bellows-type feces collector. With such a device it would not be necessary to vent cabin gas, nor purify the gases which would be collected and sealed in the container. Figure 8 illustrates such a system.

To operate the system, the man removes the seat and container caps, attaches the inlet gas line to the form and connects the wire to the bottom of the container. He straps himself into the seat with his anus positioned over the container and manually collapses the container. The release button is set at the stop position and the handle turned to increase the tension on the clock spring. The release button is now released and the container partially opened by the spring force creating a vacuum within the container that seals the man's perineum to the form. The man is now prepared to defecate.

During defecation the container stays open from the spring force and a vacuum is maintained. After defecation the flushing valve is opened and jets of air from the small orifices in the form enter, forcing the feces deep into the container as it continues to open under spring force.

The pinchers are operated, squeezing the container shut and sealing the feces in the bottom of the container. The man removes himself and wipes his anal perimeter, placing the paper into the container. The container is capped, the inlet line connection broken, and the wire disconnected. The container is removed from the seat and the seat opening capped to complete the operation.

This technique requires a small amount of equipment and it has the potential capability of requiring a very small amount of cabin gas for feces guidance. However, certain disadvantages of this system are evident, namely:

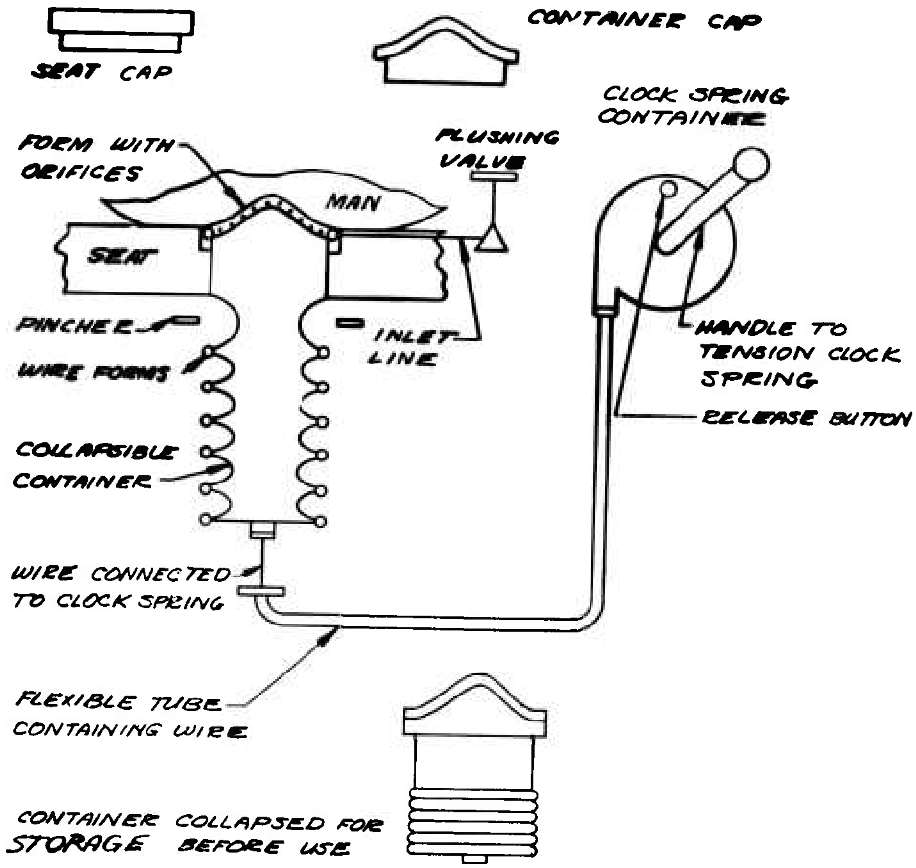

Figure 8. Pneumatic Feces Collection System with Collapsible Container

1. The container has an irregular inner surface which would be difficult to clean if the container was to be reusable.

2. A constant spring tension would enable the container to suck-in cabin gas if the crewmember broke the seal between his perineum and the form.

Reusable Container Collector - Figure 9 illustrates a system which uses a reusable container and hand pump operated pneumatic system. The operation is as follows:

The man removes seat and container caps, attaches pressure and vacuum lines to the container, and inserts the container in the seat. He straps himself into the seat with his anus positioned over the container and operates the hand pump. A vacuum is created in the container sealing the man's perineum to the container form by exhausting excess air to the cabin through the relief valve. The excess air travels from the container through the tube, vacuum line, deodorizer, and pump to the relief valve. The man is now prepared to defecate.

