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DEVELOPMENT OF A
PROTOTYPE WASTE COLLECTION
SYSTEM
(THE HYDRO-JOHN)

Prepared by:

J. J. Reville and R. W. Murray

Space Systems Organization

Space Division

General Electric Company

under Contract NAS 9-9741

M. OWEN - TECHNICAL MONITOR

FOR

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

MANNED SPACECRAFT CENTER

HOUSTON, TEXAS

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SECTION 1

SUMMARY

The prototype waste collection system described in this report (The Hydro-John) demonstrates spacecraft type sanitary urine and feces collection techniques for male personnel. The system features a manually initiated, automatically controlled anal wash and dry cycle after defecation as well as a feces/wash water blending and discharge cycle. It also features an adjustable urinal which is designed to collect urine while preventing spillage during micturition. Both the feces and urine collection techniques are designed for use in either a zero or one gravity environment.

The system was developed for the National Aeronautics and Space Administration - Manned Spacecraft Center located at Houston, Texas under Contract NAS 9-9741 with the General Electric Company, Life Support Engineering Operation located at Valley Forge, Pennsylvania.

Overall reactions to the system by eight users were favorable and are defined in section seven of this report.

SECTION 2

INTRODUCTION

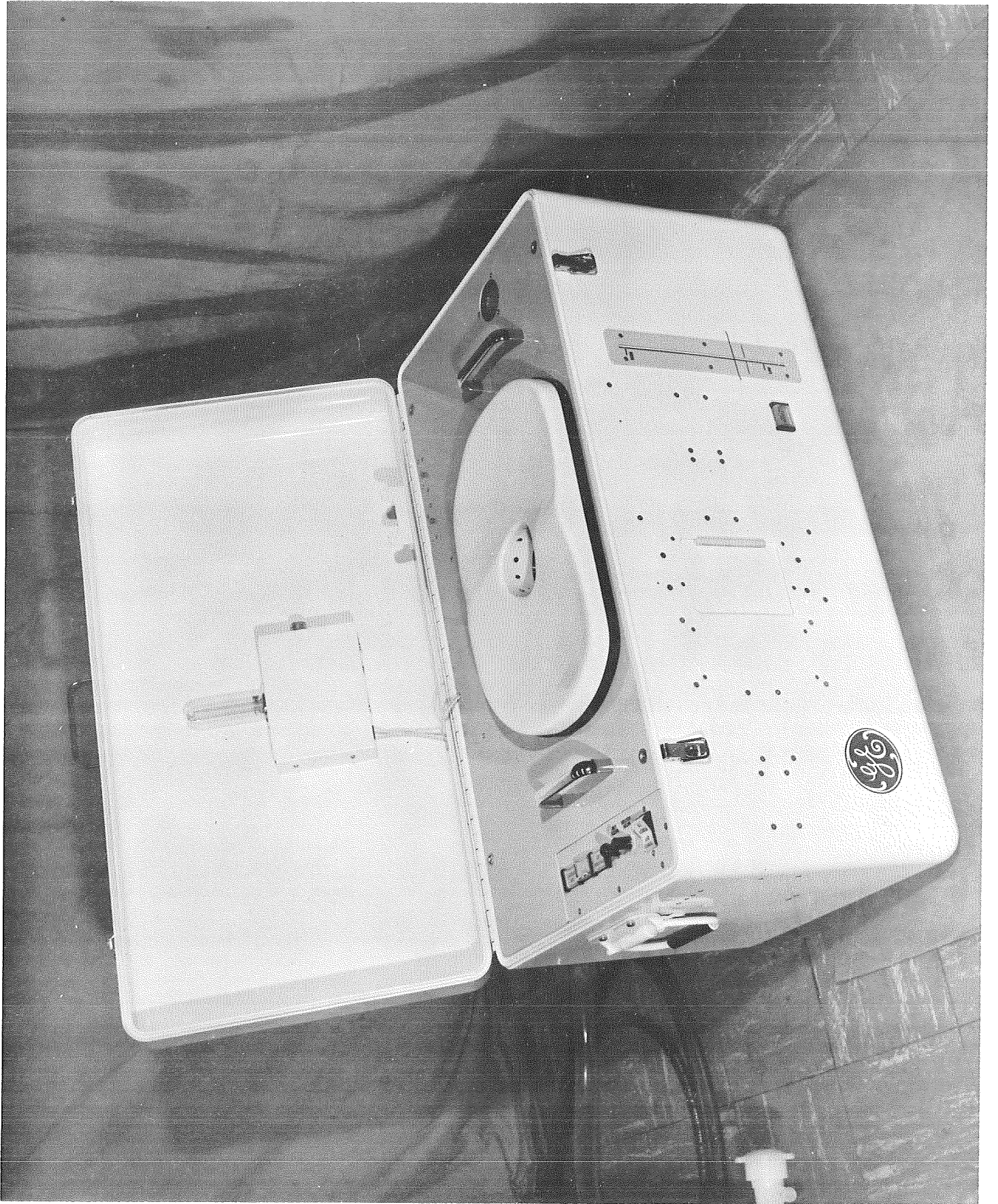
The system shown in Figures 1 thru 4 was designed, developed, fabricated, and tested to meet the following requirements:

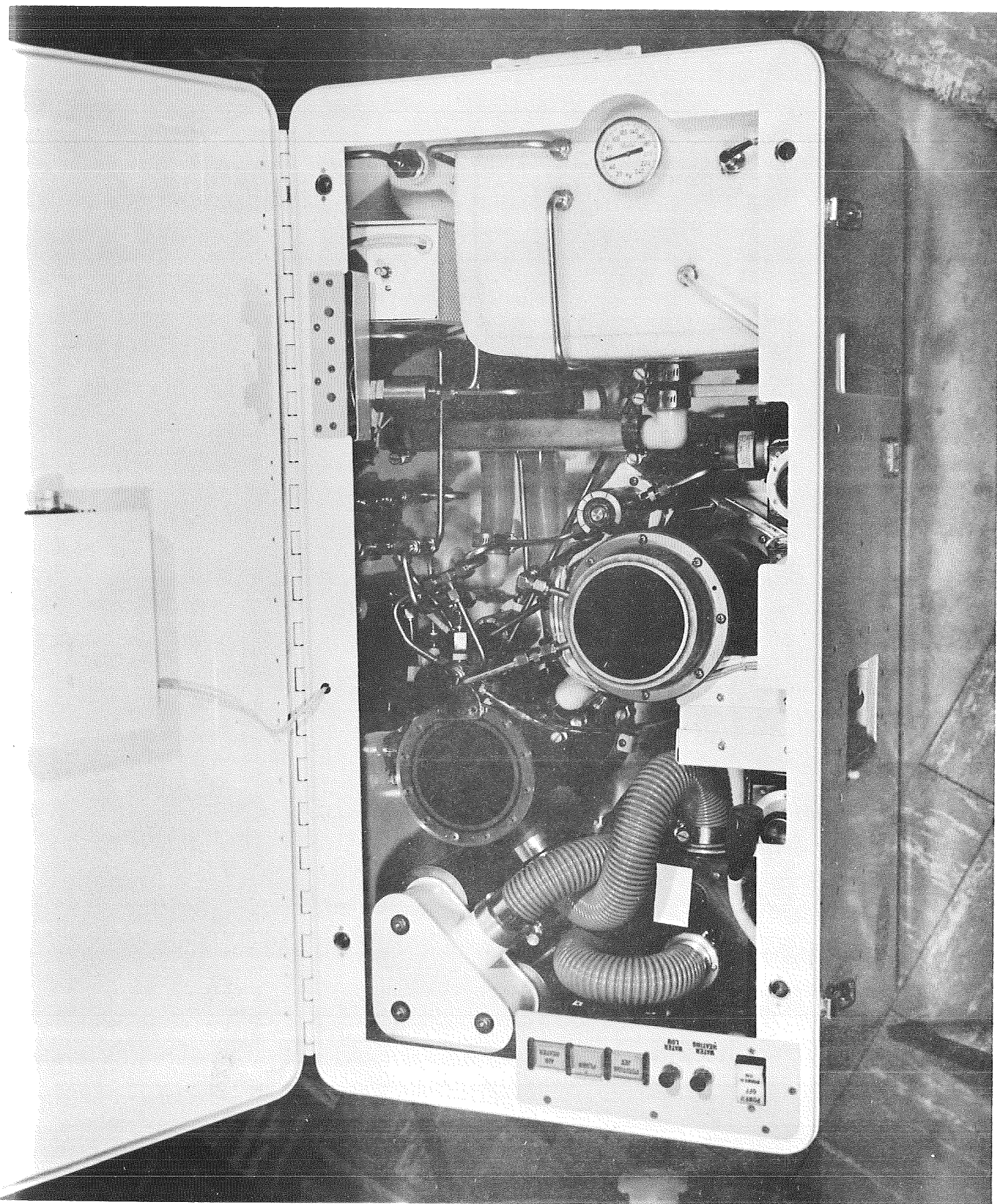
- (a) Compact, portable, and self-contained.
- (b) Suitable for use by flight, engineering, and medical personnel.
- (c) Gravity dependent with provisions for modification to a zero gravity configuration.
- (d) Interfaces limited to a water supply, a 115 VAC electrical supply and a waste disposal (external commode).
- (e) Provide expendable materials for 1,000 operations.
- (f) Packaged to allow easy replacement of short life components.
- (g) Provide sanitary feces collection using a contoured commode seat and positioning jets to center the user over the seat opening.
- (h) Provide sanitary urine collection using a space type urinal with a sealing diaphragm.
- (i) Provide a warm air flow to direct both feces and urine away from the user and into the unit. This air must also be used to dry the anal area after washing. The flow requirement is 10-20 CFM and it must be warmed for the anal drying cycle.
- (j) Provide for anal and collection equipment wash with a bacteriocide-water solution. Four flushes of four pounds each of $100^{\circ}\text{F} \pm 10^{\circ}\text{F}$ water are required before the system needs refilling.
- (k) Blend the deposited feces, urine, and flush water into a slurry and discharge it to an external commode.
- (l) Between uses sanitize the contoured seat using ultra-violet light.

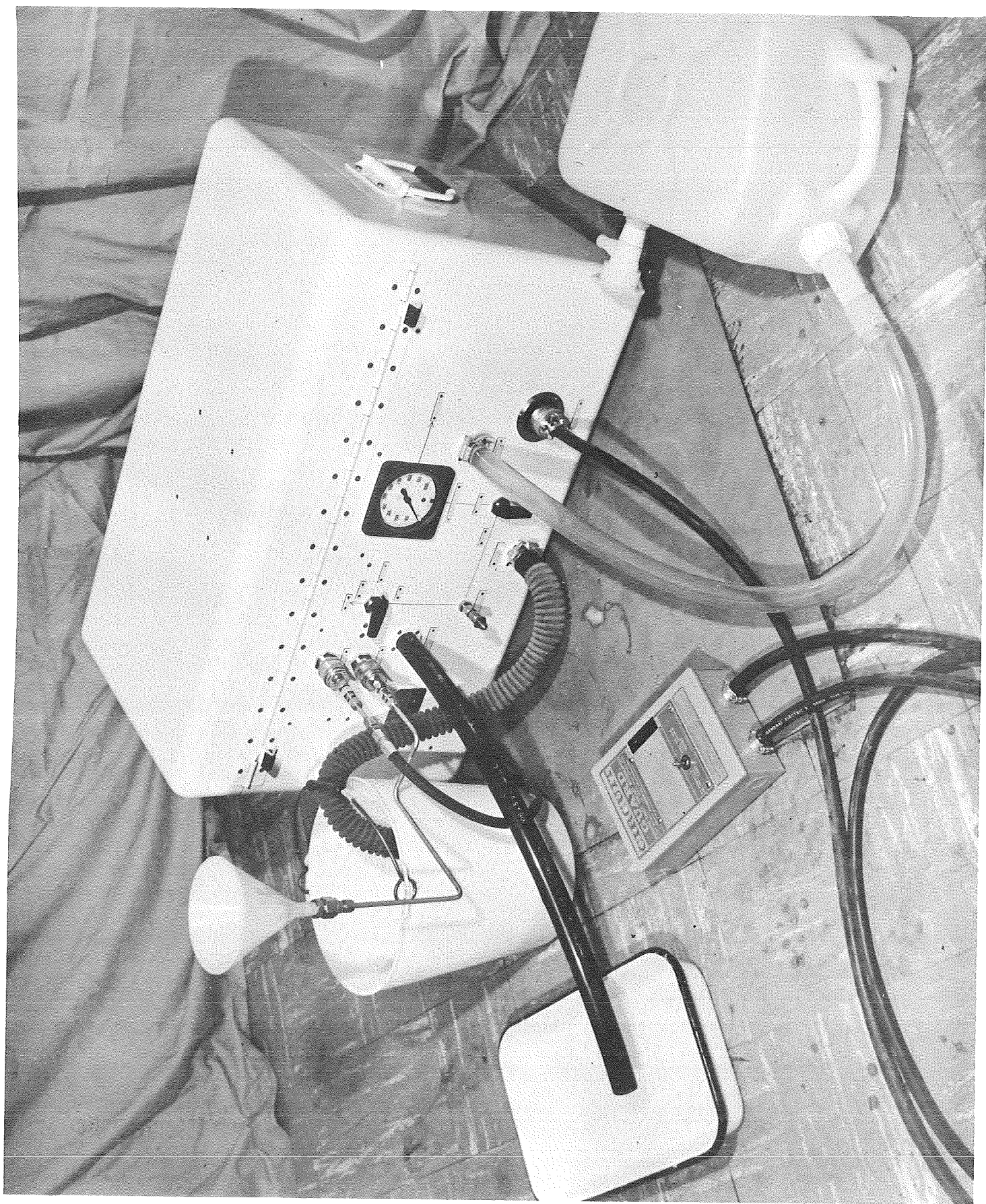
(m) Contain objectionable odors.

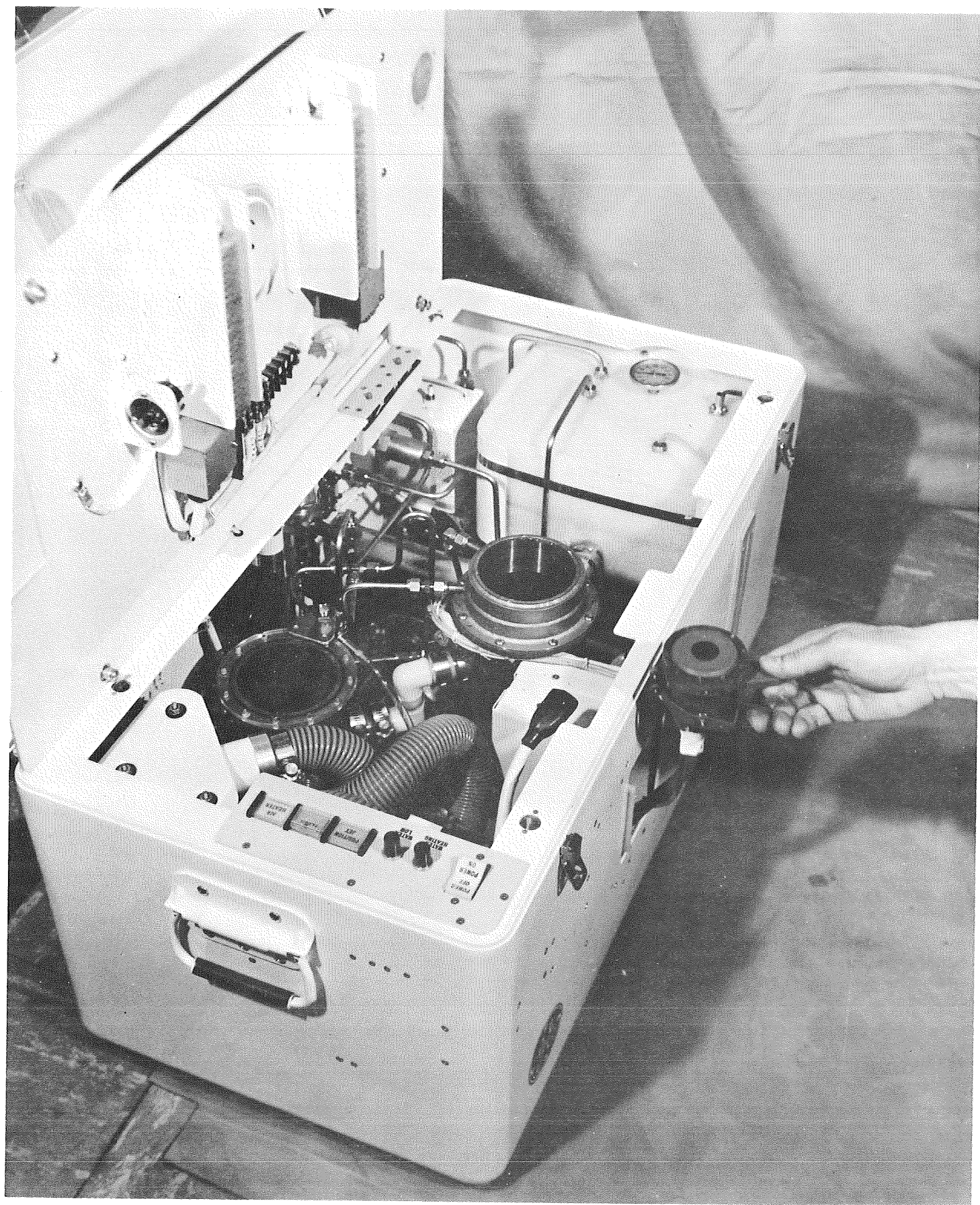
(n) Be capable of manual activation and automatic timing of all functions.

A description of the unit's operation is in the following section of this report.









SECTION 3

SYSTEM DESCRIPTION

The system as shown in Figure 5 is composed of four major subsystems; namely, pneumatic, transport air, flush water, and electrical. The first three are activated by the electrical subsystem and function as described in the following paragraphs.

3.1 Overall Operation

The feces and urine are deposited into the unit as shown in Figure 5. A steady flow of transport air draws the feces into the blender and the urine into the phase separator. When the user activates the flush cycle after defecation and micturition flush water washes his anal area and the urinal. This wash water is drawn into the system in the same manner as the feces and urine. When a small quantity of water has accumulated in the blender, the feces already present is mixed with the water to form a slurry. After a timed period of mixing, the resulting slurry is pumped out of the unit along with the urine. During the pump-out cycle, flush water continues to flow thereby washing both the user and the collection system. Following the flush cycle, the user is dried by the transport air which can be heated if desired to hasten the drying process. Detailed descriptions of the subsystems are contained in the following paragraphs and diagrammed in Figures 6 and 7.