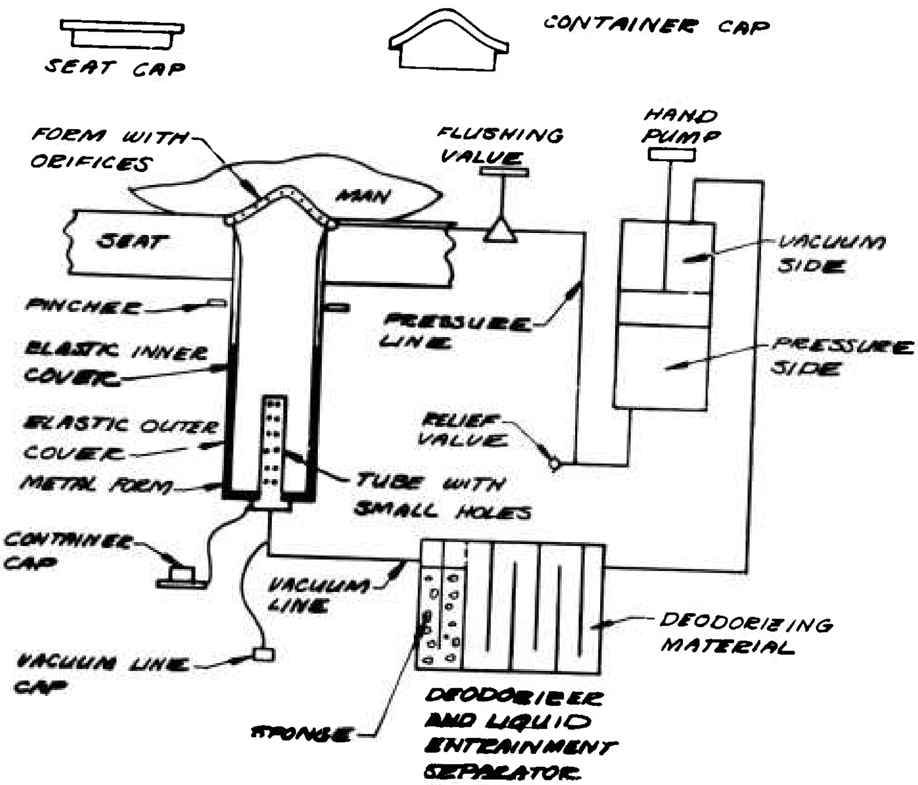

Figure 9. Pneumatic Feces Collection System With Reusable Container

During defecation the pump is operated as required to maintain the vacuum. When defecation has been completed the flushing valve is opened and the hand pump operated. Air and gases from the container circulate through the tube, vacuum line, deodorizer, pump, pressure line, form and back into the container. Pumping is continued until the odors have been removed and the jets of air from the small orfices in the form have forced the feces deep into the container.

The pinchers are operated squeezing the container, sealing the feces in the bottom. The man removes himself, wipes his anal perimeter, and places the paper in the container. The container and vacuum line are capped, pinchers withdrawn and the container is removed from the seat for storage. Replacing the seat cap completes the operation.

This system has the advantage of not requiring the venting of cabin gas, a controlled flow of gas in the container, and a container which could be easily cleaned and reused. The system requires a deodorizer and sorbent material, but this could be regenerated on long-duration missions. Because of these advantages, it was decided to further consider the design variations possible with such a system.

Disposable Container Collector - Another version of the previous technique that was explored was to use a disposable rather than a reusable container. Figure 10 illustrates such a system.

To use, the man removes the seat and container caps, unrolls the container, placing the ring inside with the container overlaying it, and then inserts the assembly in the seat. During insertion the orientation of the ring is maintained so that the male end of the pressure line pierces the container and enters the female receptacle in the ring. He straps himself into the seat with his anus positioned over the container and operates the hand pump. A vacuum is created in the container sealing the man's perineum to the container form by exhausting excess air to the cabin through the relief valve. This excess air travels from the container through the tube, vacuum line, deodorizer, and pump to the relief valve. The man is now prepared to defecate.