3.2 Pneumatic Subsystem

This subsystem is used to assist the user in centering himself over the seat opening. It consists of an 850 psig source of nitrogen gas which is regulated to 30 psig before discharging through two small orifices (one is shown in Figure 22) which are aimed at the user's anal area. The gas discharges on command through a normally closed solenoid valve located between the regulating valve and the two orifices. The valve is controlled

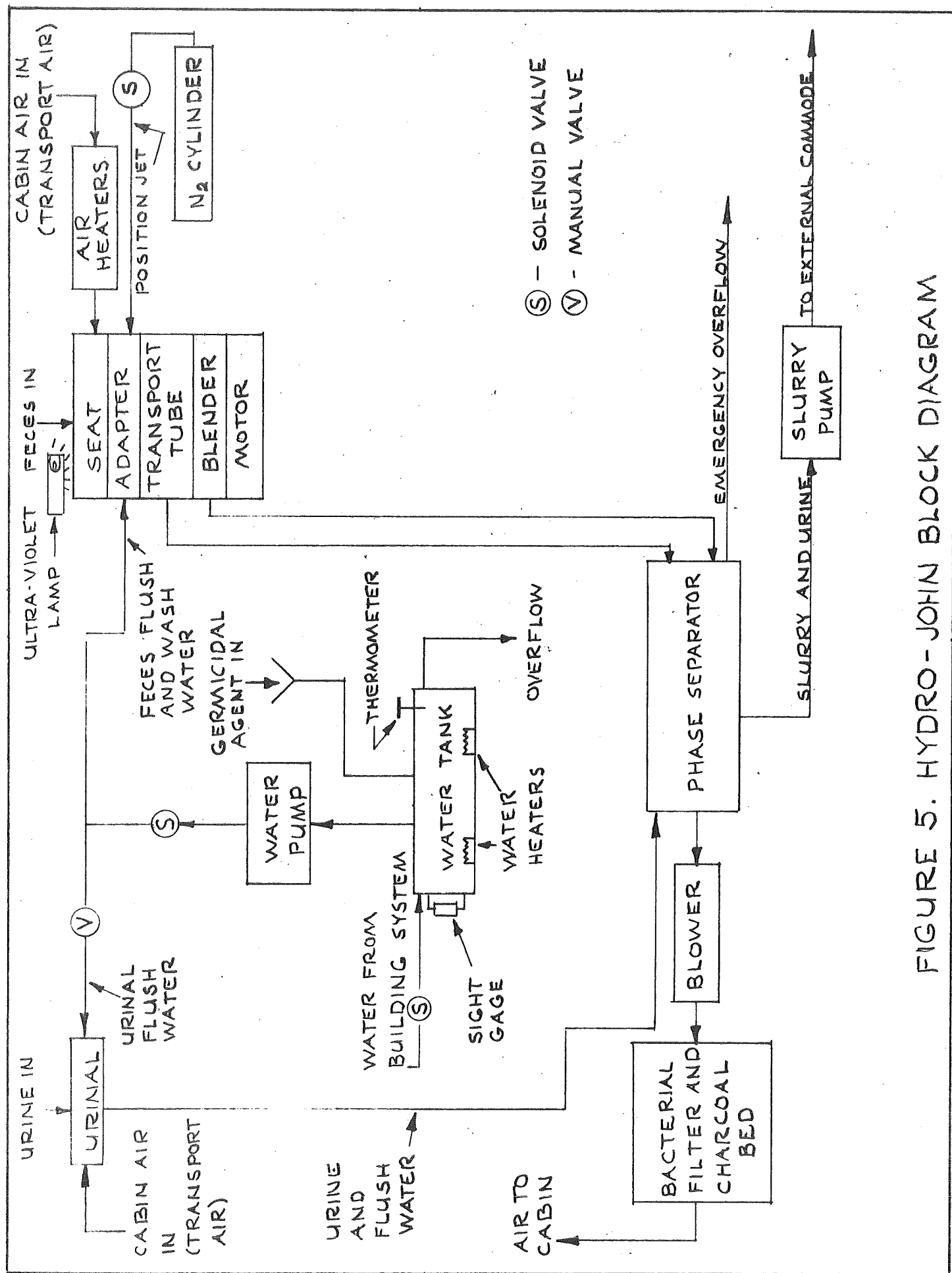


FIGURE 5. HYDRO-JOHN BLOCK DIAGRAM

by a switch located on the control panel (marked "Position Jet"). The discharge continues for as long as the user maintains the switch closed.

Centering in this manner has the dual effect of assuring that the feces is directed into the blender and that there is a complete seal around the seat opening. The seal is created by the user being in reasonably symmetrical contact with the contoured seat.

3.3 Transport Air Subsystem

This subsystem circulates cabin air by means of a blower through openings under the seat (Figure 10) past the user's anal area, into the transport tube and phase separator through the blower and discharges it back to cabin atmosphere downstream of the blower after passing it through a bacterial filter-charcoal bed combination as shown in Figure 5. The blower starts when the lid on the unit is raised and before the user is seated. In a zero gravity environment the air would serve the purpose of transporting feces away from the user and into the blender blades located at the bottom of the transport tube. In addition, it serves the purpose of drying the user after a flush/wash cycle has been completed. Raising the lid also shuts off a germicidal lamp which radiates to the seat when the unit is not in use and the lid is down. In the unlikely event that the lid switch S2 fails closed, the lamp will stay on when the lid is raised. DO NOT LOOK DIRECTLY AT THIS LAMP WHILE IT IS ENERGIZED SINCE ITS RADIATION CAN CAUSE PERMANENT EYE DAMAGE.

Two heaters which are energized on command by means of a switch located on the control panel (marked "Air Heater") heat the air as it flows into the openings under the seat. The heated air assists in drying the user's anal area after the wash cycle. The heaters are energized as long as the switch is held closed by the user. This switch is connected

in series with an interlock switch activated by the lid so that the air heaters can only work if the lid is raised. This redundant switching offsets the possibility of overheating the heaters in the event the "Air Heater" switch was to fail closed. During the comparatively long periods between uses with the lid closed and no air flowing the air heaters could burn out if they were energized in this manner.

Small openings on the urinal (Figure 8) allow air to flow in the same manner as it does under the seat except that this air discharges from the urinal directly into the phase separator and then through the blower-bacterial filter-charcoal bed combination before being returned to the atmosphere. There is no provision for heating this air.

3.4 Flush Water Subsystem

The water subsystem consists of an aluminum tank (See Figures 17 through 20) equipped with two 500 watt immersion heaters and two thermostats which automatically maintain the 16 pounds of water in the tank at $95^{\circ} \pm 5^{\circ}$. Water is admitted to the tank by connecting the source to a quick disconnect on the back of the unit. All water entering the tank is filtered through a sintered metal filter. There is an additional quick disconnect on the back of the unit which allows for a gravity fill admission of Wescodyne F-53, a germicidal agent, to the water tank.

Admission of water to the tank is accomplished by plumbing the system to the house water line. A built-in solenoid valve-timer combination will automatically fill the tank after four four-pound discharges of water have occurred.

Discharge of water from the tank is accomplished as follows: (Refer to Figures 6 and 7). When the "Flush" switch on the control panel is momentarily depressed after defecation, Timer T1 is energized for .2

seconds. One of the output relays of Timer T1 is connected to energize the coils of Timers T2, T3, and T4. This means that the coils of T2, T3, and T4 can only be energized for .2 seconds preventing the user from energizing them for a longer period regardless of how long he holds the "Flush" switch depressed. This has importance since timers T2, T3, and T4 transfer their output relays immediately upon coil energization. It is only when the coils of these timers are de-energized that they begin their pneumatically controlled time delay period and at the end of the time delay period their output relays transfer to their normal positions. For a more complete description of these timers, see Figures 32, 33, and 34. If their coils were to be energized for random periods of time differing from use cycle to use cycle, there would be no control over how much water would be dispensed during each use cycle since T2 controls the water pump and water solenoid valve. As shown in Figure 6, the output relays of timer T2 are connected to the water pump and a normally closed solenoid valve located between the water tank and the water pump. When T2, T3, and T4 are energized, the solenoid valve opens, the water pump starts, and the blender starts. After 24 seconds, the required four pounds of water have been discharged through 12 orifices in the stainless steel adapter under the seat and directed at the user's anal area. This water is moved by the transport air (and gravity) to the bottom of the blender where it is mixed into a slurry with the already deposited feces. For the first second, water accumulates in the blender and phase separator. At the end of one second, T4 times out, transferring its output relays so that the slurry pump starts. The blender and phase separator are evacuated in a few seconds by this pump (to an external commode) but the flush water continues to flow for another 23 seconds. After a total of 24 seconds have elapsed T2 times out thereby

closing the solenoid valve, and stopping the water pump. The slurry pump and blender continue to run for another 23 seconds to assure a complete liquid evacuation. At that timer T3 times out stopping both the slurry pump and the blender and the flush cycle is complete. If at any time during the flush cycle the "Flush" switch is again momentarily actuated, all the timers reset and a new flush cycle is started.

The one second delay in starting the slurry pump was found to be the best setting for using the unit. Actually the intent of this delay setting (adjustment of T4 can increase the delay in starting of the slurry pump) was to allow accumulation or "holding" of water in the blender to assure thorough blending. The increased delay was found to be unnecessary and also troublesome since by delaying pump-out the liquid may raise too high in the blender and phase separator. This can cause liquid to enter the blower.

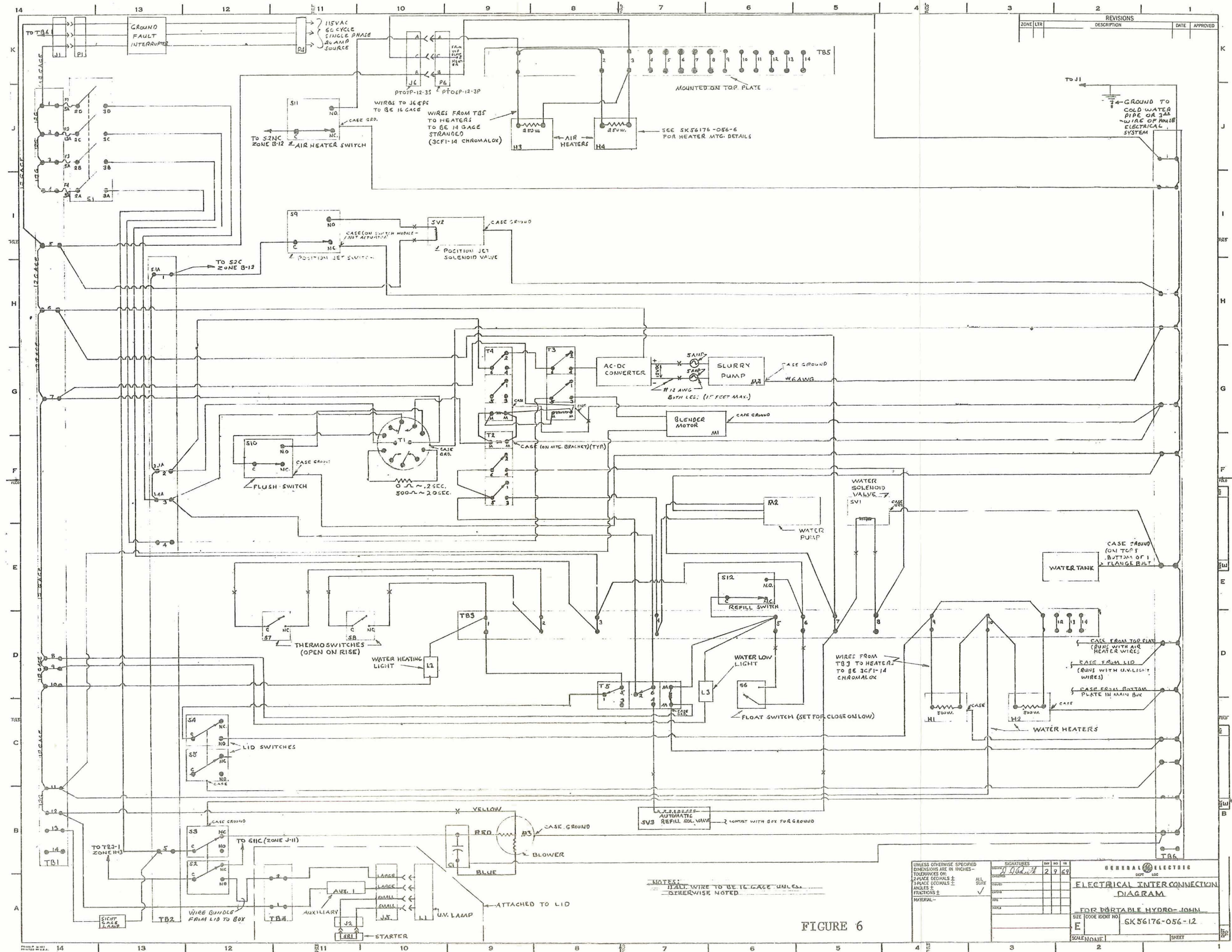
On the front of the unit there is a sight gage which shows the user the level of water in the tank (Figure 1). The gage's red line indicates the level below which the unit will not provide at least one four-pound flush of water. There is a flashing red "Low Water" light on the control panel which is actuated by a float switch in the tank. In conjunction with timer-relay T5, this switch locks out the water pump and water heaters thereby protecting them from dry running if the tank water level becomes too low.

In addition, when it is energized by the float switch, T5 energizes SV3 thereby opening it and allowing water from the house plumbing to flow into the water tank for up to 200 seconds, depending upon the timer (T5) setting. Thus, the tank will be automatically refilled if the water goes so low as to actuate the level switch. When the water level is below the aforementioned red line, but not at a level to actuate the float switch, there is a "Refill" switch next to the sight gage (Figure 1). Momentarily depressing this switch

will actuate T5 in the same manner as the float switch and refill the water tank.

The stored water temperature can be determined from a dial thermometer to the left of the seat. A flashing red "Water Heating" light on the control panel indicates if the water is heating. The heaters are controlled by two series connected thermostats which are immersed in the water. This control redundancy offsets the possibilities of a switch failure such that the water would overheat with the resulting possibility of personal injury.

At the time water is pumped into the adapter-transport tube assembly, a small quantity of water is diverted to the urinal, thereby washing it. This water is driven by gravity and transport air into the phase separator and is pumped out with the fecal slurry. Urine admitted to the urinal is discharged in the same manner.



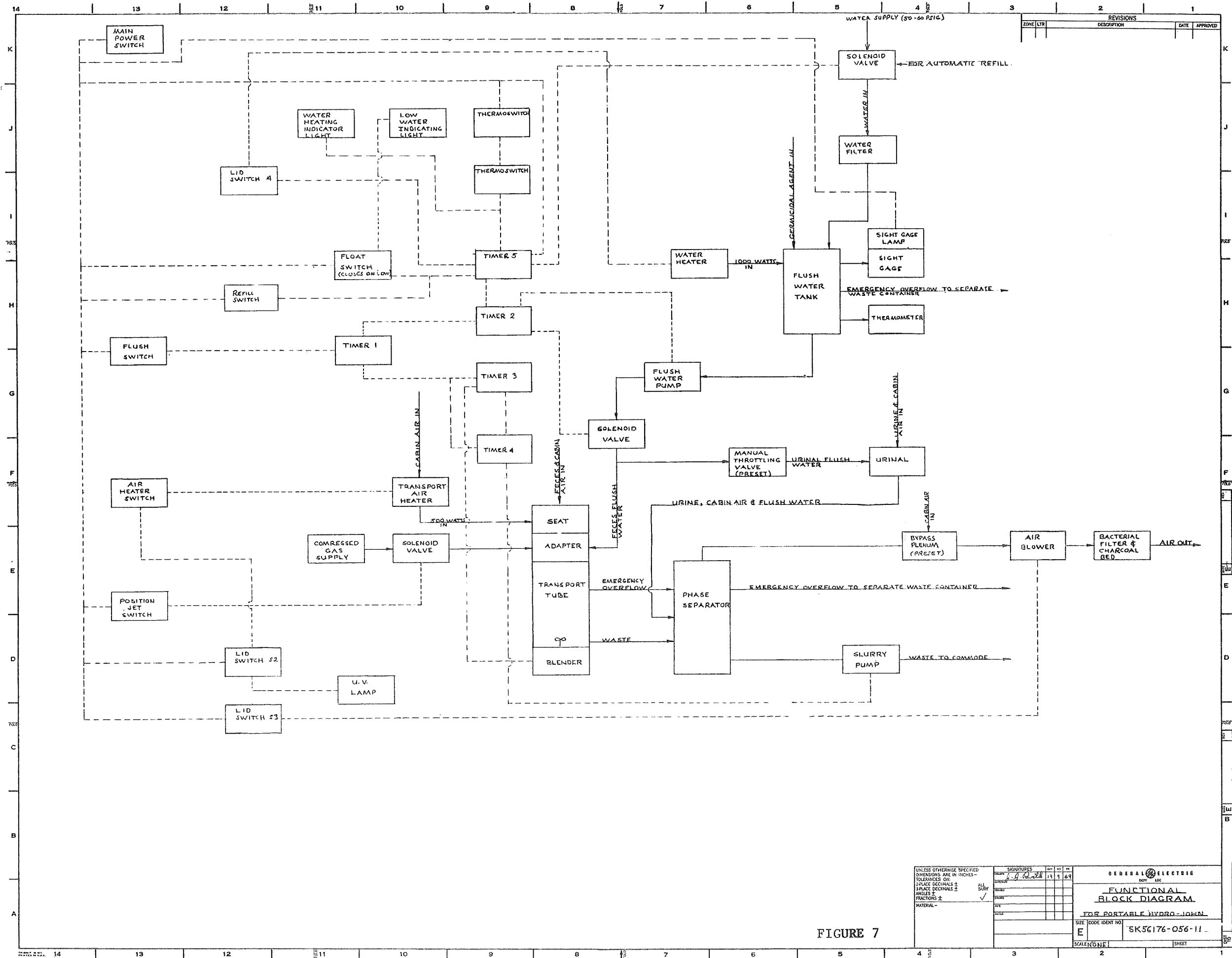


FIGURE 7

SECTION 4

COMPONENT DESCRIPTIONS

The following paragraphs discuss details of all major components which are used in the unit. Excluded are minor items such as hinges, etc.

4.1 Urinal (See Figures 8 and 9)

This is a custom made device which receives urine directly from the user while providing a seal around the penis during urination. It has provisions for admitting transport air and flush water and is designed primarily as a zero gravity urinal. It is made of 6061-T6 aluminum and is coated with "Tufram" an anodic finish which is highly resistant to corrosion.

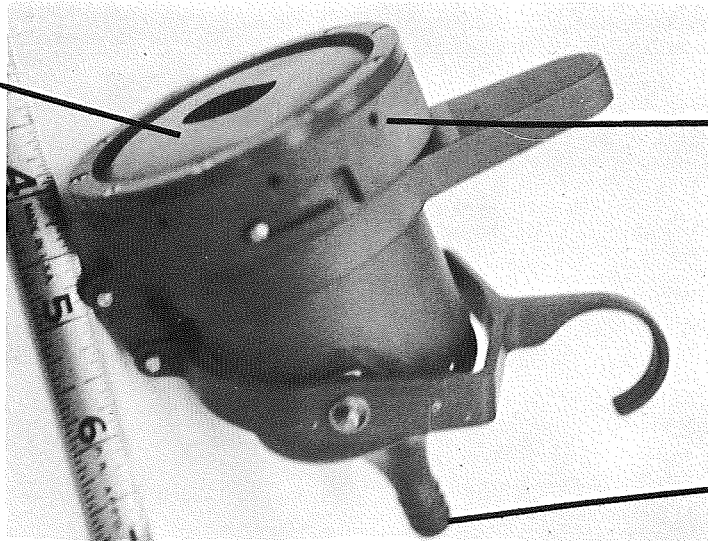
4.2 Seat (See Figure 10)

This is a fiberglass layup. It was contoured to fit a variety of test subjects. In the transport tube position of the seat are 12-1/4 inch diameter holes which admit the transport air to the user's anal area.

4.3 Blender (See Figure 11)

This is 6061-T6 aluminum cylinder (Transport Tube) mounted on a General Electric BL2 blender. It is fitted under the adapter which is in turn positioned directly under the seat opening. Fecal material and water admitted to the tube are mixed into a slurry by the rotating stainless steel blender blades. All aluminum surfaces are coated with "Tufram". Discharge from the tube to the phase separator is accomplished through a one inch O.D. port on the tube's bottom. There is a one inch I.D. overflow port located above the half-full mark which also discharges into the phase separator. This is to preclude a spill resulting from the unlikely possibility of the bottom exhaust port becoming clogged.

"Iris" Type
Seal



Transport Air
Holes

Discharge
Tube

FIGURE 8. URINAL

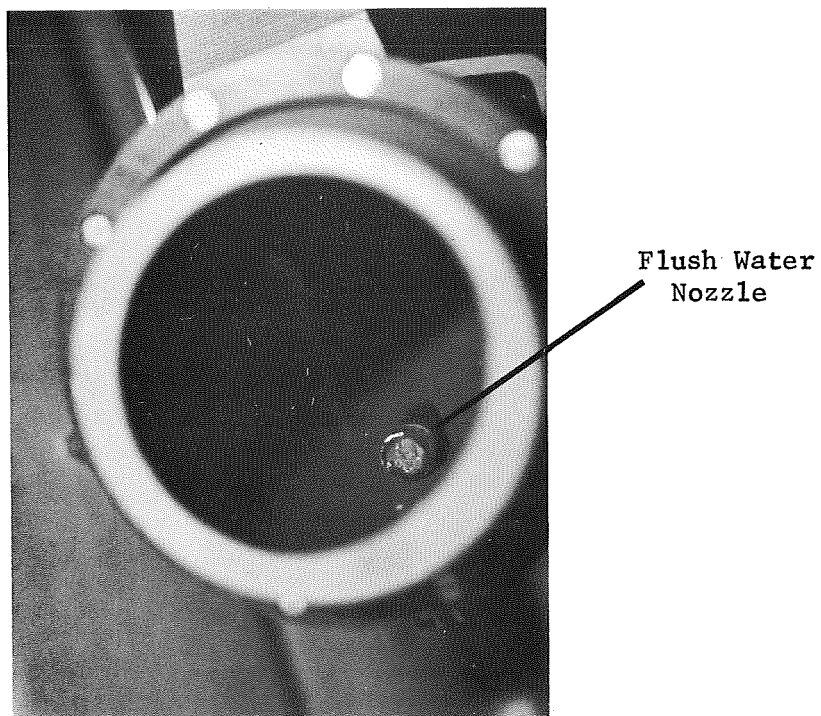


FIGURE 9. URINAL

Transport Air Holes

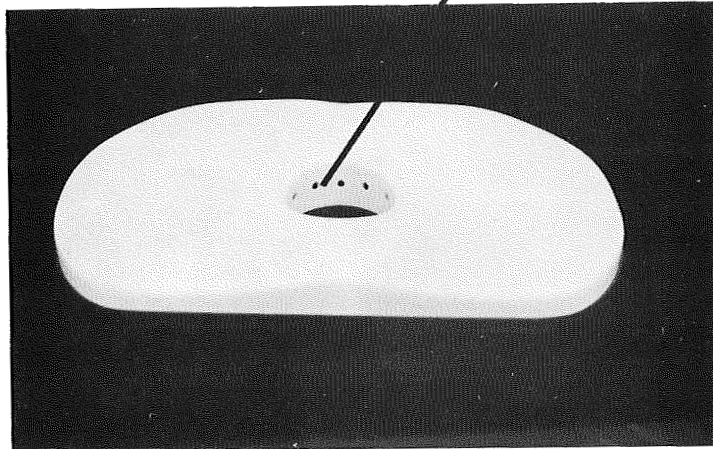


FIGURE 10. SEAT

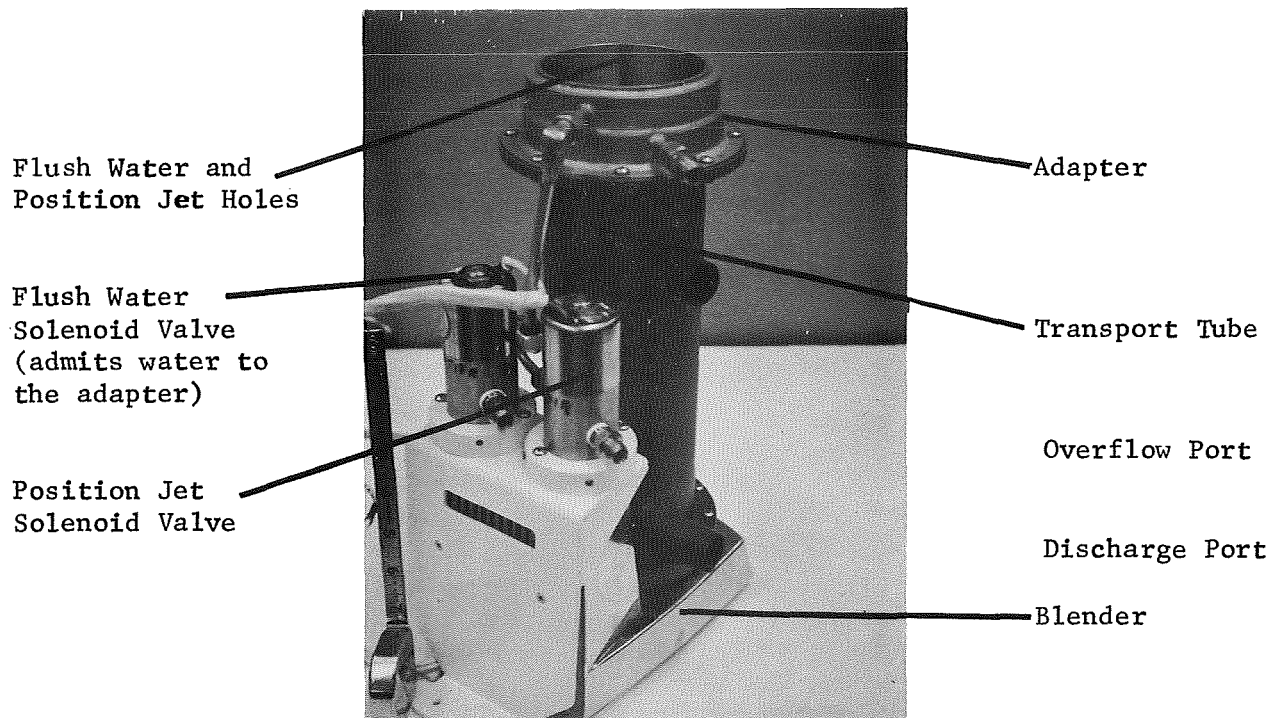


FIGURE 11. BLENDER ASSEMBLY

4.4 Phase Separator (See Figure 12)

This is also a "Tufram" coated 6061-T6 aluminum cylinder. It has inlets for fecal slurry flowing from the adapter, and urine flowing from the urinal. It serves the purpose of a settling pot in a one gravity environment thus allowing gas bubbles mixed with the waste liquids to separate from the liquid. These gases are forced by the blower through the bacterial filter-charcoal bed before returning to the atmosphere.

4.5 Slurry Pump (See Figure 13)

This is a model 5690, 12 volt diaphragm pump manufactured by Peters and Russell, Inc. It can pump approximately 3.5 gpm of water against a three foot head of water. This flow rate exceeds the flow rate of water into the system which is approximately one gpm.

4.6 Air Blower (See Figure 14)

This is a SL2EA2AB spiral type air blower made by the Rotron Manufacturing Co. It has a nominal capacity of 30 CFM at 20 inches of water. Associated with it is a 25 mfd 330 VAC capacitor. Not shown in Figure 14 but mounted directly on top of the blower is a small plenum which serves as an air system bypass which balances the air flow. Without this device too much air can be drawn into the system causing water from the phase separator to enter the blower. The bleed hole on this plenum has been adjusted in size so as to prevent this and still allow enough air flow to draw water into the blender and prevent it from flowing under the seat during a flush cycle.

4.7 Air Heaters (See Figure 15)

There are two 250 watt General Electric SEF-10 finstrip air heaters with secondary insulation bushings attached to the underside of the top plate. All of the transport air drawn under the seat by the blower passes

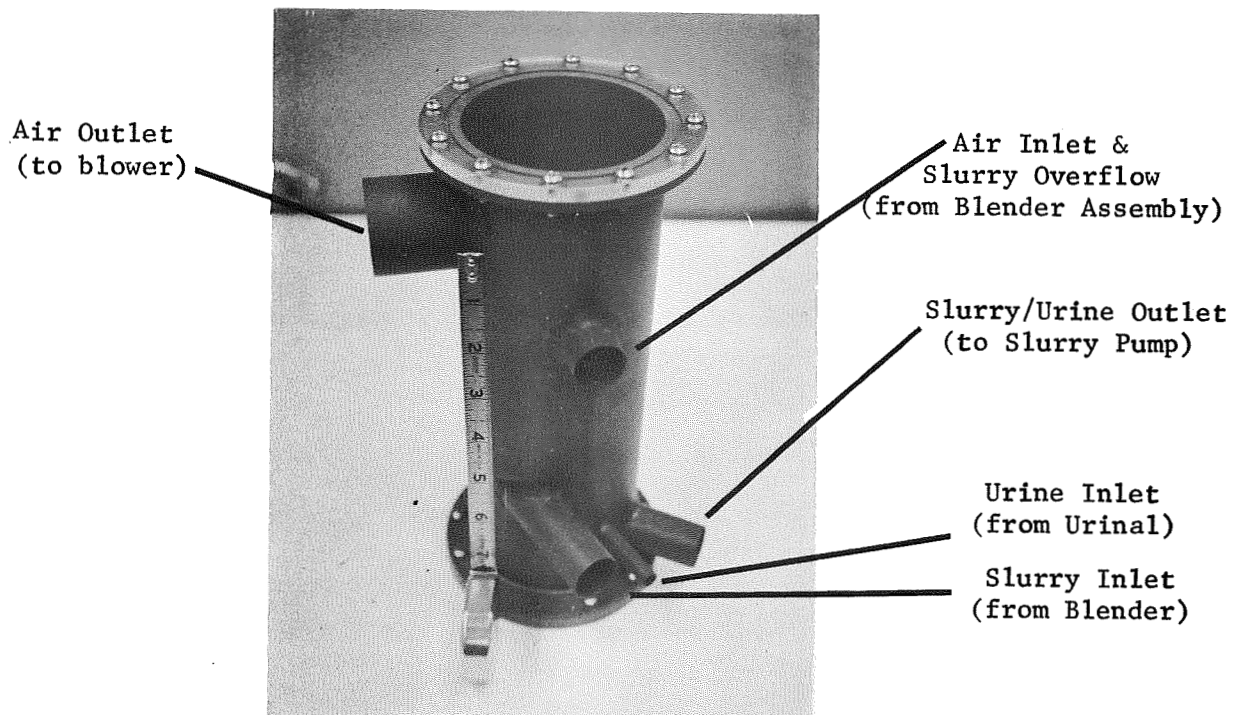


FIGURE 12. PHASE SEPARATOR

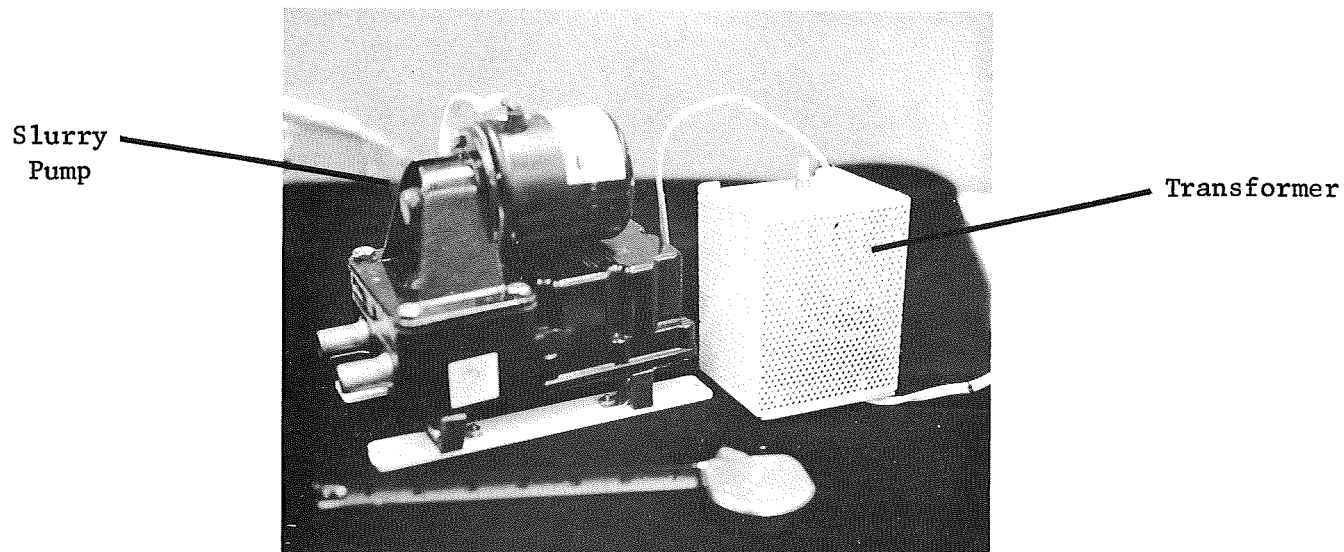


FIGURE 13. SLURRY PUMP

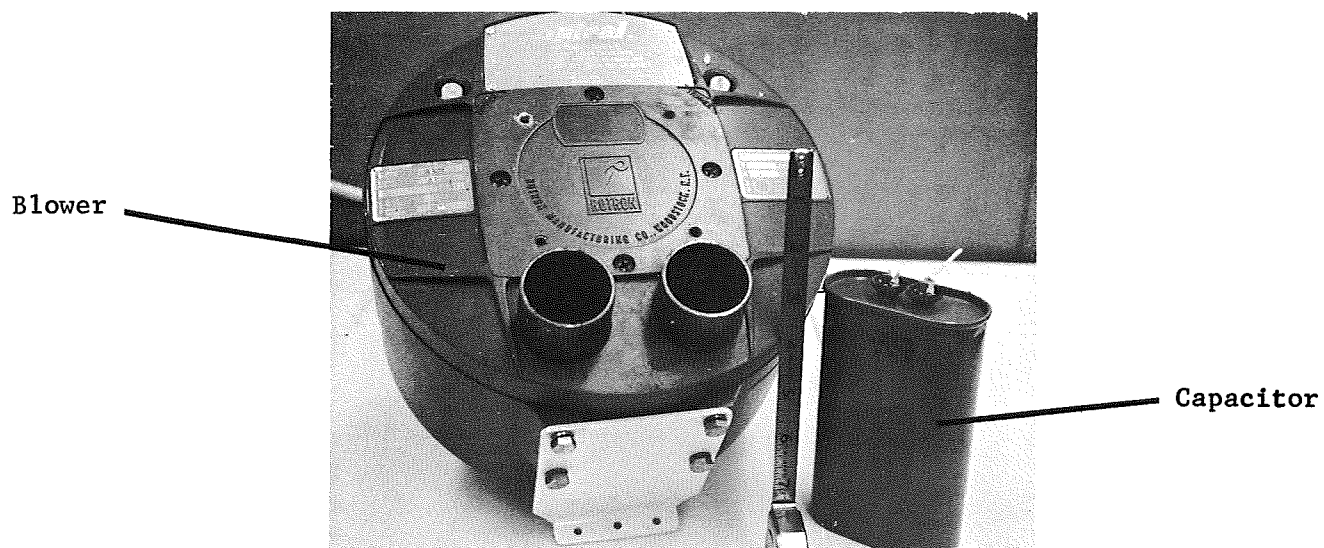


FIGURE 14. AIR BLOWER

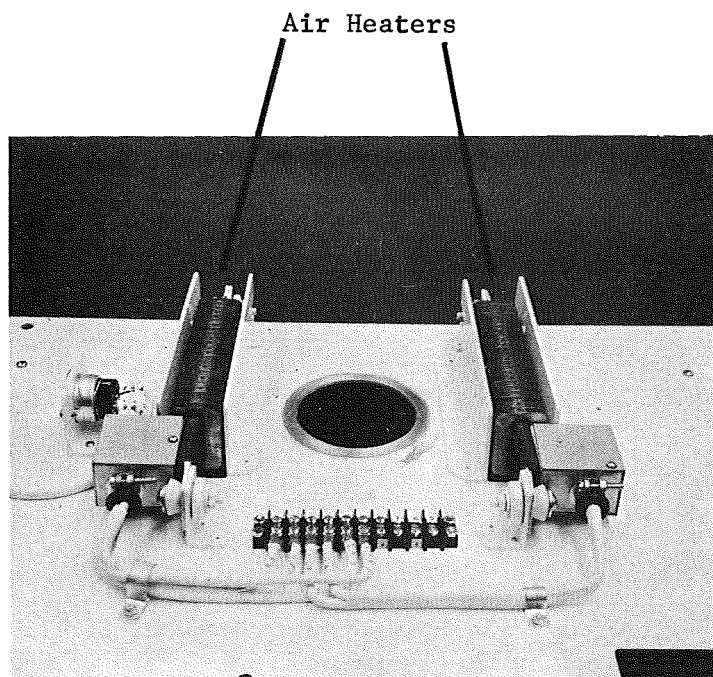


FIGURE 15. AIR HEATER ASSEMBLY

over these heaters. They can be energized by the user at will by depressing the "Air Heater" switch located on the control panel. Releasing the switch deenergizes the heaters.

4.8 Air Filter Assembly (See Figure 16)

There are three Aircraft Porous Media, Inc. ACS 1001CVH filter-charcoal bed units mounted on a custom made base and manifold. The .9 micron filters are arranged so that the air flows through them before passing through the charcoal beds to the atmosphere.

4.9 Water Tank (See Figures 17, 18, 19, and 20)

This is a Z113-169 aluminum enclosure and lid made by the Zero Manufacturing Co. It measures approximately ten and one half inches long, seven inches wide and 11 inches high. The sides and top are covered with a 5/8" thick layer of Styrofoam insulating material and the tank itself is coated with "Tufram".

4.10 Thermostats (See Figures 18 and 19)

These are 17102-0 open on rise switches manufactured by Fenwal Incorporated. They have an adjustable control range of -100°F to 600°F and are set for use in this unit to maintain the flush water at 95°F to $\pm 5^\circ\text{F}$.

4.11 Water Heaters (See Figures 18, 19, and 20)

There are two 500 watt General Electric Co. type RB-50 immersion heaters installed in the water tank. They are capable of heating the 16 pounds of usable water in the tank from 50°F to 100°F in approximately 30 minutes.

4.12 Water Pump (See Figure 21)

This is a model VW-1 rotary vane pump made by Eastern Industries, Inc. It has a nominal delivery capacity of 1 gpm of water at 40 psig.

4.13 Float Switch (See Figures 18 and 19)

This is a LS-1800 level switch manufactured by the Gems Corporation.