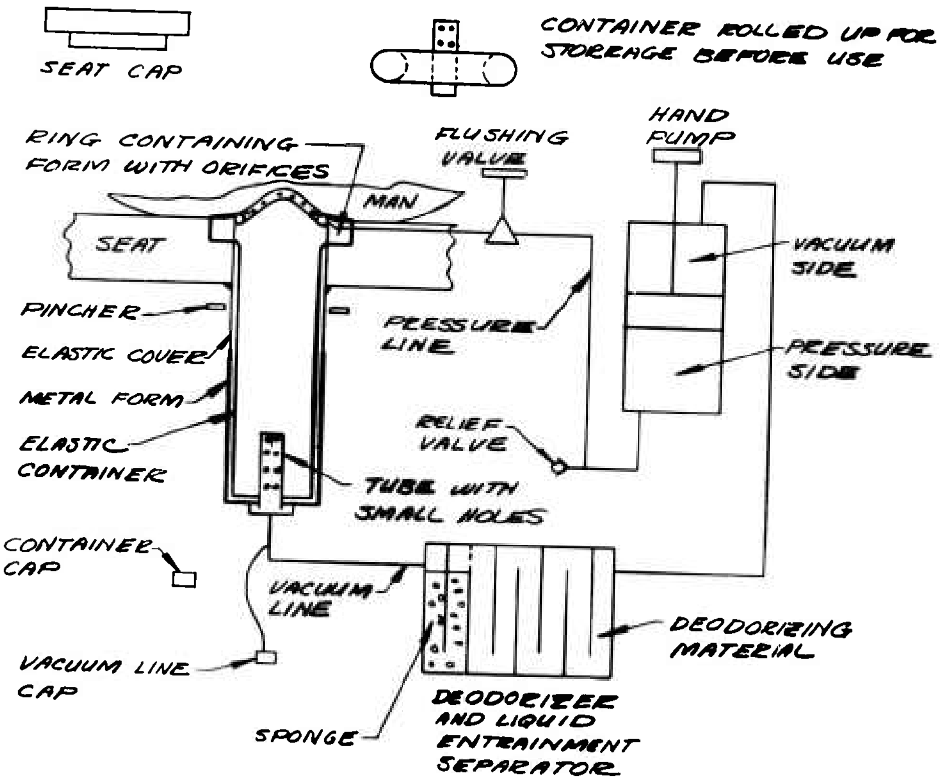

Figure 10. Pneumatic Feces Collection System With Disposable Container

During defecation the pump is operated as required to maintain the vacuum. When defecation has been completed the flushing valve is opened and the hand pump operated. Air and gases from the container circulate through the tube, vacuum line, deodorizer, pump, pressure line, the form and back into the container. Pumping is continued until the others have been removed and the jets of air from the small orifices in the form have forced the feces deep into the container.

The pinchers are operated, squeezing the container, and sealing the feces in the bottom. The man removes himself, wipes his anal perimeter, and places the paper in the container. The ring is removed from the container and the container top is closed with a spring clip. The vacuum line connection to the container is broken and the line and container capped. The container is removed from the seat and the seat capped to complete the operation.

A distinct advantage to this system is that the crewmember's perineum is separated from the collection seat by the disposable container, and feces never contact the seat or system. Sanitary conditions are thus easily maintained.

The systems of figure 9 (reusable container) and figure 10 (disposable container) are of similar design. The associated mechanical equipment is light in weight and easily stored under a minimum size seat. The feces collection containers are small in volume in comparison to the other systems since flatus and flushing air that pass through the container are deodorized and then vented to the cabin.

Urine Collection Techniques

The collection of urine in the absence of gravity is not as difficult as the collection of feces, since urine is imparted with a velocity when expelled from the penis. The sick-room type, self-sealing penis receptacle discussed in Section 2 is readily adapted to the purposes of a space vehicle. However, the container to collect and retain the urine offered more difficulty in design. Therefore, the collection container was the primary subject of investigation. Two methods were considered.

The first system depends upon a bladder or bag that is evacuated pneumatically by a hand pump. The evacuation of the system would be either independent of the feces collection device or integrated with it, depending upon mission length and crew size. However, this system would be relatively complicated in comparison to the following system.

The second system considered for collecting urine consisted of a bellows-type collapsible container. In this study, urine was to be collected for reprocessing, so it was necessary to physically transfer the urine from the container to the water recovery system. Figure 14 on page 21 illustrates a system capable of both functions.

To operate, the bellows is squeezed together and the penis is inserted into the attached receptacle. The crewmember then micturates and simultaneously releases the bellows at a rate which still provides a slight vacuum.

A three-way spool valve at the neck of the container would allow the release of the penis by "bleeding off" the partial vacuum when micturition is completed. The valve can then be pushed to the closed position. To unload, the neck of the container is inserted into the collection or processing device, the valve pushed to the open position, and the bellows squeezed to force the urine from the container into the water recovery system.

Gas Absorber Design

It has been found that the composition of human flatus from normal individuals subsisting on an ordinary diet which is free of milk and cabbage is as follows (ref. 4):

Gas	Composition % by Volume
CO_2	9.7
O_2	5.5
CH_4	3.1
H_2	12.0
N_2	70.0
H_2S	0.0001

As seen, the toxic constituents of flatus are hydrogen, methane, and hydrogen sulfide.

Time did not permit a study of the optimum quantity of gas absorbents necessary for this unit. A time chart is also needed to indicate when sorbent replacement is necessary with a given crewmember.

Conclusions

In the design analysis we found that the most desirable method of collecting feces is a hand-operated pneumatic system utilizing a disposal container similar to that shown in figure 10. This method was considered to be the best compromise among weight, size, and ease of operation.

It was determined that the most suitable method of collecting urine is a self-opening, collapsible container attached to a modified sickroom-type penis receptacle. The collapsible container was found to have the advantage over the bladder-type container of not requiring an external source of evacuating power. Also, the collapsible type has the advantage of ease of transferring the urine into the reprocessing equipment.

SECTION 4

SYSTEM DESIGN

The final assembly drawing is presented in figure 11, and subassembly drawings indicating important details are shown in figures 12, 13, and 14.