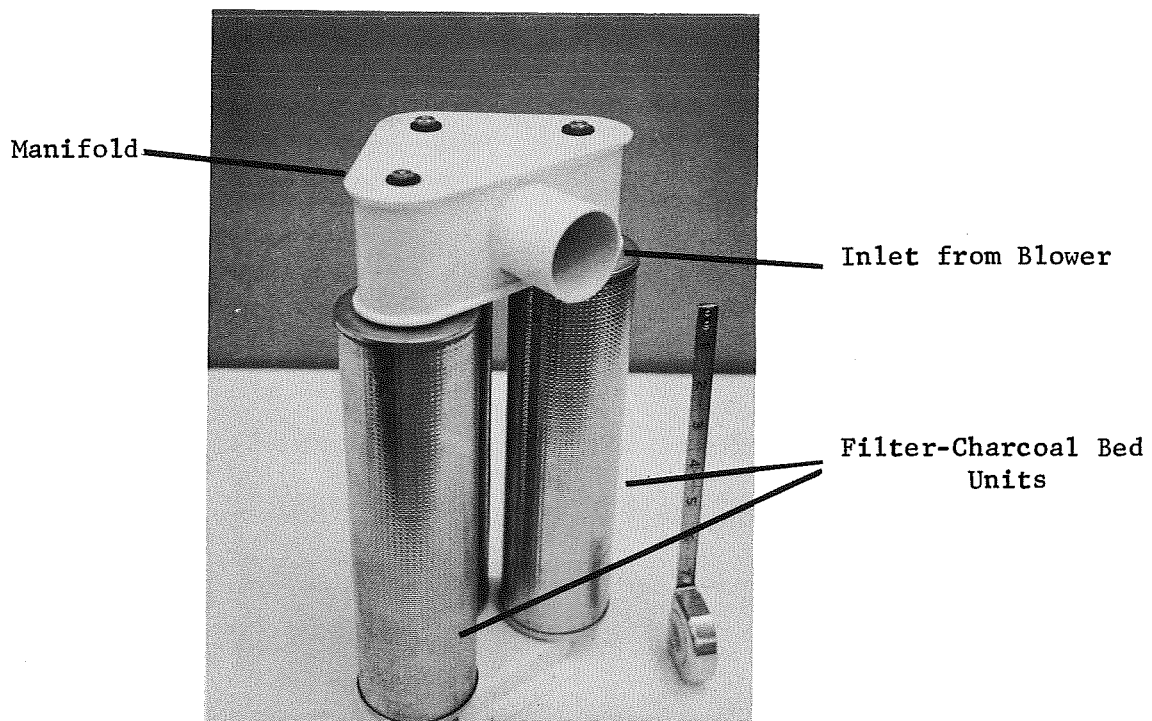


FIGURE 16. FILTER ASSEMBLY

Insulation

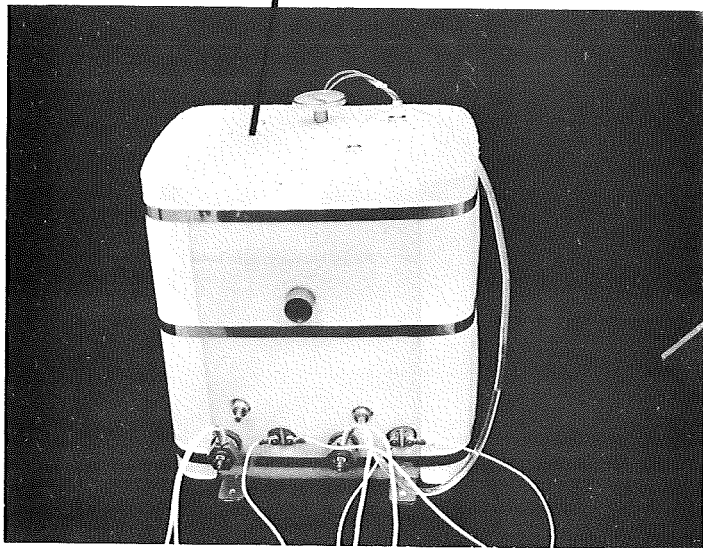


FIGURE 17. WATER TANK ASSEMBLY

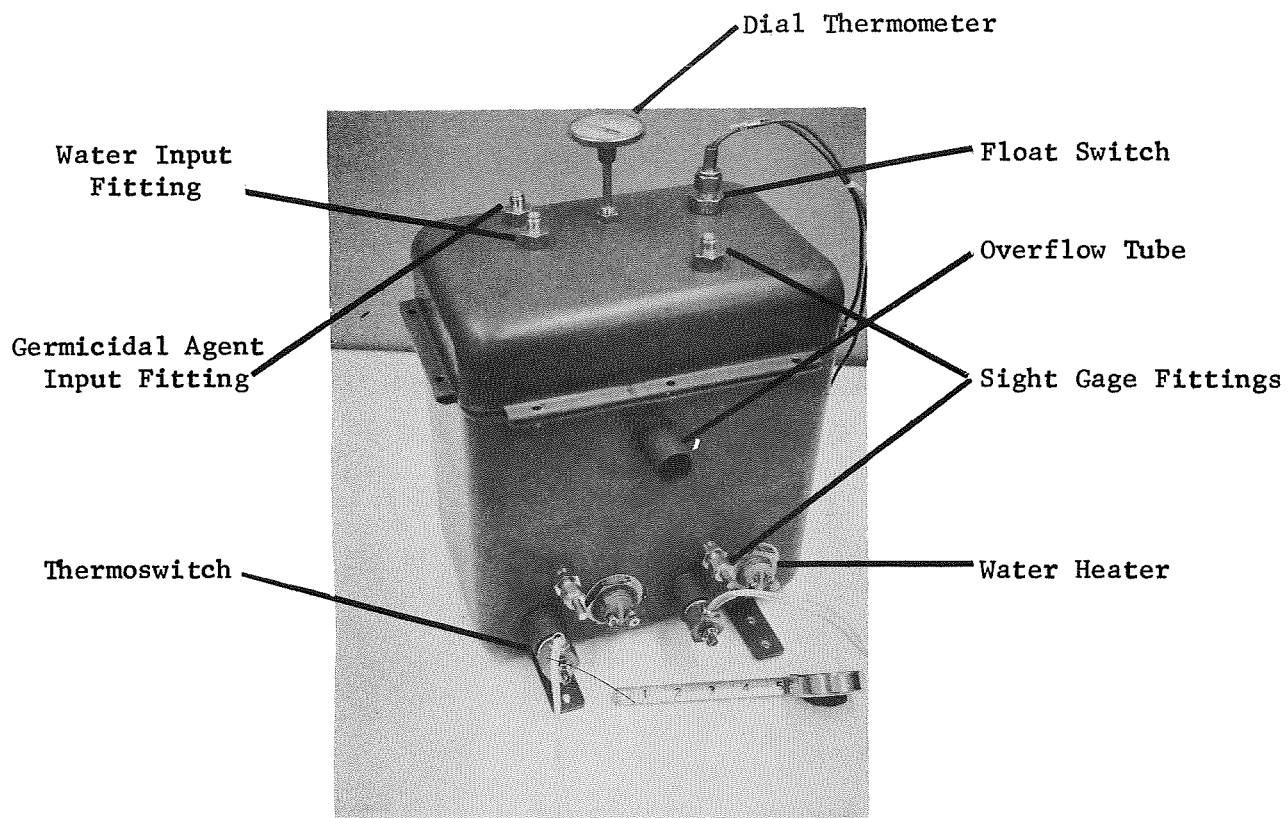


FIGURE 18. WATER TANK

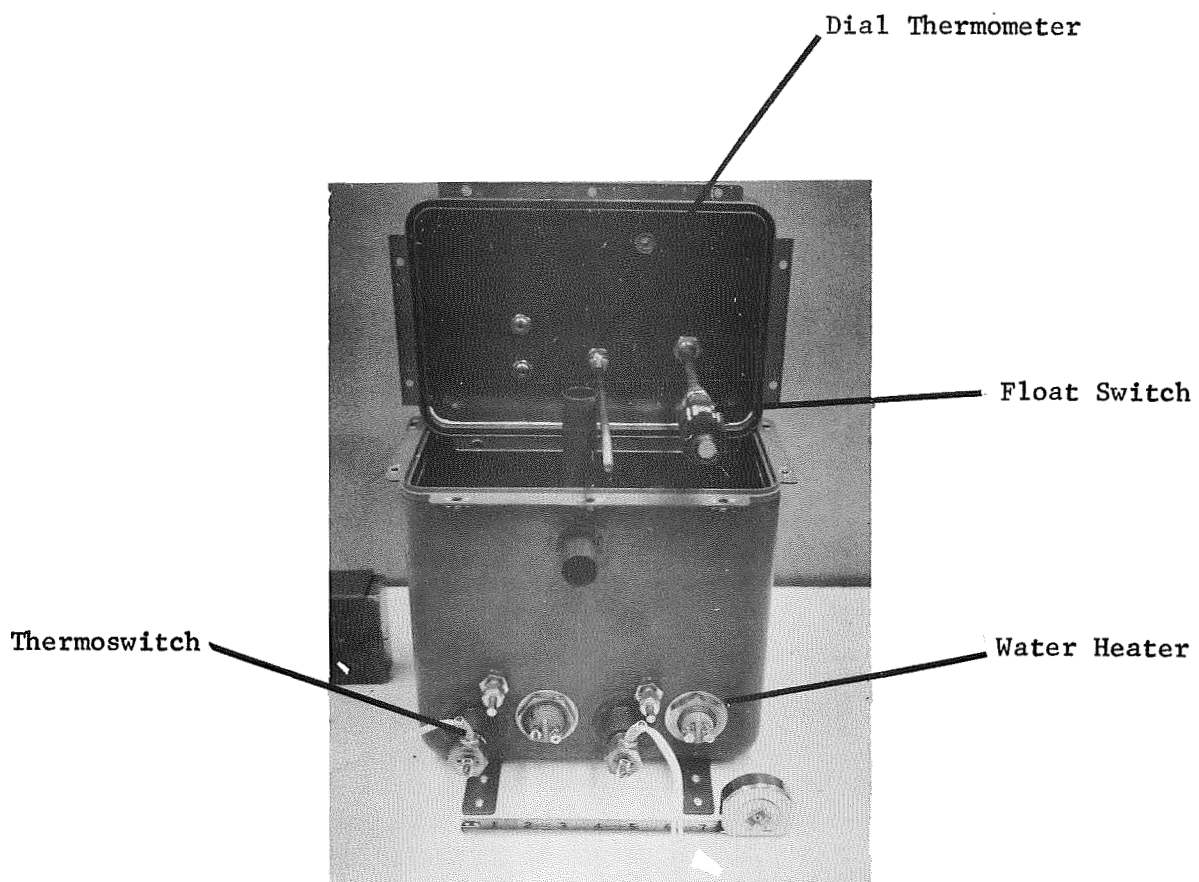


FIGURE 19. WATER TANK

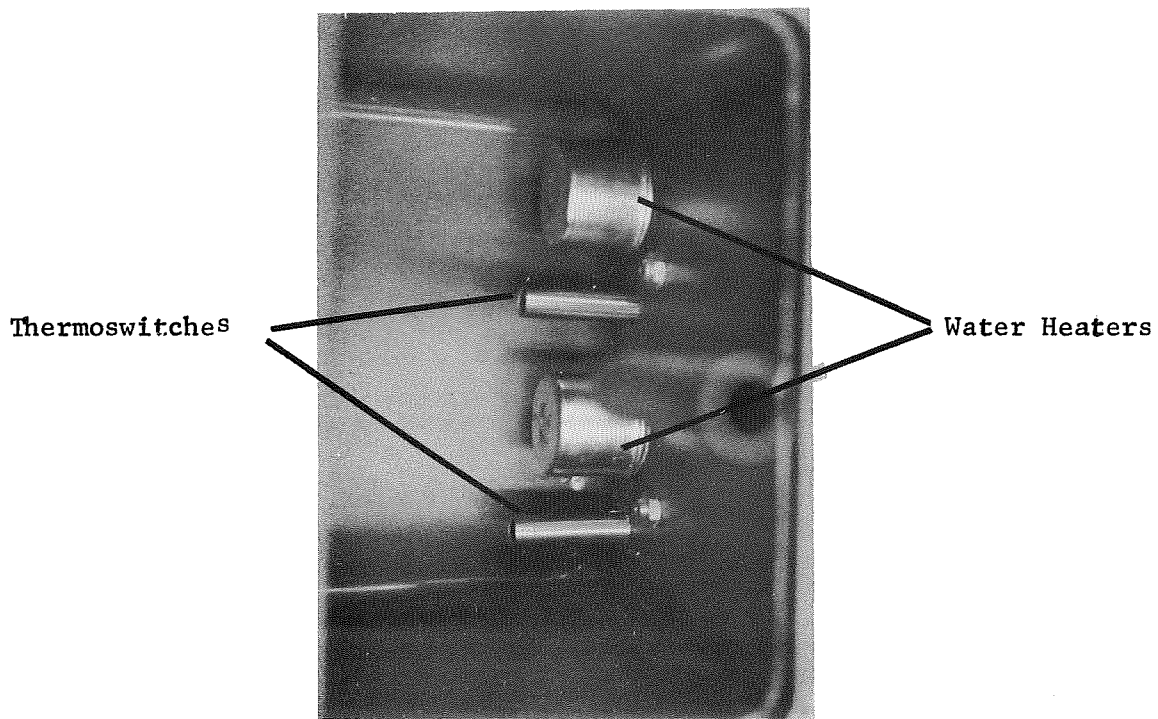


FIGURE 20. WATER TANK INTERIOR

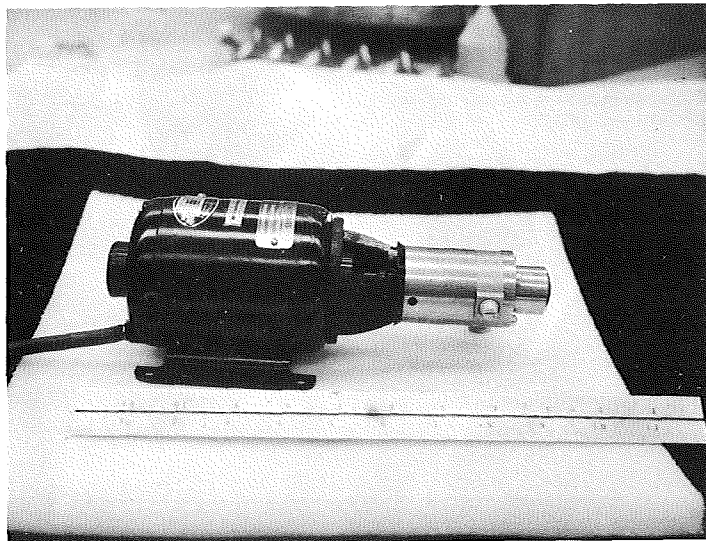


FIGURE 21. WATER PUMP

It is used to sense low level in the water tank and actuate a timer relay to electrically lock out the water pump and water solenoid valve and to open another solenoid valve to admit external water to fill the tank.

4.14 Dial Thermometer (See Figures 18 and 19)

This is a model 2281-0015010, two inch dial thermometer manufactured by the Weston Instrument Company. It has a range of 20°F to 240°F and a stem length of 12 inches.

4.15 Water Filter

All water admitted to the water tank is filtered by a model 4FR-7 filter manufactured by the Nupro Company.

4.16 Adapter (See Figures 11 and 22)

This is a stainless steel device which manifolds and diverts "Position Jet" nitrogen and flush water to the user's anal area through a series of .05 inch diameter holes. There are 12 such water holes and two nitrogen holes.

4.17 Quick Disconnects and Fittings

All stainless steel fittings on the unit are Swagelock type made by the Crawford Fitting Co. The two quick disconnects used for water and germicidal agent fill are type S29N4-4-57 manufactured by SNAP-TITE, Inc.

4.18 Solenoid Valves (See Figure 11)

There are two R2DX40 solenoid valves in the unit. They are used in the water system. One is used to admit water from the water pump to the adapter during the flush cycle. The other is attached to the water supply system and controlled by one of the timers (T5) to automatically refill the water tank from an outside source.

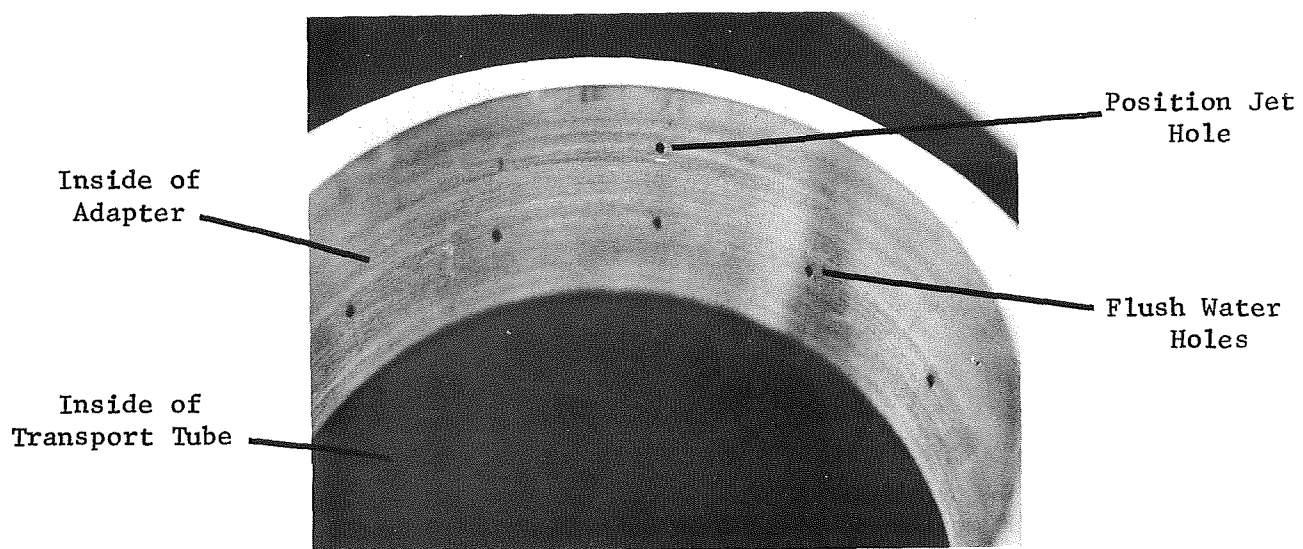


FIGURE 22. ADAPTER

In addition to these three is a R2HDX20 solenoid valve which is controlled by the "Position Jet" switch. It admits 30 psig nitrogen to the adapter when the user employs the position jet feature of the unit.

These three valves are manufactured by the Skinner Co.

4.19 Manual Valves (See Figure 23)

Two Whitey Research Tool Co. 43S4-316 ball valves are used in the pneumatic system, one for system shut-off and the other for system vent. In the water line leading to the urinal there is a Whitey 1KS4-316 forged body valve. This is preset to throttle the water flow to the urinal during the flush cycle.

4.20 Pressure Gage (See Figure 24)

This is a Type 410 Helicoid pressure gage made by the American Chain and Cable Company, Helicoid Division. It has a 0-1000 psig range.

4.21 Nitrogen Tank (See Figure 25)

This is a 62236 seamless high pressure cylinder manufactured by the Water Kidde Co. It has a working pressure rating of 2200 psig. In this unit it is used at 850 psig. At this pressure it allows for approximately 30 seconds of position jet service at 30 psig.

4.22 Relief Valve (See Figure 24)

This is a model 5159T-2MP-900 pressure relief valve manufactured by the Circle Seal Co. It is preset at 900-950 psig.

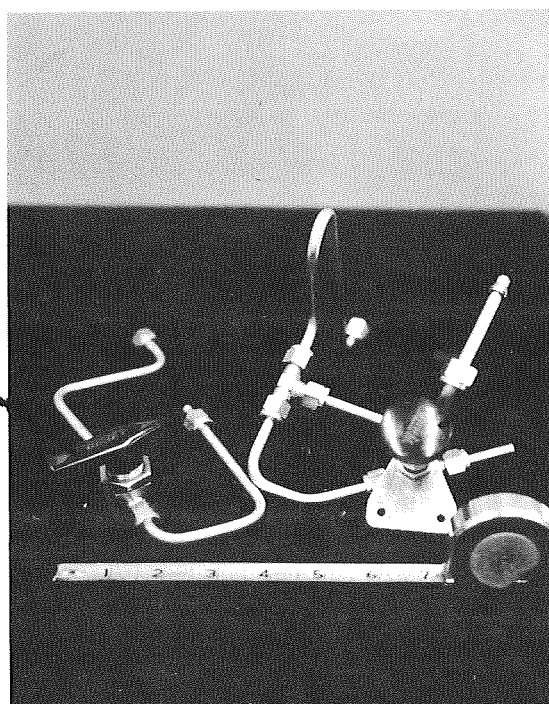
4.23 Regulating Valve (See Figure 24)

This is a 2C-30-R pressure regulator manufactured by the Pneu-Hydro Valve Co. It has a maximum upstream rating of 1000 psig and is preset to deliver 30-40 psig throughout a 50-1000 psig upstream range.

4.24 Flashing Indicator Lights

There are two Dialight Corporation 928-1422-1631-638 red indicator lights on the control panel which alert the user to a low water or water

Whitey 43S4-316
Ball Valve



Whitey 1KS4-316
Valve

FIGURE 23. MANUAL VALVES

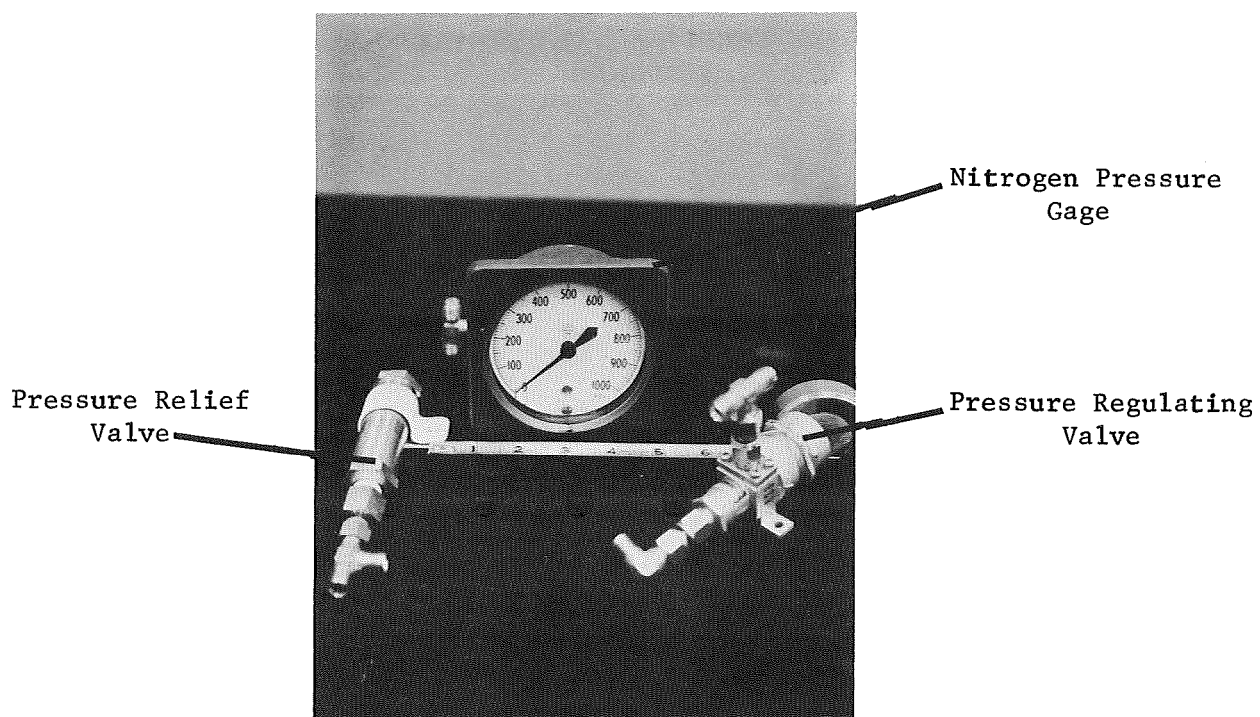


FIGURE 24. PNEUMATIC COMPONENTS

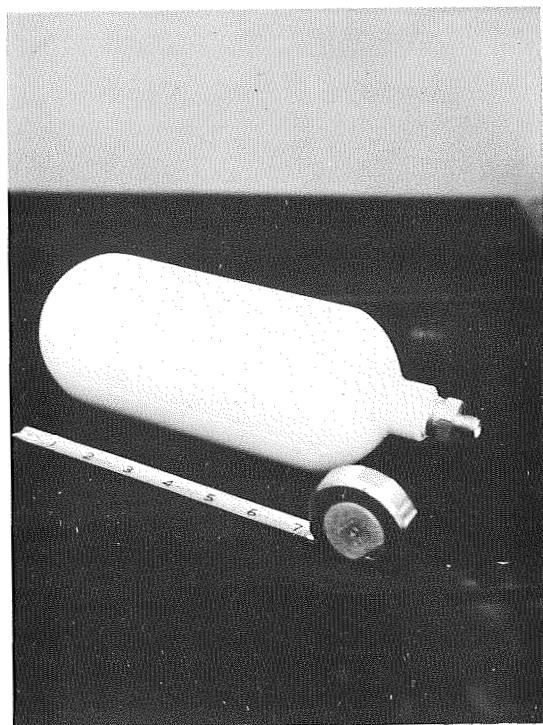


FIGURE 25. NITROGEN STORAGE TANK

heating condition.

4.25 Control Switches

The switches are Minneapolis Honeywell Microswitches. They are provided with either push button or rocker type actuators.

4.26 Timers (See Figure 26)

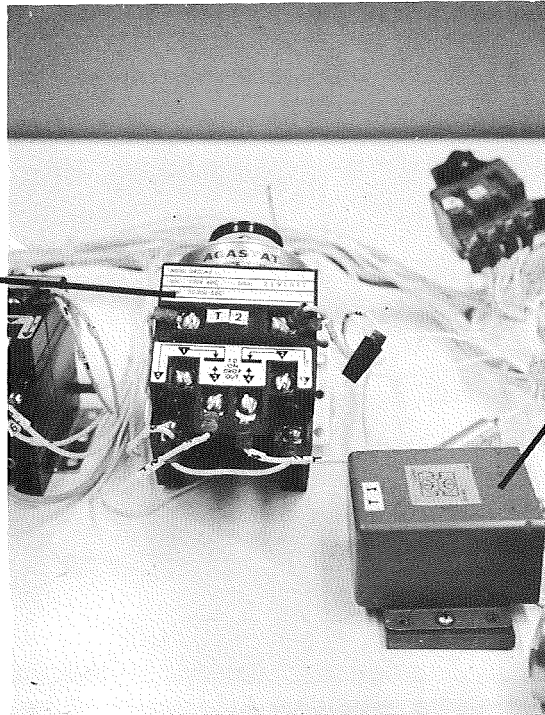
There are four model 2422AE Agastat timers located inside the unit. These are manufactured by the Elastic Stop Nut Corporation. Three of them are used to time the water pump, water solenoid valve, blender motor, and slurry pump in the desired sequence. The fourth is used as a control relay in conjunction with the level switch to lock out the water pump, water solenoid valve, and water heaters in the event of low water level in the water tank. It is also used to energize SV3, the water fill solenoid valve, thereby automatically refilling the water tank. Each of these four timers are manually adjustable through a range of 0-200 seconds by means of control knobs on the tops of their cases.

In addition, there is one 2847Y81C Agastat timer used to control the electrical power to three of the 2422AE timers. This one cannot be manually adjusted and is preset at .2 seconds. The timers are connected in such a manner that the user cannot over demand flush water by keeping the "Flush" switch indefinitely depressed. Once the flush switch has been transferred to a closed position by the user, the timers automatically take control of the system for one cycle unless the user again depresses the flush switch during the cycle. This has the result of starting a new cycle.

4.27 Germicidal Lamp Assembly (See Figure 27)

Attached to the underside of the top cover is a nine watt General Electric G4T4-1 germicidal lamp which is "on" only when the lid is

Agastat Timer
Model 2422AE



Agastat Timer
Model 2847Y81C

FIGURE 26. TIMERS

WARNING: LOOKING DIRECTLY AT THIS LAMP WHILE IT IS LIGHTED RESULTS
IN PERMANENT EYE DAMAGE.

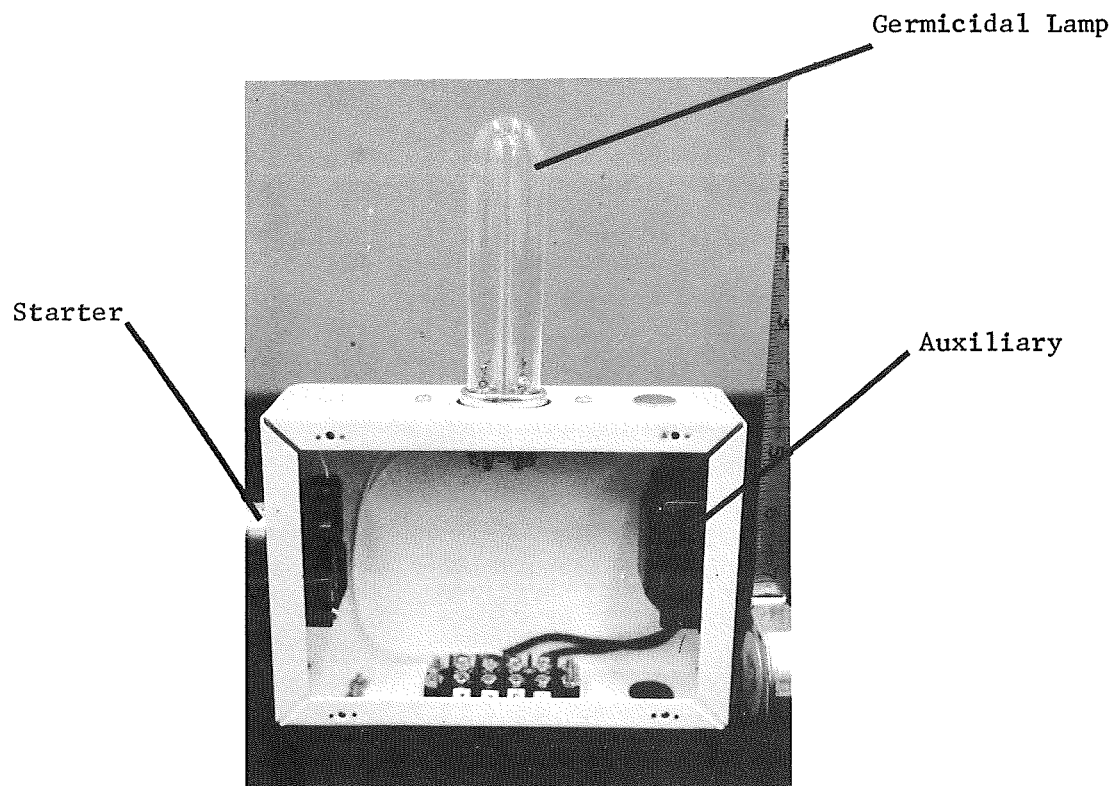


FIGURE 27. GERMICIDAL LAMP ASSEMBLY

closed. Never look directly at this lamp when it is energized since its ultra-violet radiation is harmful to the eyes. Lifting the lid automatically deenergizes the lamp. Associated with the lamp are an 89G504 auxiliary and an FS-5 starter.

4.28 Structure (See Figure 1)

This is a ZCC271-527 aluminum enclosure and lid manufactured by the Zero Manufacturing Co. It measures approximately 33 inches long, 17 inches wide, and 17½ inches high.

4.29 Ground Fault Circuit Interrupter (See Figure 28)

This is a GFB-120 Hubbell Co. differential ground fault circuit interrupter suitable for 120 volt, 60 cycle, 20 amp service. It is a safety device which interrupts electric power to the unit in the event something in the unit is shorted to ground. A current unbalance of 4.0 to 4.6 milliamps will trip this device in one fortieth of a second. It does not protect against line to line faults.

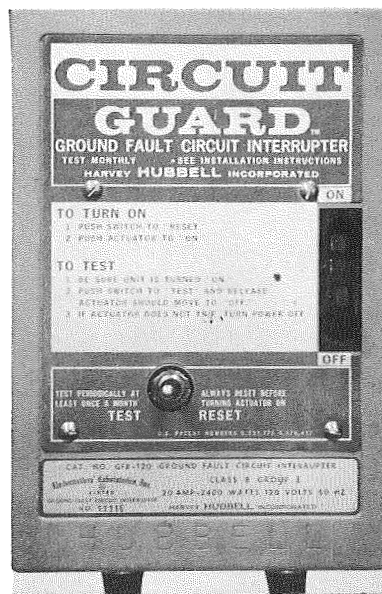


FIGURE 28. GROUND FAULT CIRCUIT INTERRUPTER

SECTION 5
INTERFACES & INSTALLATION

The unit requires positioning on the floor so that the slurry outlet on its back is within four feet of a standard lavatory commode. The height of the commode should be no higher than 16 to 17 inches off the floor. It is not necessary to fasten the unit to the floor. The following paragraphs, in conjunction with Figure 29, describe in detail installation interfaces of the unit's various subsystems.

5.1 Electrical

The unit requires connection to a 115 VAC, 60 HZ, single phase source of electrical power with 20 amp circuit breaker capability.

For safety reasons it is essential that:

- 1) The unit be powered only thru the Ground Fault Circuit Interrupter (GFCI) which is provided with the unit.
- 2) There be a grounded neutral third wire in the house system providing the electrical power.

The GFCI is wired to connect both to the Hydro-John thru a receptacle on the back of the unit and to any standard three prong receptacle on the house electrical system.

If desired, it is possible to run another ground wire from the ground terminal in the GFCI to a good ground path such as a nearby cold water pipe.

After initial installation is complete and before the first live use cycle is started, the GFCI should be tested as described in paragraph 8.2.1 and Figures 38 and 39 of the Maintenance Section of this report. The test log referred to in these instructions should be positioned in a conspicuous place and this first, as well as all subsequent tests, should be properly logged.

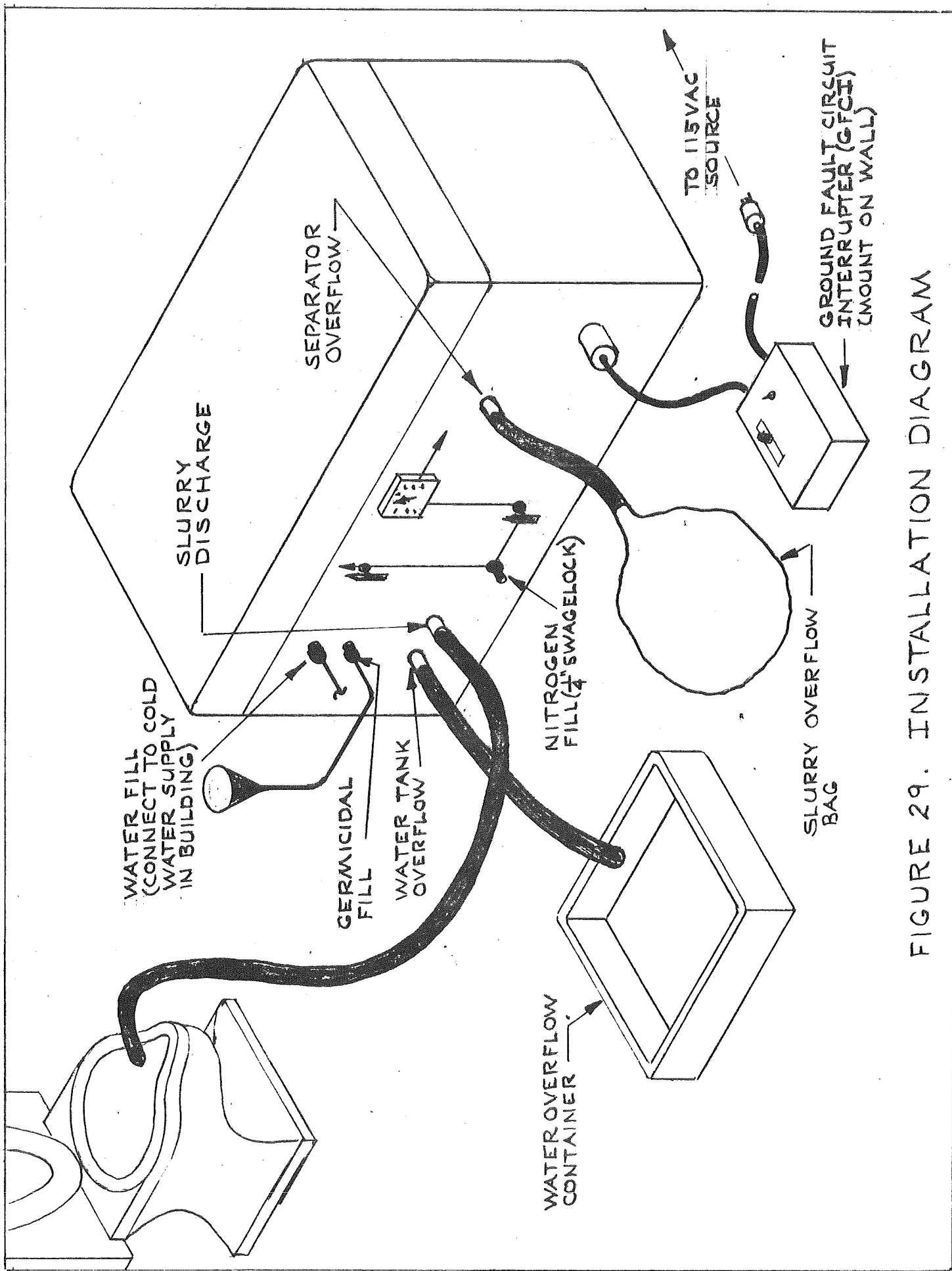


FIGURE 29. INSTALLATION DIAGRAM

It is recommended that there be a slab of minimum one quarter inch thick dry insulating rubber, under and in front of the unit, positioned so that the user's feet rest on it during the use cycles.

5.2 Pneumatic

It will be necessary to periodically charge the pneumatic system with 850 psig (maximum) of nitrogen (approximately after 6-10 use cycles).. An alternative to this would be to connect a standard nitrogen cylinder to the nitrogen fill fitting (1/4" Swagelock) on the back of the unit, if the unit is permanently located in one place. The small cylinder in the unit is intended to provide a degree of portability and self-contained capability.

5.3 Water

The water fill quick disconnect should be connected to the house cold water line. If the tanks is overfilled, the excess water will flow out through the "Water Tank Overflow" fitting which projects outside the back of the unit. It is necessary that this fitting be connected to any suitable open water container (See Figure 29) which is located a few feet from the unit and which has its inlet and at least three gallons of its capacity at a lower elevation than the overflow fitting on the Hydro-John. Connection to the fitting is made with a one inch ID flexible tubing and a hose clamp.

The valve V2 leading to the urinal is preset at approximately 1/10 turn open. Changing this setting could have the result of spraying water inside the box with the resulting danger of electrically shorting the system. If the valve requires resetting, test the flow with the urinal safety removed from the unit.