Description of Unit as Designed

The seat and support frame comprise the basis of the unit to which all other items are attached. The seat is composed of Fiberglas molded over a composite contour of the two male wax molds discussed in Section 2. The seat back rises on either side against which the operator uses his pelvis as a guide to locate his anus over the container. The slot in the seat is for passage of the feces container sealing form when the sliding drawer is moved forward to place a disposable container over the anal form.

To operate the unit, the sliding drawer center section is pulled forward from under the seat. A rolled, unused plastic container is removed from the storage compartment, unrolled and placed over the anal sealing form. The bottom of the container is forced downward and clipped to the bottom of the drawer section. Simultaneously, the drawer clip pushes aside the container bottom which leads to the vacuum reservoir.

The drawer unit is pushed back under the seat until the quick-disconnect self-sealing coupling on the sliding drawer couples with its mate on the vacuum reservoir. Operation of the hand pump evacuates the vacuum reservoir (approximately 7 psia) to the cabin through the deodorizer. The system is now ready for the operator to defecate.

During flatuation, the push-button closing the vacuum line from the container to the vacuum reservoir is slightly depressed to allow a small air flow through the line. Air enters the container at the top through a porous orifice ring molded to the container. The orifice is located on top of the form and is squeezed between the operator's perineum and the form when the operator is seated in position over the container. The amount of squeeze of the ring and resulting orifice size are controlled by a compression spring mounted behind the form, which is sufficient to create a seal between the form and the operator's perineal area. The low-order vacuum (approximately a difference of 0.5 psi) created in the container prevents flatus from venting to the atmosphere through the orifice. The difference between the large vacuum in the vacuum reservoir and the container vacuum causes the flatus to flow into the reservoir. During defecation, the button is completely depressed, creating the same high vacuum in the container that is in the reservoir. The airflow and velocity across the orifice ring are greatly increased in order to force the feces to the bottom of the container.

Water from the feces and small particles of feces that pass through the screen at the bottom of the container are absorbed in the vacuum reservoir in a polyurethane sponge. This sponge is in a polyethylene bag which is removable when filled to facilitate sanitary removal of the sponge.

At the completion of defecation, the control lever is released and the feces-container pinchers operated. The operator wipes his anal area and