5.4 Waste Material

There is a plastic fitting projecting from the back of the box labeled "Slurry Discharge". It is necessary that a minimum one inch ID tubing be attached to this by means of a hose clamp. The slurry pump which discharges into this tube has a head capability of approximately three feet of water at a water flow rate of three and one half gallons per minute. It is necessary that the tube's end be located in a commode (See Figure 29). To reduce the head that the slurry pump must discharge against, it is desirable to keep the entire length of this tube as low as possible, preferably below the top level of the Hydro-John's lid. There is also a plastic "Separator Overflow" fitting on the back of the unit similar to the "Water Tank Overflow" fitting and "Slurry Discharge" fitting. This is connected to the phase separator. A length of one inch ID plastic tube should be connected to it to allow drainage of emergency overflow waste material into the flexible plastic bag which must be attached to the other end of this tube (See Figure 29). This receptacle should be positioned on the floor a few feet from the unit with its inlet as well as at least two gallons of its capacity lower than the plastic fitting on the Hydro-John. This receptacle affords a safe, sanitary place for waste material to flow in case of emergency overflow. Without the emergency overflow capability in the phase separator waste fluid can flow into the air blower. It is important that all connections to this plastic receptacle be sealed against air being pulled through it or the line to the phase separator. If too much air is flowing through this line, overflow water may flood the blower and not go into the overflow receptacle.

5.5 Germicidal Agent

The plastic funnel (See Figure 29) provided with the unit should be connected to the "Germicidal Fill" quick disconnect on the back of the unit. It is recommended that for every complete filling of the water tank, 4 cubic centimeters of Wescodyne F-53 with anti-foam also be admitted to the tank. This can be accomplished by filling a 25 cc beaker with 4 cc of Wescodyne F-53 and spraying the inside of the beaker for one to two seconds with Dow-Corning Anti-Foam A before pouring the Wescodyne into the funnel. The first few additions of Wescodyne will merely fill the line from the funnel to the tank but as the unit is put in use, 4 cc will be admitted to the tank each time 10 cc are admitted to the funnel. The addition of too much Wescodyne will cause enough foaming in the phase separator to allow foam and water to be drawn into the bypass plenum and blower. If the ratio of 4 cc of Wescodyne per water tank fill is adhered to, this should not occur provided timer T2 is set for approximately 24 seconds. This setting permits approximately 1,800 cc of water to the system. One cc of Wescodyne F-53 to 1,800 cc of water seems an acceptable mixture for avoiding excessive foaming.

SECTION 6

USE PROCEDURE

Make all of the electrical and water hose connections as described in Section 5 of this report. Turn on the main power switch. If the water tank is empty, allow it to automatically fill and add 10 cc of Wescodyne F-53 to the tank as described in paragraph 5.5. Charge the pneumatic system with 850 psig of nitrogen gas. Be certain that the lid is closed since the water heaters cannot energize with the lid open. After approximately 20 to 30 minutes (depending upon house water temperature) the water temperature will be 100°F and the unit will be ready for use as described in paragraph 6.1 below. Since for safety purposes (as described below) it will be necessary for any user to be accustomed to certain sounds made by the unit, it is mandatory that familiarization with these sounds be obtained by any user before he actually makes use of the unit.

6.1 Use by Individual

- 6.2.1 Upon approaching the unit observe that the sight gage indicates at least one flush remaining. If the water level is above the red line on the sight gage, there is at least one flush in the tank.
- 6.2.2 Unlock the lid, raise it and check that the main power switch is "On". It should be left "On" at all times.
- 6.2.3 Visibly observe that the U.V. lamp is "Off". Do not look directly at the lamp as exposure to its radiation is harmful to the eyes.
- 6.2.4 Audibly monitor that the air blower has started. If the blower does not start, do not use the unit. If at any time during a use cycle the blower stops, depress the "Main Power Switch" to "Off" and leave the seat

- immediately. Without the blower operating water can get under the seat during the flush cycle. For good safety practice such "stray" water is to be avoided in this unit.
- 6.2.5 Observe that the dial thermometer is indicating a comfortable water temperature. Between 85°F and 105°F is the recommended range with 100°F being most acceptable.
 - 6.2.6 Observe that neither red light on the control panel is flashing. There are merely reminders to check water level and temperature as in steps 6.2.1 and 6.2.5.
 - 6.2.7 Position oneself on the seat spreading buttock as much as possible. Increased seat comfort is achieved by placing feet on a 6 to 8 inch high support which should be placed in front of the unit (i.e., block of wood).
 - 6.2.8 Open the urinal enclosure and remove the urinal using the top handle only. This is also necessary when replacing the urinal. Squeeze the urinal handles and insert the penis into a diaphragm opening and release handles to provide a seal.
 - 6.2.9 Depress the "Position Jet" switch. This admits positioning jets of nitrogen to the anal area for as long as the switch is depressed. These jets assist the user in centering himself on the seat assuring a proper seal with the seat.
 - 6.2.10 Defecate and urinate normally.
 - 6.2.11 Remove the urinal from the penis and replace it in its housing. Be certain it is vertically mounted and that the discharge tube has not been pinched so as to impede the flush water flow. (At this point, it is the user's option

to leave the urinal attached or replace it in its enclosure for the flush cycle.) Close the urinal enclosure.

6.2.12 Momentarily depress the "Flush" switch.

6.2.13 At this point, the user should audibly monitor that the slurry pump and blender have started. He will feel the sensation of water flow. At anytime during the period that the user feels the sensation of water flow, if any of the following conditions occur, he should immediately depress the "Main Power Switch" to "Off" and leave the seat:

- (a) The blender either does not start with the water flow or it stops before the water flow stops.
- (b) The slurry pump does not start with the water flow or it stops before the water flow stops.
- (c) The blower stops.

While being washed it is suggested that the user "strain" and also depress the "Position Jet" switch a few times to assist the washing action of the water. During the water flow he should remain fairly static on the seat so as not to break the seal thereby allowing water to spray outside the unit or "stray" into the air holes under the seat.

This latter condition can be caused by decreasing the air flow under the seat by allowing air to enter the blender directly from the top. Less air flow through the seat air holes can result in an excessive amount of water straying through these holes, if there is not enough air flow present to drive the water away from them.

- 6.2.14 When the water flow, the blender, and the slurry pump have stopped, depress the "Air Heater" switch. This will heat the air for as long as the switch is depressed. It is the user's option to continue this operation until he is dried to his satisfaction.
- 6.2.15 Leave the seat.
- 6.2.16 Close and lock the lid observing that the air blower stops. At this point if the automatic refill system has actuated, admit 4 cc of Wescodyne F-53 (with Anti-foam spray, see paragraph 5.5) to the water tank using the funnel on the back of the unit. If the automatic refill has not actuated, the user should immediately refill the water tank if his use leaves the water level below the red line on the sight gage. This can be done by momentarily depressing the "Refill" switch next to the sight gage. This will assure a supply of warm water for the next user. Again, it will be necessary to add 4 cc of Wescodyne F-53 as mentioned above. For good safety practice (See paragraph 8.4 and 8.5 of this report), observe that no waste material entered the plastic emergency overflow waste bag in back of the unit. Also, observe that the water tank overflow is empty. If either of these two containers have liquid in them, see that they are emptied before the next use of the unit. If the waste overflow bag is partially filled, also check that the air system bypass plenum, the blower and the area under the seat are dry before the next use of the unit.

6.2.17 W A R N I N G:

DO NOT DEPRESS EITHER OF THE TWO GRAY BUTTONS PROTRUDING THROUGH THE TOP PLATE AND LOCATED TO THE REAR OF THE UNIT ON THE USER'S LEFT SIDE. DEPRESSING THESE WITH THE LID OPEN WILL STOP THE AIR BLOWER AND ENERGIZE THE ULTRA-VIOLET LAMP, CREATING TWO POTENTIALLY HAZARDOUS SITUATIONS.

SECTION 7

TESTING

The test results discussed in this section are in the same order as the paragraphs in the test plan and relate directly to them (i.e., paragraph 7.1.1 relates directly to paragraph 7.2.1).

7.1 Test Plan

- 7.1.1 Observe that there are no visible liquid leaks in any of the liquid input or discharge lines during and after five use cycles and one fill cycle.
- 7.1.2 Verify the ability of the water tank overflow line to discharge a tank overflow when the unit is automatically refilled from the house system.
- 7.1.3 Verify the ability of the phase separator overflow tube to discharge overflow from the blender with the system running.
- 7.1.4 Verify that the discharge of water only from four use cycles constitutes four four-pound (1814 cc) quantities of water.
- 7.1.5 Proof test the pneumatic system to 900 psig. Verify that the relief discharges at a maximum of 950 psig.
- 7.1.6 Subject the unit to 25 waste handling cycles. A minimum of five of these will be actual use cycles by male subjects and the remaining 20 can be accomplished by live subject use or admission of previously collected waste products or simulated waste products. Obtain reactions from the five users on comfort and confidence in sanitary aspects of the unit.

7.2 Test Results

- 7.2.1 There were no leaks on any of the liquid lines during or after five complete use cycles and one fill cycle.
- 7.2.2 The water overflow tube discharged overflow from the water tank when it was being automatically filled from the house system.
- 7.2.3 The phase separator overflow tube discharged the overflow with the slurry pump deliberately disconnected. Two flush cycles were initiated to attempt a spill into the blower. Small quantities of water entered the bypass plenum, but the bulk of the water spilled into the emergency bag so long as the bypass setting remained undisturbed and the Wescodyne input was not excessive.
- 7.2.4 With Timer T2 set at approximately 24 seconds the unit delivers a nominal four-pound quantity (1,814 cc) of water per flush cycle. With the water tank filled to the "High" mark, four such quantities of water are available before the water level goes below the red line on the sight gage.
- 7.2.5 The pneumatic lines and gas cylinder successfully withstood 900 psig and the relief valve cracked between 900 and 950 psig.
- 7.2.6 The unit operated successfully for 19 live use cycles. An additional 11 use cycles were successfully completed using simulated waste material (peanut butter). After nine uses by male subjects the personal reactions shown in Figure 30 were recorded. At that time, it was obvious that the discharge pressure (approximately 20 psig) of the water pump

was not high enough to always assure cleaning. A replacement pump with a nominal discharge pressure of 40 psig was installed and the unit was used ten more times by male subjects. Their personal reactions are recorded in Figure 31. The 19 live uses recorded were accomplished by eight individuals. Those who used the unit more than once indicated that familiarity with the unit gained on the first use made some subsequent uses more acceptable since some natural apprehensions were removed.

7.3 Test Conclusions and Recommendations

- 7.3.1 The unit is basically a successful demonstration of the usefulness and feasibility of this type of system. Improvements in the areas of seat comfort and washing action are necessary. More development effort in seat contouring as well as enlargement of the seat opening should result in a higher acceptance rating in this area. Further development of spray nozzle configurations (i.e., movable nozzle similar to a shower head) will no doubt improve the cleansing action offered by this type of unit and also eliminate the admission of small quantities of water under the seat, a situation which occurs on the present unit during each use cycle.

Use	Seat Comfort	Confidence in Align- ment on Seat	Position Jet Use- fulness	Air Heater Useful- ness	Confidence in Water Wash	Confidence in Urinal not Spilling	Simplicity of Operation	Overall Reaction
1	3	3	5	3	3	3	5	L
2	3	3	5	4	3	5	5	L
3	2	4	3	4	2	5	5	L
4	2	4	4	4	3	5	5	L
5	3	4	5	5	3	5	5	L
6	3	4	5	5	3	5	5	L
7	2	4	3	4	2	5	5	L
8	3	4	4	5	2	5	5	L
9	3	4	5	5	2	5	5	L
Average	2.66	3.77	4.33	4.33	2.55	4.77	5.0	100% Liked
Mean Average	3.91							

FUNCTIONAL RATINGS: 5 - Excellent
4 - Good
3 - Fair
2 - Poor
1 - Unacceptable

OVERALL REACTION RATINGS: L - Liked Unit
D - Disliked Unit

FIGURE 30. USER REACTIONS (20 PSIG PUMP)

Use	Seat Comfort	Confidence in Align- ment on Seat	Position Jet Use- fulness	Air Heater Useful- ness	Confidence in Water Wash.	Confidence in Urinal not Spilling	Simplicity of Operation	Overall Reaction
1	4	4	4	4	5	5	5	L
2	3	4	5	5	4	5	5	L
3	2	4	3	4	3	5	5	L
4	2	3	4	3	3	4	5	L
5	2	4	3	4	3	5	5	L
6	3	4	5	5	4	5	5	L
7	4	4	5	4	4	5	5	L
8	2	4	3	4	3	5	5	L
9	3	4	5	5	4	5	5	L
10	2	4	4	4	3	4	5	L
Average	2.7	3.9	4.1	4.2	3.6	4.8	5.0	100% Liked
Mean Average	4.04							

FUNCTIONAL RATINGS:

- 5 - Excellent
- 4 - Good
- 3 - Fair
- 2 - Poor
- 1 - Unacceptable

OVERALL REACTION RATINGS: L - Liked Unit
D - Disliked Unit

FIGURE 31. USER REACTIONS (40 PSIG PUMP)

SECTION 8

MAINTENANCE

8.1 Introduction

There are four Pres-Loc fasteners on the top plate. Depressing each of these with a screwdriver releases the top plate from the unit enabling it to be removed after the air heater connector under the top plate is disconnected. It is recommended that any time this plate is removed that the electrical power connector on the back of the unit be disconnected. If it is necessary to maintain electrical power on the unit with the top cover removed, extreme caution should be exercised because even if the main power switch is "Off" there will still be some terminals that are energized. The safest method and the one used at the General Electric Co. while working on the unit is to disconnect the power plug from the house electrical system each time hands are inside or touching the box while it is being serviced. When replacing the top plate be careful not to inadvertently disconnect any of the air system flexible ducts with the air heater power cable.

In the following paragraphs some required periodic maintenance operations are discussed along with methods of adjusting parts of the system if this becomes necessary. In addition some reprints of component manufacturer's instructions are included for reference.

8.2 Electrical

8.2.1 GFCI

It will be necessary to periodically test the Ground Fault Circuit Interrupter (GFCI) by first assuring that there is power to the GFCI and that the rocker switch on its face is the the "On" position. Also, check that the GFCI is connected to the Hydro-

John. Lift the Hydro-John lid and turn the main power switch "On". Observe that the blower starts. Then push the momentary toggle switch (also on the face of the GFCI) to "Test". If the GFCI functions properly, the Hydro-John should be immediately de-energized. This can be checked by observing that the blower stops and that the sight gage lamp goes out. A third check is to see that the GFCI rocker switch has transferred to "Off". If the Hydro-John is still energized after pushing the "Test" switch on the GFCI, do not use the Hydro-John until the GFCI is either replaced or made operable. If the GFCI successfully completes this test, push its toggle switch to "Reset" and depress its rocker switch to the "On" position.

The GFCI manufacturer recommends testing this unit at least once a year and immediately after any "tripping" occurs. Provided with the GFCI is a label on which all such events should be logged and posted on a conspicuous place near the GFCI. For further reference on this device, Figures 38 and 39 are reprints of the GFCI manufacturer's instructions.

8.2.2 Ground Lines

If any component is removed, be certain on re-installation to install the case ground wire associated with it.

8.3 Water Subsystem

It is recommended that the water tank overflow container be periodically (depending on the use rate of the unit) checked to be certain it is empty enough to handle overflow which may occur from refilling the water tank. If the urinal throttling valve requires resetting, be certain that the urinal is positioned so as to avoid overflowing into the unit when testing it. Hold

the urinal upright and away from the unit. To adjust this valve setting as well as various timer settings it will be necessary to cover the seat opening to contain the water spraying from the adapter when the "Flush" switch is depressed. If for any reason the blower is not running, do not depress the "Flush" switch since without the air flow, an excessive amount of water can enter under the seat and possibly short the air heaters.

8.4 Waste Subsystem

It is recommended that the top plate be periodically removed and the insides of both the transport tube and phase separator, and all transparent lines between them and the slurry pump as well as the slurry pump discharge line be observed for clogging with solid materials. During this observation also check for water in the air system bypass plenum. In addition, see that there is no accumulation of waste material in the plastic emergency overflow bag which is connected to the phase separator through the back of the unit. This container should be kept empty. If it becomes partially filled its emergency overflow capacity is naturally less thereby increasing the possibility of flooding the blower (see paragraph 8.5 below). This capacity should always be at a maximum for safety reasons. If waste does flow into this bag, it is advisable also to check for water in the seat air plenum.

8.5 Air Subsystem

The air system bypass plenum is preset to preclude the blower from sucking waste water into itself if the water level in the phase separator is too high due to slurry pump failure, line clogging or an excessively large urine/feces deposit. Water in the blower could cause an electrical short and at best is not good for the blower. Consequently, it is recommended that this bypass plenum setting not be changed. It assures a

dry blower as well as enough air flow under the seat to keep an excessive amount of flush water from entering the seat air holes. Since a small amount of water does accumulate under the seat during each use cycle a periodic check of this is recommended to assure safe operation.

If for any reason the blower does get seriously flooded, it will stop. To empty it follow the instructions in paragraph 8.1 of this report and remove the flexible inlet and outlet ducting from the blower and bypass plenum. Remove the water from the plenum with a syringe. Tilt the entire unit until water is seen inside the blower. Remove this with a syringe. Keep tilting the unit and using the syringe until no more water can be obtained all the while keeping spillage inside the unit to a minimum. Then inject shop air or dry nitrogen into the blower inlet using a standard 1/2 inch shop air hose (no seal at the blower inlet). Continue this for one half hour and remove the hose from the blower. The blower should start. If not, repeat the shop air process and periodically (every ten minutes) test the blower until it starts. With the unit's lid open use the "Main Power" switch to energize the blower.

On the blower there are two built-in plastic trimmer valves. These have been covered with tape which should be left on.

8.6 General Maintenance

Figures 32 thru 41 are reprints of manufacturer's instructions, etc. which are included for reference.

Coil Data

Coil Part Number	Code Letter	Rated Voltage	Operating Voltage Range @ 60 cps	Operating Voltage Range @ 50 cps
2400 —	A	120	102-132	110 93.5-121
	B	240	204-264	220 187-242
	C	480	408-528	
	D	550	468-605	
	E	24	20.3-26.5	
	F			127 108-140
	G			240 204-264
	H	12	10.2-13.2	
	J	6	5.1-6.6	
	K	208	178-229	
K DUAL VOLTAGE COIL (COMBINES A & B)				

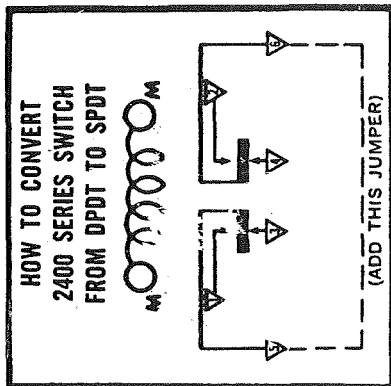
AC SPECIALS L1, L2, etc.
A C Coils (Part No. = 2400 followed by dash and code letter above)

Coil Part Number	Code Letter	Rated Voltage	Operating Voltage Range D.C.
2410 —	M	28	22.5-33.5
	N	48	38.5-57.5
	O	24	19.2-28.8
	P	120	96-144
	Q	12	9.6-14.4
	R	60	48-74
	S	250	200-300
	T	550	440-660
	U	16	12.8-19.2
	V	32	25.6-38.4
	W	96	76.8-115
	Y	6	4.8-7.2
	Z	220	176-264

DC SPECIALS X1, X2, etc.