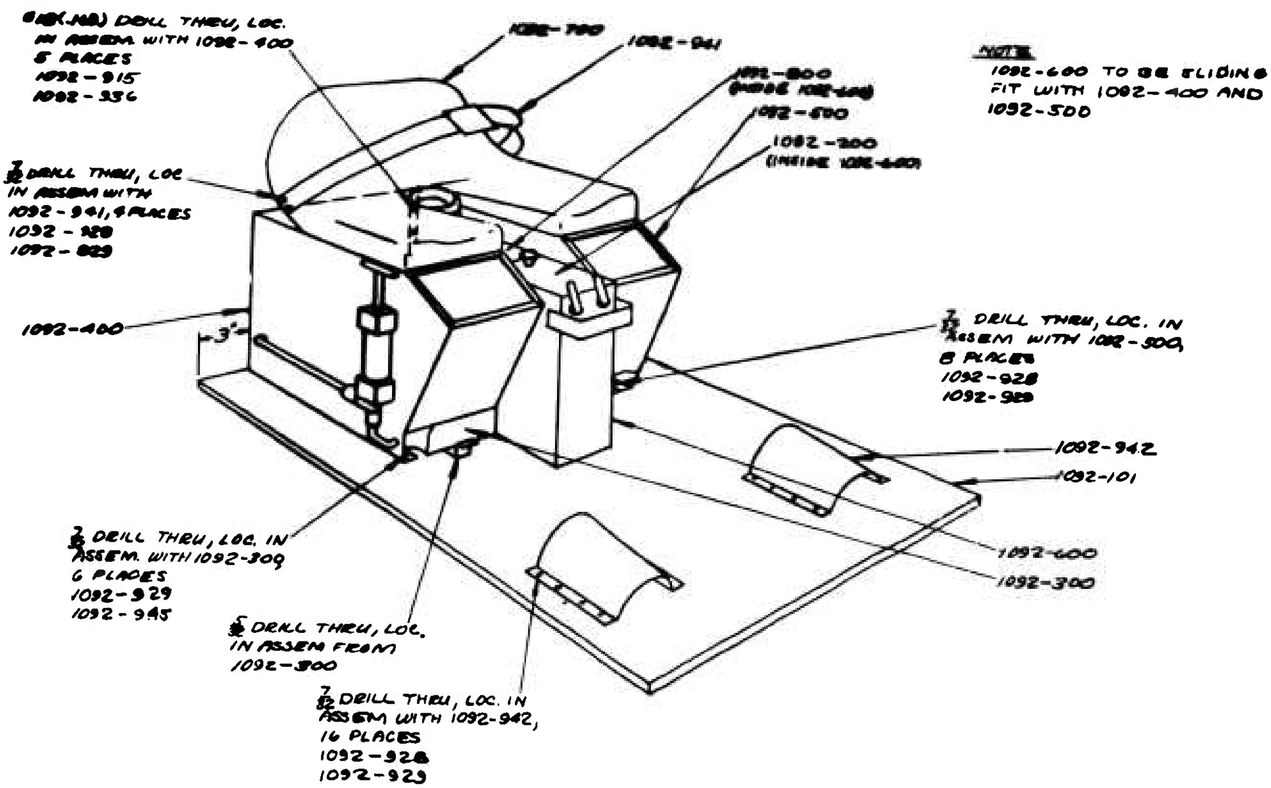

Figure 11. Assembly Drawing of Waste Collection Unit

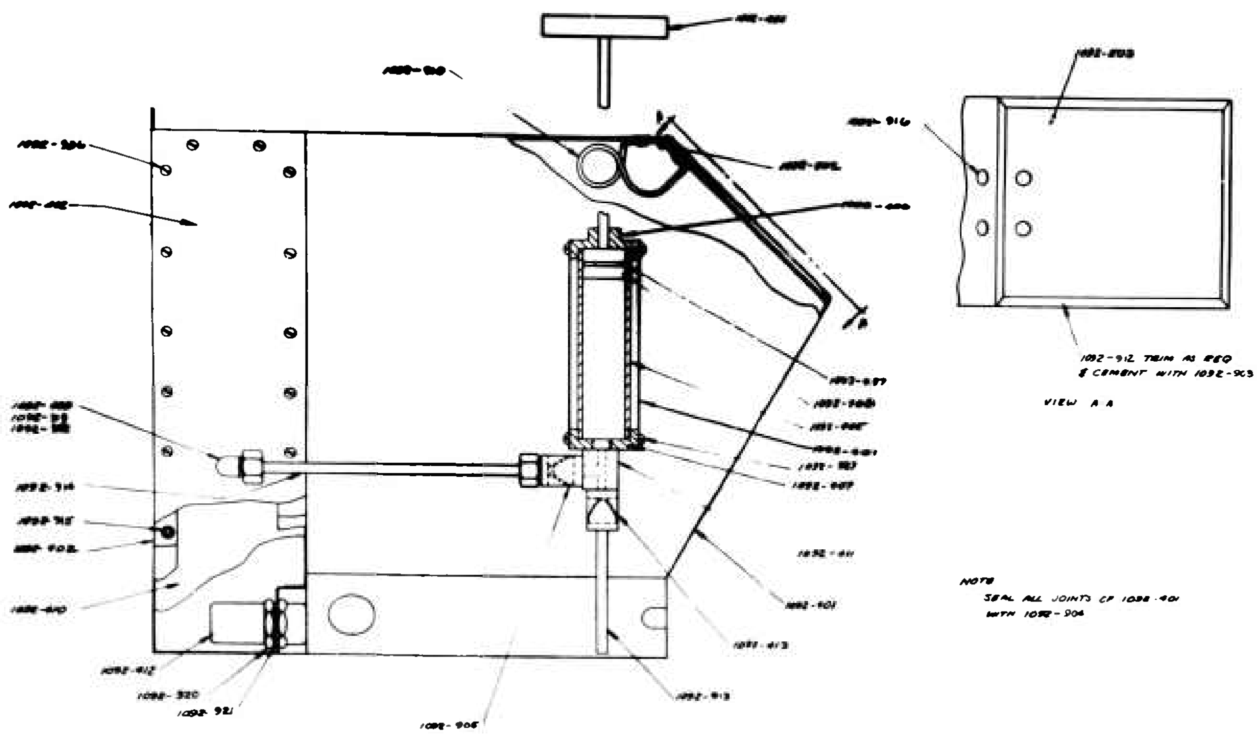

Figure 12. Vacuum Reservoir, Storage Container and Hand Pump Assembly

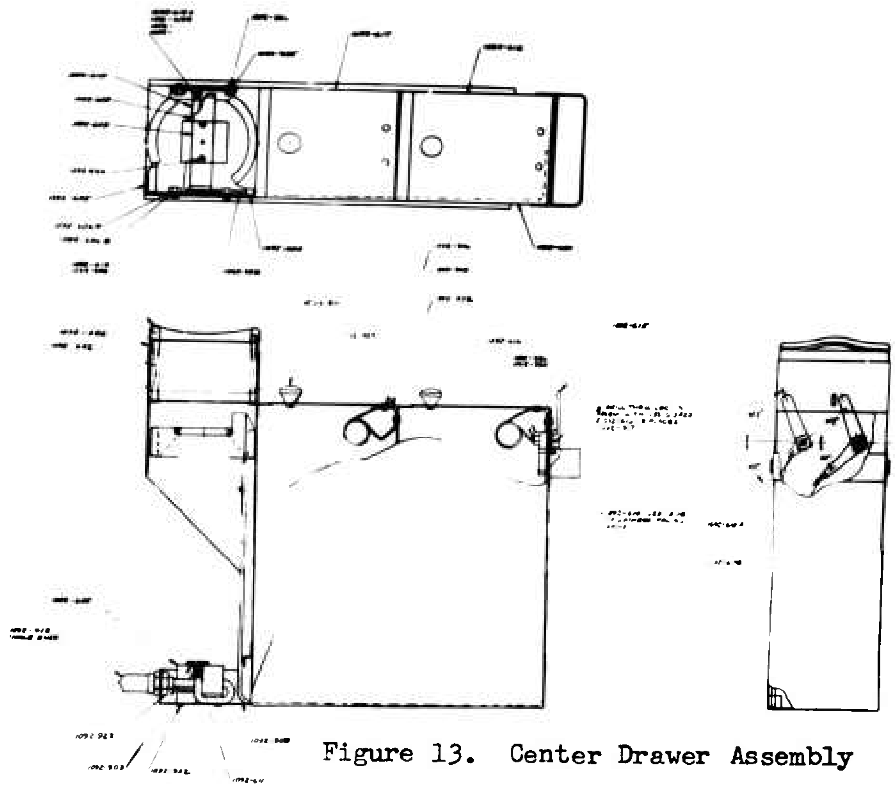

Figure 13. Center Drawer Assembly

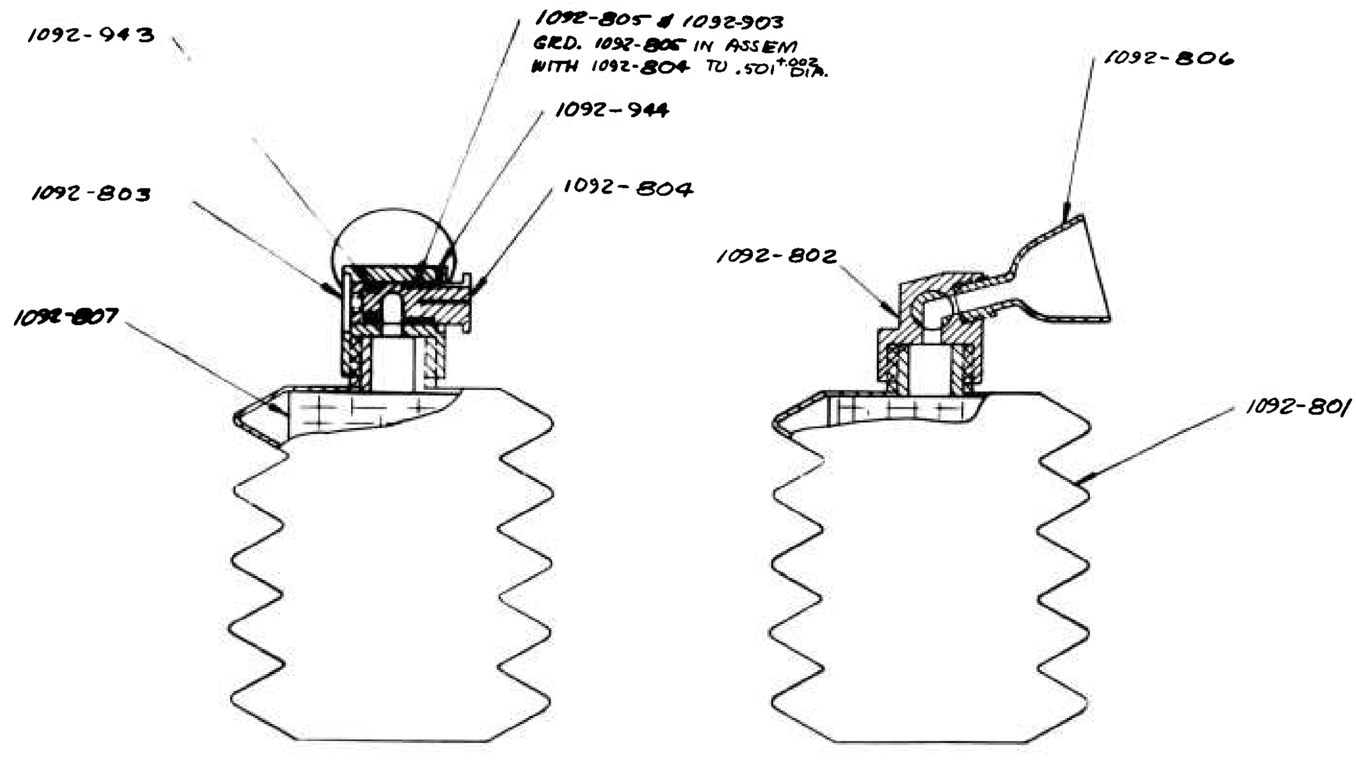

Figure 14. Bellows Type-Collapsible Urine Collector

inserts the paper in the container. The sliding box is pulled forward from under the seat, the container is removed from the form, and a drawstring in the lip around the top of the container is pulled to seal the container top. The container is removed by pushing the container form from the drawer clip into the container clip without exposing the hole in the container bottom to the cabin atmosphere. This completes the defecation operation and the feces-filled container is ready for storage.