DC Coils (Part No. = 2410 followed by dash and code letter above)
All units draw approximately 8 watts power at rated voltage.
Minimum operating voltages are based on vertically mounted 2412 (Type 1) units. 2412 horizontally mounted or 2422 (Type 2) vertically or horizontally mounted units will operate satisfactorily at minimum voltages approximately 5% lower than those listed.

A C units drop out at approximately 50% of rated voltage. D C units drop out at approximately 20% of rated voltage. All units may be operated on intermittent duty cycle at voltages 10% above the listed maximums. (Intermittent duty —maximum 50% duty cycle and 30 minutes "on" time.)



WARRANTY

The AGASTAT timing relay is warranted against mechanical and electrical defects for a period of one year from date of shipment from factory if it has been installed and used in accordance with factory recommendations. New parts will be furnished free of charge in exchange for parts which have proven defective. The furnishing of these parts shall constitute fulfillment of the Company's obligations and liabilities.

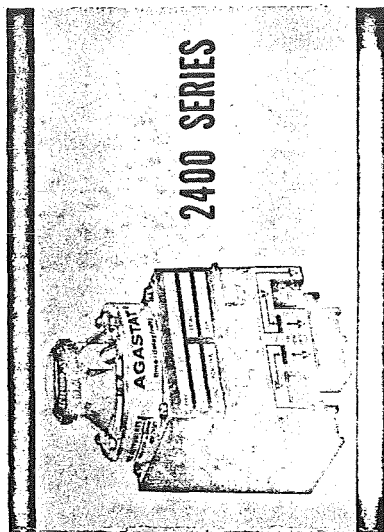
AMERACE-ESNA
CORPORATION
AGASTAT DIVISION
1027 Newark Avenue
Elizabeth, New Jersey 07208

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4/69
(Supersedes 2/68)

AGASTAT® timing relay

INSTRUCTIONS for INSTALLATION and OPERATION



Every AGASTAT timing relay is a precise timing instrument which balances pneumatic, electrical and mechanical forces in a unique design using a minimum of moving parts. Its accuracy and performance to specifications have been carefully tested before shipment. Properly applied, it offers exceptional life expectancy. A few minutes spent in familiarizing yourself with these instructions will help you get the best possible service from this unit in your application.

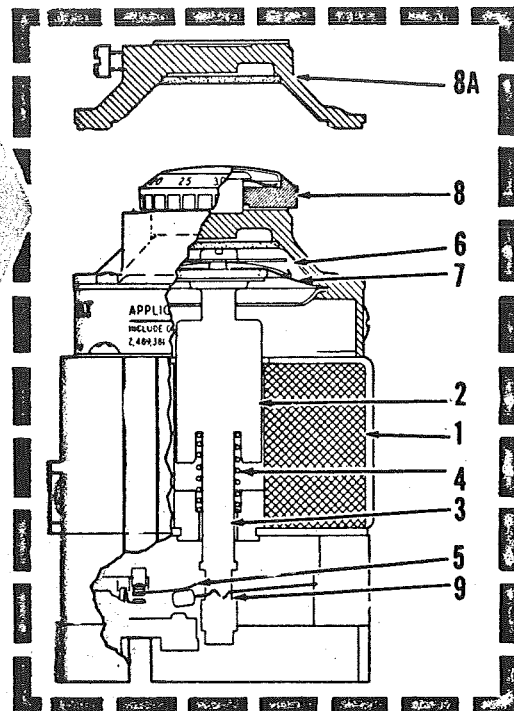
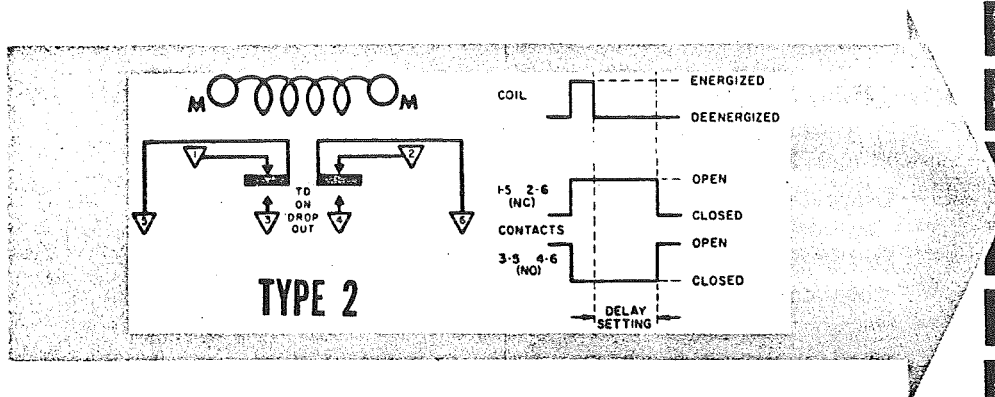
Because of the skilled calibration and adjustment required on certain components prior to final assembly, we recommend that field servicing be limited to the replacement of the switchblock and coil assemblies, listed below. These have been designed to insure factory-built performance after field servicing without elaborate calibration. In cases where damage or abuse make it impossible to restore satisfactory performance by replacing these assemblies, the unit should be returned to the factory for repair or replacement.

FIGURE 32. TIMER DATA

All 2400 Series units may also be mounted horizontally. If horizontal mounting was not specified on your order, unit may require adjustment to match horizontal timing with dial markings. This is accomplished by moving lower collar up or down on spindle. While holding spindle stationary with 1/16" Allen wrench, use 1/4" open end or socket wrench to reposition collar. Screw collar up (clockwise) to decrease time, down (counterclockwise) to increase time.

PART NO.	DPDT Switchblock Assembly
2412-30	Coil Assembly, voltage as specified by code letter (See Coil Data Chart)
24200-(AC)	Auxiliary Switch Kit (Code L)
2410-(DC)	Auxiliary Switch Kit (Code T)
2412-120	
2412-121	

-65-



2422 SERIES TIME DELAY ON DROP-OUT

When the coil (1) is energized, it pulls down (or pulls in) the core (2), which is rigidly attached to the spindle assembly (3). This compresses operating spring (4) and trips switch assembly (5), transferring its contacts from the NC position to the NO position. Air is simultaneously drawn rapidly into the timing chamber (6) through a one-way valve in the diaphragm (7). When coil (1) is deenergized, the core (2) and spindle assembly (3) are forced up against the diaphragm (7) by the operating spring (4). Air

trapped in the timing chamber (6) is forced out by the diaphragm (7) through an adjustable orifice. The rate of flow, which determines the length of time delay, is adjusted by means of the calibrated dial (8) or needle valve (8A) on the timing head. As the air passes through the orifice, the spindle assembly (3) continues upward until the collar (9) on the end of the spindle trips the switch assembly (5), returning the contacts to their initial position.

AUXILIARY SWITCH ADJUSTMENT

2412 SERIES

1. INSTANT TRANSFER AUX. SWITCH (CODE L)

Aux. switch should transfer immediately when relay coil is energized, and should reset shortly before solenoid core returns to its normal position, following deenergization. If it fails to reset before end of core's downward stroke, loosen screw in slotted hole of mounting bracket and move switch closer to terminal block.

2. TWO STEP AUX. SWITCH (CODE T)

Aux. switch contacts should transfer following first delay period after coil energization, and should reset shortly before core returns to its normal position, following coil deenergization. To increase first delay period, increase the distance between actuator screw head and arm by turning it clockwise, using 1/16" Allen wrench. *

2422 SERIES

1. INSTANT TRANSFER AUX. SWITCH (CODE T)

Aux. switch should transfer immediately when relay coil is energized, and should reset shortly before spindle returns to its normal position, following deenergization. To increase aux. switch delay period, increase the distance between actuator screw head and arm by turning it clockwise, using 1/16" Allen wrench.

2. TWO STEP AUX. SWITCH (CODE T)

Check operation as for Instant Transfer, above. Increase first delay period by turning actuator screw clockwise until the desired delay before aux. switch transfer is reached.

*First Delay Is Independently Adjustable, But Must Be at Least 25% of Overall Delay. (Recommended Max. 30 Sec.)

CONTACT RATINGS

Contact Capacity in Amperes (Resistive Loads)

Contact Voltage	Min. 100,000 Operations	Min. 1,000,000 Operations
30 vdc	15.0	7.0
110 vdc	1.0	0.5
120 v 60 cps	20.0	15.0
240 v 60 cps	20.0	15.0
480 v 60 cps	12.0	10.0

Inductive and capacitive loads should not have inrush currents that exceed five times normal operating load.

Contact rating as listed under the UL Component Recognition program is 240 VAC 1/4 H. P. - 10 A. Resistive, and is so identified on the relay.

TIMING RANGES

A .1 to 1 sec.	F .5 to 10 min.
B .2 to 5 sec.	G 1 to 20 min.
C .8 to 15 sec.	H 1 to 30 min.
D 2.5 to 50 sec.	I 2 to 60 min.
E 10 to 200 sec.	J 3 to 120 cyc.
	K 1 to 300 sec.

All dial head units are furnished with dials calibrated in linear increments covering the range selected. In addition, time-calibrated ranges C through K, provide non-linear adjustment from .2 second to the beginning of the linear zone. For easiest adjustment and lowest cost, the shortest time range suitable for the application should be selected.

In addition to the dial head models above, the 2400 Series are also available with needle valve adjustment. They are recommended only for applications where frequent readjustment of the delay period is not required, or where initial cost is a prime consideration. One timing range is offered:

N .2 to 180 sec.

All needle valve models are factory adjusted to the delay specified; if no delay is specified, the unit is set for an approximate 10 seconds delay. To change this setting, turn the adjusting screw SLOWLY clockwise to increase the time delay, counterclockwise to decrease it, as indicated by the "increase" and "decrease" arrows on the timing head. CAUTION: Turn the screw only a fraction of a revolution before each timing check to avoid damaging the needle or orifice.

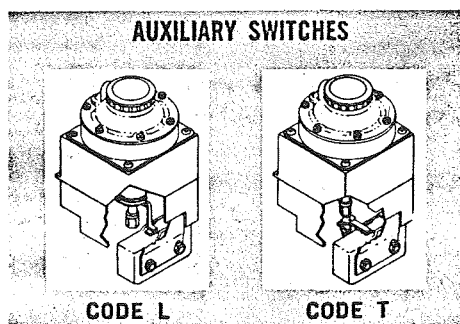


FIGURE 34. TIMER DATA

Instructions For Your **Fenwal** THERMOSWITCH Units

YOUR THERMOSWITCH TYPE

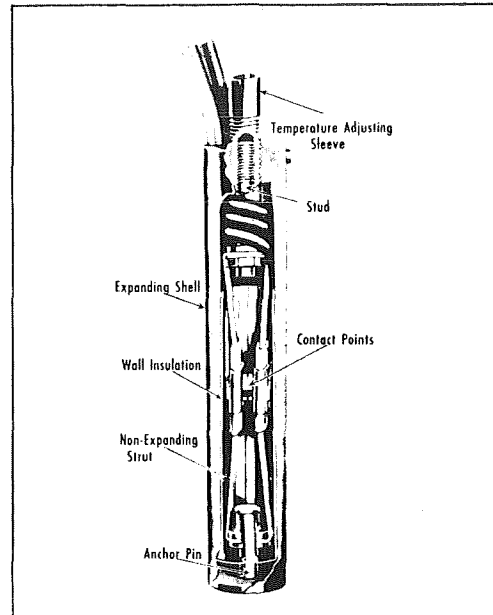
The shell of your THERMOSWITCH unit contains the Catalog Number, the Current Rating, the Temperature Range and the Contact arrangement.

The fifth digit of your catalog number describes whether contacts open or close on temperature rise. If contacts open on temperature rise, the fifth digit of catalog number is an even number such as 17000, 17102, etc. If contacts close on temperature rise, the fifth digit is an odd number such as 17001, 17103, etc.

The fourth digit of your catalog number will quickly determine whether the unit is tension or compression operated.

Tension operated indicates that the contacts are operated by exerting tension on the ends of the strut mechanism. If the fourth digit is other than "2" or "7" (such as 17000, 17030, etc.) it is tension operated. Tension operated units may be subjected to momentary temperature exposure of 100°F above their set point within their temperature range, or subjected to any temperature below their set point without damage.

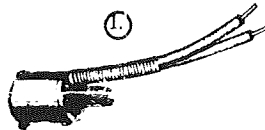
Compression operated indicates that contacts are operated by varying the compressive force on the ends of the strut mechanism. If the fourth digit is "2" or "7" (such as 17020, 17070, etc.) it is compression operated. Compression units are recommended if overshoots are to be encountered. The compression feature allows a unit to be overshoot 400°F above the high limit of its temperature range for short periods of time, and undershoot to -65°F from any setting within its temperature range. **IMPORTANT:** Overshoot must not exceed 550°F for Low Temperature Units and 750°F for High Temperature Units. When in doubt, the factory should be consulted.



INSTALLATION

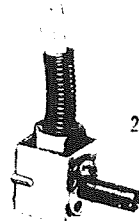
Your THERMOSWITCH units come in four basic models (1) Cartridge type, (2) Block Head type, (3) Threaded type and (4) Flange type.

① **Cartridge Type**—Insert in a 5/8" reamed hole (13/16" for heavy duty units) in the medium to be controlled. Hole should have short spline to receive the 1/8" locating pin. This prevents the cartridge unit from rotating when the adjusting sleeve is turned. It may also be used for surface control if inserted in a Fenwal surface mounting block (Cat. No. 11100-2) or clamp to the surface in a manner which does not restrict the expansion or contraction of the temperature sensing shell.



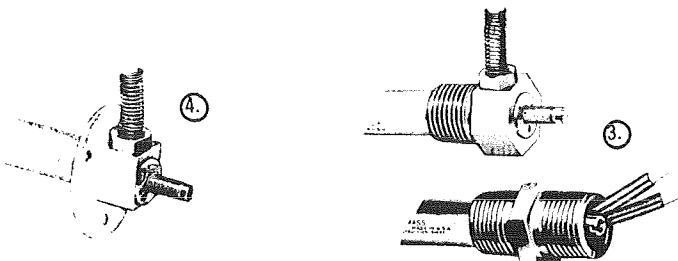
② **Block Head Type**—is mounted similarly to the cartridge type. If the unit is to be inserted in a reamed hole, two short pins should be mounted on either side of the hole. The pins should rest against the sides of the block head to prevent rotation of the unit.

③ **Threaded Type**—can be installed like any pipe fitting. Avoid applying undue torque to the unit. Torque in excess of 35 foot pounds for the standard size (5/8" diam. shell) or 70 foot pounds for the heavy duty (13/16" diam. shell) will offset the preset temperature of the control.



if the threaded units are installed in a pipe tee, the tee should be large enough to allow adequate circulation of the fluid around the temperature sensitive section of the unit.

④ **Flange Type**—Three holes in flange allow for easy mounting on any flat surface.



CAUTION!

DO Be certain that there is sufficient but not excess room for the installed THERMOSWITCH unit to expand in diameter and length.

DO Use a Well (Series 11100, 11200) where the THERMOSWITCH unit is being subjected to corrosive fluids, or to electrolytic action.

DO Insulate head of the THERMOSWITCH unit where large external temperature variation may occur. This precaution is not necessary on the junction box type. (Series 17700, 17800)

DO Use a Fenwal adjustable seal (Modification 8) and leadwire packing gland (Modification 13) where moisture can condense on lead wires or adjusting screw.

DON'T REMOVE ADJUSTING SCREW OR TURN ADJUSTING SCREW IN FURTHER THAN NECESSARY FOR DESIRED OPERATION! THIS ACTION MAY PERMANENTLY DAMAGE THE UNIT AND MAY VOID STANDARD FENWAL GUARANTEE!

DON'T exceed the ratings indicated on THERMOSWITCH unit shell.

DON'T immerse your unit in liquids or vapors unless it was specified for that job.

DON'T oil your unit. Oil around adjusting screw will flow inside, contaminating contacts.

DON'T try to repair unit yourself.

DON'T thermally shield unit from medium being controlled.

DON'T handle unit with pliers or force it into position either by hand or tools, or apply excessive torque in tightening threaded units.

DON'T subject shell of unit to deformation.

NOTE: All factory temperature settings are at contact make.

FIGURE 35. THERMOSWITCH DATA

TESTING AND ADJUSTMENT

The arrow on the head of THERMOSWITCH unit indicates direction to turn adjusting screw to increase temperature setting. Torque in excess of 15 inch pounds on adjusting screw will deform slot.

Each full turn of adjusting screw will change the temperature the approximate number of degrees as follows:



ADJUSTMENT RATES for THERMOSWITCH UNITS			
Tension Operated		Compression Operated	
Catalog Series Number	Approx. °F per full turn of adj. screw	Catalog Series Number	Approx. °F per full turn of adj. screw
—	—	13121-1	1000
15050 to 16051	165	—	—
17000 to 17503	90-115	17020 to 17523	90-100
17700 to 17701	145	17720 to 17721	85
17702 to 17703	180	17722 to 17723	100-150
17800 to 17801	125	17820 to 17821	75
17802 to 17803	160	17822 to 17823	115
18000 to 18003	80-100	18020 to 18023	70-135

After the THERMOSWITCH unit has been installed, final adjustment can be made by allowing the unit to operate for several cycles to permit the controlled system to stabilize and then adjust to desired temperatures. The system should then be cooled to ambient temperature, reheated and stabilized to check the setting.

Where extremely accurate temperature control is desired several readjustments may be necessary to stabilize the THERMOSWITCH Control after which the adjustment will be maintained.

CONTACT PROTECTION

Capacitors are not required under average conditions. For smoother control at small loads, on D.C. applications or to prevent contact bounce due to vibration, the following chart is recommended as a guide:

Current	Service	Capacitance MFD
115 V.A.C.	Resistance	None required
230 V.A.C.	Resistance	.1
115 or 230 V. A.C. or D.C.	Relays, Magnetic contactors	.001 to .01
15 — 25 V. A.C. or D.C.	Relays	.02
115 or 230 V. A.C.	Motor	Use relay

NOTE: Capacitors should be wired in parallel with thermostat lead connections.

IF TESTING TEMPERATURE SET POINT IS REQUIRED

The **Set Point Temperature** is the temperature at which the contacts on a THERMOSWITCH unit just "make" (close). All THERMOSWITCH units are set at room temperature (75°F ± 15°F) unless otherwise specified in which case they are factory preset at any specified temperature within listed temperature range and setting tolerance of THERMOSWITCH unit.

If customer requires testing of temperature set point, it is recommended that testing devices be used similar to those at the factory. An ideal thermal installation may require that the THERMOSWITCH unit be located as near as possible to the heat source. Testing the temperature set point of a THERMOSWITCH unit in an application or under conditions where heat source is remotely located from THERMOSWITCH unit, or when ambient temperature conditions are far below or above 75°F, may give misleading results. In some cases, this has led to rejection of units which were actually within proper setting tolerance. Therefore we recommend the following procedures as a guide for testing temperature set points on Fenwal THERMOSWITCH units of the 17XXX, 18XXX and 67XXX Series types.

1. The use of a Fenwal Model 80001-0 Test Kit.
2. For customers who wish to build their own test equipment we recommend that you contact your nearest Fenwal Representative. He is equipped to give you further guidance in setting up a good thermal test system.