Two storage compartments are provided for storage of feces-filled containers. These compartments may also be used for additional unused containers and paper storage in excess of the quantity storable in the sliding drawer.

The flatus and other fecal odors remain in the vacuum reservoir until the hand pump is operated to evacuate the vacuum reservoir with the next usage of the unit. At this time the hand pump evacuates the vacuum reservoir to the cabin through the deodorizer. The charcoal and molecular sieves in the deodorizer remove the odor-bearing elements during passage of the gases through the deodorizer.

The urine collector shown in figure 14 is stored in the sliding center drawer immediately in front of the feces collector form. It is an independent transportable unit and does not require an outside power or vacuum source for operation. It is composed of a penis receptacle attached to a self-opening bellows-type collapsible container with a three-way valve, as described in the design analysis section. To operate, the container is collapsed, the penis inserted into the penis receptacle, the shut-off valve opened, and the container is gradually allowed to open itself during urination.

Variations Also Possible

The present size of the seat as designed is considered minimum for comfortable sitting. The storage area under this seat is considered to be adequate unless there is to be an accumulation of feces-filled containers over a long period. In this case the boxes may be extended out to the side of the unit to increase storage capacity.

The feces container shown in the unit is a disposable type. However, a reusable type may be substituted without change in the unit design.

In the event that cabin gas is to be vented, the hand pump, deodorizer and vacuum tank can be replaced by additional feces storage volume.

SECTION 5

FABRICATION OF THE SYSTEM

The system was fabricated from 0.031-inch aluminum, and the estimated total weight of the system was calculated to be 10 pounds. The actual weight of the system, however, turned out to be 13 pounds. The system weight could be conceivably reduced by several pounds with the use of custom made parts instead of standard parts as used on the present system.

Photographs of the completed system are presented in figures 15 and 16. Figure 15 shows the center drawer section containing the feces bag and the urine collector. Figure 16 shows the complete assembly with storage compartments, deodorizer, pump, and fiberglas-polyester seat. Size of the unit is indicated by the scale accompanying the figure.

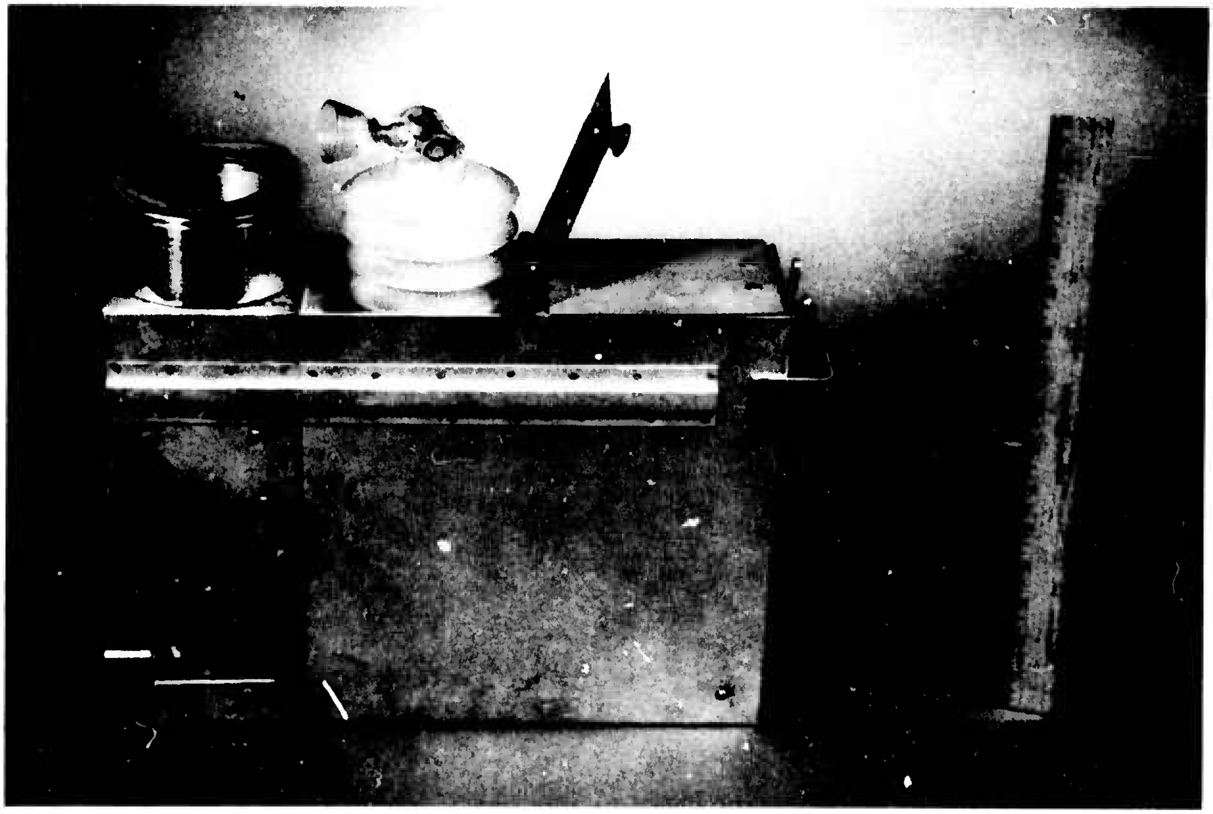

Figure 15. Photograph of Fabricated Center Drawer Section and Urine Collector

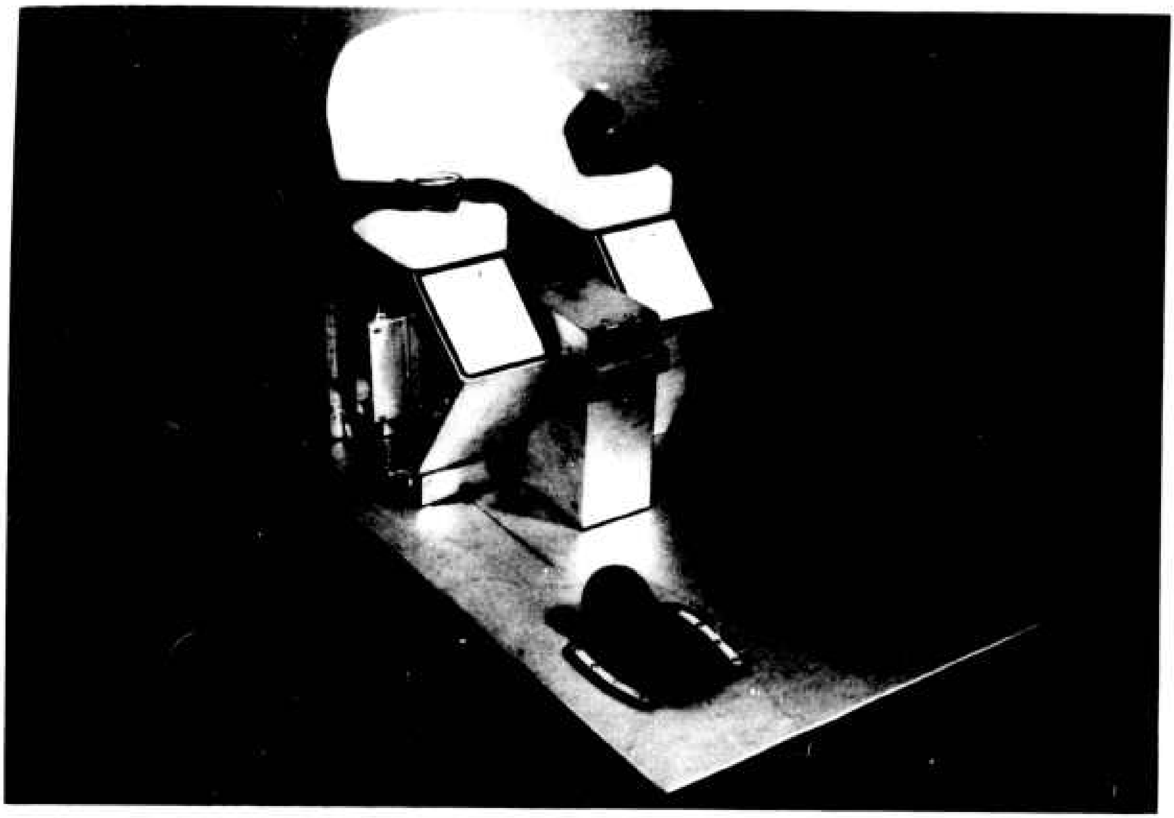

Figure 16. Fabricated Waste Collection System - Complete Assembly

SECTION 6

REFERENCES

1. Gerathewohl, S. J., Ritter, O. L., Stallings, H. D. "Producing the Weightless State in Jet Aircraft," Epitome of Space Medicine, USAF School of Aviation Medicine, Randolph AFB, Texas, August 1957.

2. Evans, C. L., Starling's Human Physiology, Twelfth Edition, Philadelphia, Lea and Febiger, 1956. pp 1038-1048, 918-923.

3. Houssay, B. A., et al. Human Physiology Second Edition, McGraw-Hill, 1955. pp 751-754, 376-380.

4. Physical and Physiological Data for Bioastronautics, USAF School of Aviation Medicine, Randolph AFB, Texas, 1958.

5. Martin, M. W., Private Communication, Convair, Fort Worth, Texas, dated February 25, 1959.

6. American Hospital Supply Corp., Catalog No. 100, 1955, Evanston, Illinois.

7. Husar, R. E., Private Communication, Illinois Surgical Supply Company, Chicago, Illinois, dated January 12, 1959.