FENWAL INCORPORATED • ASHLAND, MASSACHUSETTS

Division of Walter Kidde & Company, Inc.

MC-146H PRINTED IN U. S. A.

FIGURE 36. THERMOSWITCH DATA

INSTRUCTIONS FOR INSTALLATION AND OPERATION OF

HUBBELL CIRCUIT GUARD

TRADE MARK

(To be retained for information of user)

CAUTION—ELECTRICITY IS DANGEROUS

The Hubbell "Circuit Guard" protects persons from lethal electric shocks by limiting the magnitude of the effect of electrical shock, and duration of fault currents to ground which may occur through inadvertent contact or defective or incorrectly installed equipment. However, persons who have certain heart problems or other conditions where electrical current may cause serious injury cannot rely on protective devices such as the Hubbell "Circuit Guard" to prevent serious injury from electrical shocks or currents. Swimming pools are particularly hazardous due to the combination of water (providing an excellent ground path), electric lights and equipment (subject to touching with wet hands), and the generally care-free activities in these areas. The Hubbell

"Circuit Guard", properly installed by a qualified electrician, affords a high level of protection against line to ground faults. No attempt should ever be made to wire around the "Circuit Guard" and defeat its purpose.

The Hubbell "Circuit Guard" protects against ground faults only in that circuit in which it is installed. It does not protect against ground faults in other circuits.

There is no known device or method to provide protection from Line-to-Line contact or simple disrespect for the known dangers of electricity. LET CAUTION PREVAIL.

DESCRIPTION

Patented Hubbell "Circuit Guard" Interrupters are listed by Underwriters' Laboratories, Inc., as follows:

Cat. No.	Classification	Rating	Use
GFA-100 (Indoor)	Class A, Group I	15A, 120 VAC, 60 Hz	General Use or Swimming Pool Equipment
GFA-300 (Outdoor)	Class A, Group I	15A, 120 VAC, 60 Hz	General Use or Swimming Pool Equipment
GFB-120 (Indoor)	Class B, Group I	20A, 120 VAC, 60 Hz	Underwater Swimming Pool Lights

This equipment is designed to interrupt or trip the electrical circuit to the load when a fault current to ground exceeds the established levels in each classification.

Catalog Numbers GFA-100 and GFA-300 may be employed for General Use Ground Fault protection or with swimming pool equipment installed in accordance with the 1965 National Electrical Code.

Catalog Number GFB-120 may be used in conjunction with new Swimming Pool Lights which require a Class B Interrupter, or existing Underwater Swimming Pool Lights installed prior to the 1965 National Electrical Code requirements.

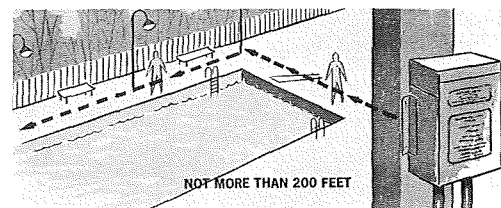
The "Circuit Guard" is housed in a rugged raintight enclosure suitable for indoor or outdoor installation, or in a sturdy indoor type steel box.

MAINTENANCE AND PERIODIC TESTING

The Hubbell "Circuit Guard" is recommended to be checked at monthly intervals. Should the "Circuit Guard" actuator fail to operate upon pushing the momentary toggle switch to "TEST" position, breaker at main panel should be turned off. A qualified electrician should determine that power is available to unit and that wiring is correct. Should the "Circuit Guard" still fail to respond to "TEST" check, return unit under warranty terms.

A "Test Reminder" label is furnished with the Hubbell "Circuit Guard" to remind the user to operate the "TEST" switch at least annually and immediately after any "tripping" occurrence. The label (having a pressure sensitive backing) should be placed on a conspicuous wall.

NUISANCE TRIPPING

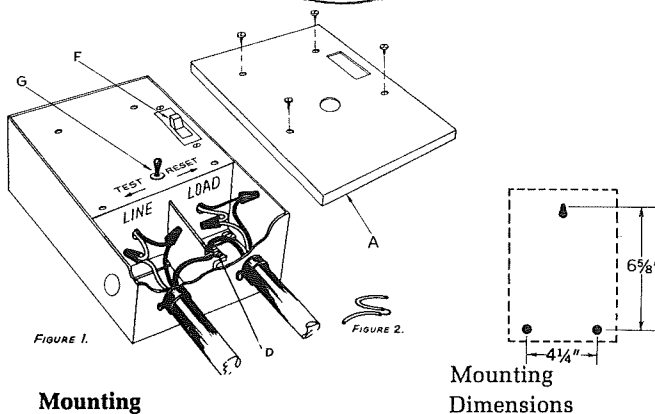


The low trip level deemed necessary to protect individuals may also contribute to occasional nuisance tripping. Such nuisance tripping may be caused by lightning or unusual loads on other circuits. Also, the total one-way conductor run from the Hubbell "Circuit Guard" to pool lighting and equipment should not exceed recommended lengths or excessive nuisance tripping may result.

INSTALLATION HUBBELL CIRCUIT GUARD

(To be installed by Qualified Electrician)

FOR GFA-100 AND GFB-120



Mounting

1. Be sure all power is off from the main service.
2. Unscrew 4 screws and remove cover plate "A".
3. Completely run in one special head mounting screw into wall, panel board or post at approximately five feet above ground level. Mount unit on screw using keyhole slot on back surface. Run in 2 mounting screws through holes in wiring compartment.

Wiring

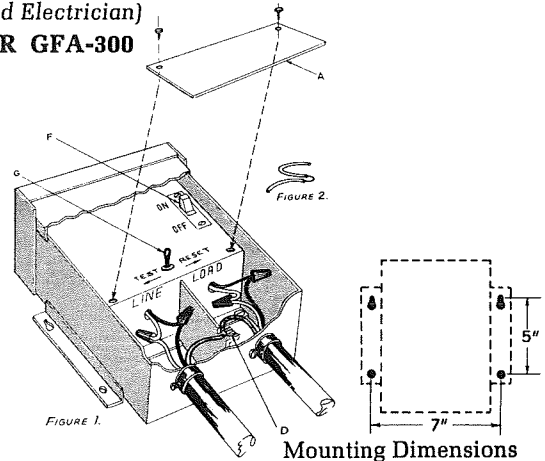
1. Connect Line and Load wires making sure conductors remain in proper partitioned compartments. Connectors are supplied in envelope for making electrical connections. All load conductor terminations and splices to the load circuits must be separated from all other wiring by suitable barriers, sleeving or taping. (Subject to local requirements, properly spliced and insulated conductors as well as continuously insulated conductors may be run with other wiring.)
2. Provision is made for a continuous unbroken ground to be fed from the distribution panel, through and attached to the ground terminal of the "Circuit Guard", and carried through and attached to the ground terminal in the junction box. To preserve the continuous unbroken grounding wire (green), carefully strip the insulation as shown in Fig. 2, and attach as in "D" in Fig. 1, and wiring diagram on inside cover.
3. Replace cover plate in position and fasten with 4 screws as shown in Fig. 1.

OPERATION AND TESTING

After installation, complete system should be checked for proper operation.

1. Turn on breaker at main breaker panel.
2. Push momentary toggle switch (G) to "RESET" position and release.
3. Turn on actuator (F) in "Circuit Guard". Lights and other protected circuits should now be on.

FOR GFA-300



Mounting

1. Be sure all power is off from the main service.
2. With cover hinge up, mount the unit on a wall, panel board, or post, at approximately five feet above ground level; #10 wood screws are supplied in envelope for this purpose.

Wiring

1. Remove cover plate "A" and connect Line and Load wires making sure conductors remain in proper partitioned compartments. Connectors are supplied in envelope for making electrical connections. All load conductor terminations and splices to the load circuits must be separated from all other wiring by suitable barriers, sleeving or taping. (Subject to local requirements, properly spliced and insulated conductors as well as continuously insulated conductors may be run with other wiring.)
2. Provision is made for a continuous unbroken ground to be fed from the distribution panel, through and attached to the ground terminal of the "Circuit Guard" and carried through and attached to the ground terminal in the junction box. To preserve the continuous unbroken grounding wire (green), carefully strip the insulation as shown in Fig. 2, and attach as in "D" in Fig. 1, and wiring diagram on inside cover.
3. Replace cover plate in position and fasten with 2 screws as shown in Fig. 1.

HUBBELL DIVISION

HARVEY HUBBELL INCORPORATED/BRIDGEPORT, CONNECTICUT 06602 Telephone 333-1181

FIGURE 39. GFCI INSTRUCTIONS

-71-

PETERS AND RUSSELL, INC., SPRINGFIELD, OHIO

6960 "SEA GULP JUNIOR" BILGE PUMP

These instructions pertain to all pumps of this model built after
Serial Number F 238-1

PERFORMANCE AND CAPABILITY RATING

Continuous service, lift 3 feet, head 0 feet. Flow rate 5 g.p.m.
Current drain 4.1 amps (12 volt) Current drain 1.5 amps (32 volt)
Intermittent service, lift 5 feet, head 3 feet. Flow rate 3.5 g.p.m.
Current drain 4.9 amps (12 volt) Current drain 2.1 amps (32 volt)
Overall dimensions: Length 8½", width 4¾", height 6⅝", weight 5 lbs. 1 oz.

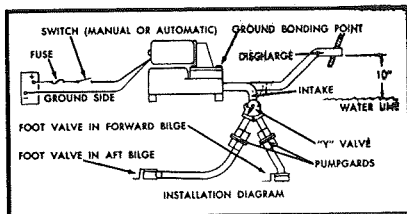
INSTALLATION, OPERATING, AND MAINTENANCE INSTRUCTIONS

INSTALLATION

Pump should be installed in accordance with the applicable Fire Protection Standards for Motor Crafts #302 and/or the standards of the American Boat and Yacht Council, Inc.

MOUNTING

1. Pump is self-priming, therefore, may be mounted in any convenient location above the bilge water level where it will remain dry under normal service conditions.
2. Mount pump securely in an upright or horizontal plane using #10 x ¾" stainless steel fasteners or a suitable equivalent, and in accordance with performance and capability ratings.
3. Suction height should be greater than discharge height.



PLUMBING

1. Run intake to lowest part of bilge and connect to PAR #3988 or #3990 foot valve and locate discharge at least 10 inches above the water line using through-hull fitting. It is also recommended that a PAR #5285 Pumpgard strainer be used in each lead from bilge.
2. **WARNING:** This pump was designed to operate on a minimum of ¾" I.D. corrosion-resistant hose, pipe or tubing. Any decrease in size of the inlet or discharge overworks component parts of pumps causing early failure. We will not be responsible for any failure from this cause.
3. All plumbing connections should be galvanically compatible. Stainless steel clamps of ½" minimum width should be used for all hose connections.

WIRING

Wiring should be stranded copper wire of a type described in NFPA #302.

1. Wire sizes for 12 and 32 volt systems: Use #12 wire for distances up to 15 ft. from power source to pump and return. Use #10 wire for distances from 15 to 50 ft. from power source to pump and return.
2. **WARNING:** Our warranty does not cover motor burnout caused by low voltage or poor installation. It is important to keep a fully charged battery at all times to maintain full, smooth efficiency of unit.
3. Circuit should be overload protected in live lead at source of power.
4. Circuit protection should not be over 125% of maximum rated current. For 12 volt system use 6 amp fuse rating and on 32 volt system use 3 amp rating.
5. A bonding conductor which shall be at least a #6 AWG conductor may be connected to the pump under the head of one. #5501 tie down screw and paint should be removed from motor mount at this point to assure a good ground.
6. After installation, check voltage at motor under full load. If voltage is less than 11 volts on a 12 volt system or 30 volts on a 32 volt system with a fully charged battery, check wires for bad connections or corrosion which will cause a decrease in voltage. **IMPORTANT:** It is also advisable at this time to check amperage draw of operating unit. This should be not more than 5.2 amps on a 12 volt or 2.6 amps on 32 volt, or motor burnout; which is not covered in our warranty, will result.

MAINTENANCE AND TROUBLE SHOOTING

The PAR bilge pump has been designed to provide trouble-free operation with a minimum amount of maintenance which can, in the majority of cases, be performed without disconnecting the plumbing or electrical connections to the unit.

SYMPTOM: LOSS OF SUCTION TO PUMP.

CURE: 1. Check to see that foot valve or end of intake hose is submerged.

2. Be sure strainer is clean.

3. Check power supply.

4. Dismantle unit and check valve assemblies to make certain no foreign material is between valve and valve seat causing loss of suction. This is done without disturbing plumbing as follows:

a. Remove (4) #5501 screws only.

b. Lift motor, drive and diaphragm assembly off base.

c. Lift valve assemblies from pockets and clean all foreign material from the valve and valve seat.

d. Replace valve assemblies back in same pockets, being sure rubber valve is UP on INTAKE side and DOWN on EXHAUST side.

e. Replace top assembly and bolt back together, being careful to tighten evenly.

SYMPTOM: RADIO INTERFERENCE CAUSED BY PUMP.

CURE: Due to worn brushes in the pump motor, radio interference may develop when the pump is running. This may be eliminated as follows:

1. Reverse motor leads.

2. If reversing of motor leads does not suppress noise, then a .1 MFD condenser should be placed in the line with pigtail to hot side of line, and the case grounded.

SYMPTOM: DIAPHRAGM DAMAGED BY FOREIGN MATERIAL ENTERING PUMP.

CURE: Diaphragm may be removed as follows:

1. Remove (4) #5501 screws and lift motor and diaphragm assembly off base.

2. Turn assembly up-side-down, place in vise (not too tight) and remove (2) #4743 screws from bottom and separate.

3. Leaving connecting rod on eccentric, remove #5502 diaphragm screw and diaphragm being careful not to twist off connecting rod.

4. Place new diaphragm and washers in position, being careful to align by locating with #5501 screws through diaphragm and diaphragm ring, and retighten #5502 screw, again being careful not to twist off connecting rod.

5. Reassemble motor and diaphragm assembly back on pump being sure all parts are in good alignment. Tighten evenly.

SYMPTOM: CONNECTING ROD NEEDS RE-OILING.

CURE: The connecting rod bearing is made of oil impregnated iron and packed with an oil soaked wick. This supply of oil should be enough to last 500 hours, but if for any reason is should not, the connecting rod may be re-oiled as follows:

1. Remove #5434 cover.

2. Resaturate wick found in connecting rod with good grade of SAE 10 wt. oil and replace cover.

FALL LAY-UP

Whenever possible, it is preferable to store PAR bilge pumps in a warm, dry place free from freezing, condensation, and corrosion, which are the enemies of any electrical apparatus. In doing this, the complete unit need not be removed, only the motor, diaphragm, and valve assemblies. This is done as follows:

1. Remove (4) #5501 screws.

2. Remove motor leads.

3. Lift motor and diaphragm assembly from pump.

4. Remove valves from pockets and clean.

5. Store in warm, dry place until warm weather.

When removal and warm winter storage is not possible, the unit should at least be drained as follows to prevent freezing:

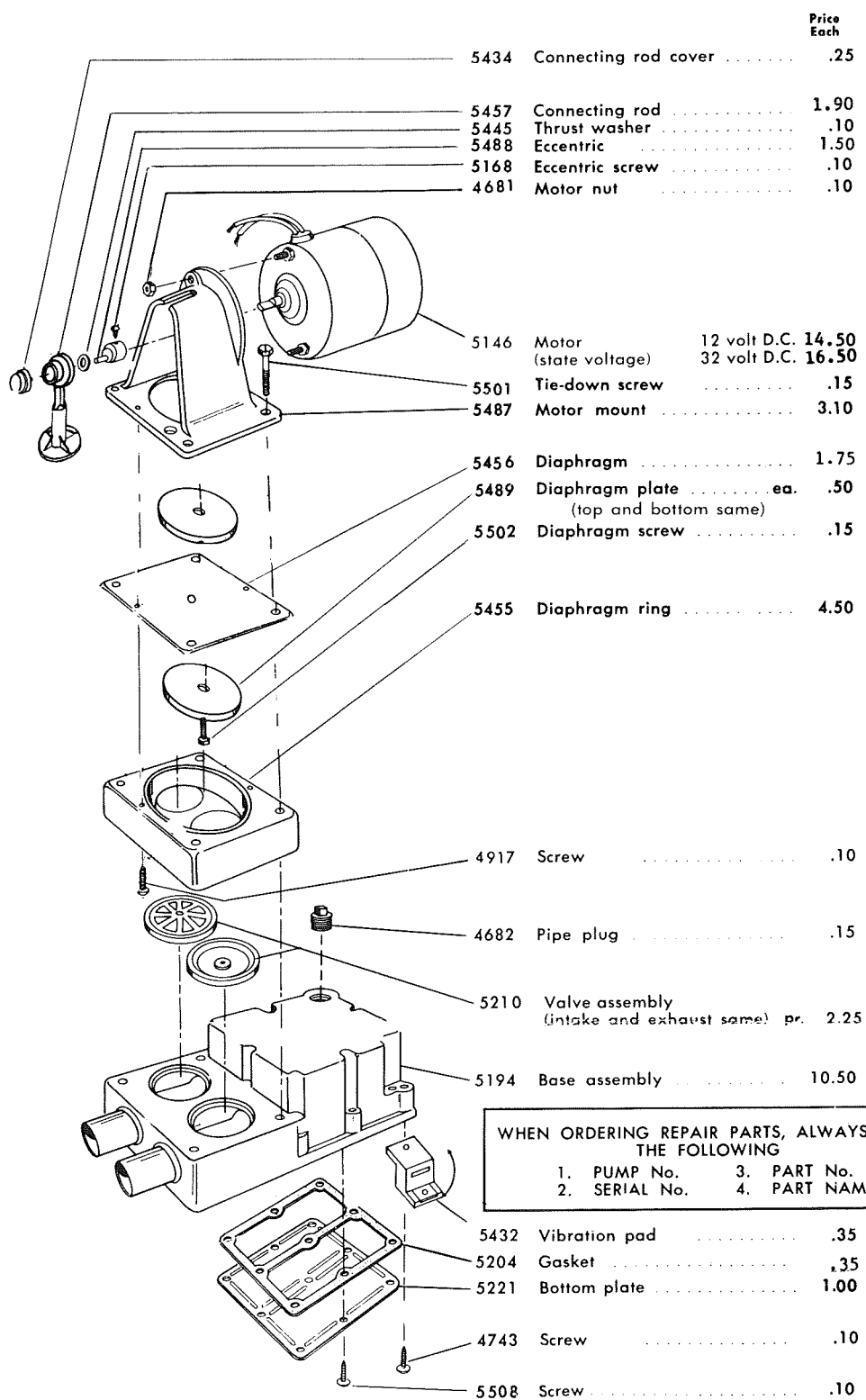
1. Take intake out of water and run unit for approximately one minute after motor speeds up. **NOTE: Running dry will not harm unit.**

2. Remove intake and exhaust hoses from unit and allow to run until all water is expelled.

3. Do not reconnect unit until warm weather unless plumbing is completely void of water.

4. Spray motor and leads with CRC Marine Formula 6-66 (Corrosion Reaction Consultants, 116 Chestnut Street, Philadelphia, Pennsylvania) to protect from damage caused by moist atmospheres.

6960 "SEA GULP JUNIOR" BILGE PUMP



WHEN ORDERING REPAIR PARTS, ALWAYS GIVE
THE FOLLOWING

- | | |
|---------------|--------------|
| 1. PUMP No. | 3. PART No. |
| 2. SERIAL No. | 4. PART NAME |

FIGURE 41. SLURRY PUMP PARTS