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APOLLO OPERATIONS HANDBOOK

EXTRAVEHICULAR MOBILITY UNIT

VOLUME I — SYSTEM DESCRIPTION

CSD-A-789-(1)

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PREFACE

This document is the fifth revised issue of Volume I of the Apollo Operations Handbook. This revision incorporates applicable portions of revisions I, II, III, and IV, and reorganizes the presentation for the Apollo J missions.

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ACRONYMS

AM	amplitude modulation
BSLSS	buddy secondary life support system
CLA	cover layer assembly
CMP	command module pilot
CWG	constant wear garment
DV	diverter valve
ECG	electrocardiogram
ECS	environmental control system
EMU	extravehicular mobility unit
EV	extravehicular
EVA	extravehicular activity
EVC	extravehicular communicator
EVCS	extravehicular communications system
FCS	fecal containment subsystem
FM	frequency modulation
IHSB	inflight helmet stowage bag
IRIG	interrange instrument group
ITLSA	integrated torso limb suit assembly
ITMG	integrated thermal micrometeoroid garment
IV	intravehicular
LCG	liquid cooling garment
LEVA	lunar extravehicular visor assembly
LM	lunar module

MWC	multiple water connector
OPS	oxygen purge system
PCV	pressure control valve
PGA	pressure garment assembly
PHA	pressure helmet assembly
PLSS	portable life support system
RCU	remote control unit
TLSA	torso limb suit assembly
UCD	urine collection device
UCTA	urine collection and transfer assembly
UV	ultraviolet
ZPN	impedance pneumogram

1.0 INTRODUCTION

1.1 PURPOSE

This volume provides familiarization information essential to the operation of the extravehicular mobility unit (EMU), and describes the configuration combinations for the A7LB separable-components and the accessory contract end items. Configuration deviations may be made as dictated by specific crew/mission requirements. Operational procedures and malfunction detection procedures are found in Volume II of this handbook.

1.2 SCOPE

The descriptive information for the EMU subsystems and related components is given in section 2.0. A description of the EMU systems is provided in section 3.0.

2.0 EXTRAVEHICULAR MOBILITY UNIT SUBSYSTEMS AND ACCESSORIES

2.1 GENERAL DESCRIPTION

The EMU (fig. 2-1) is designed to protect the crewman in a low-pressure, micrometeoroid, and thermal environment and to provide comfort, mobility, dexterity, and a specified unobstructed range of vision during lunar-surface or free-space operations outside of the spacecraft. The EMU (table 2-I) provides the extravehicular (EV) crewman with a habitable environment for a 5-hour design mission without replenishment of expendables (based upon a 1200-Btu/hr metabolic rate with a 300-Btu/hr heat-leak rate).

There are two basic pressure garment assembly (PGA) configurations which support Apollo missions. One configuration is designated as the command module pilot (CMP) A7LB PGA which provides low-pressure and fire protection in the intravehicular (IV) mode and protection from the free-space environment during extravehicular activity (EVA) from the command module. The second configuration is designated as the EV A7LB PGA which provides low-pressure and fire protection in the IV mode and protection from the lunar surface environment during EVA. The EV A7LB PGA also provides free-space environment protection during open-hatch operations associated with command module (CM) EVA. Exterior connectors permit both configurations to interface with spacecraft systems for pressurization, ventilation, communications, cooling, and waste management. The EV configuration interfaces with the portable life support system (PLSS) for pressurization, ventilation, communications, and temperature control when used for EVA. The CMP A7LB PGA interfaces with the command service module (CSM) EVA umbilical assembly, the oxygen purge system (OPS), the purge valve, and the pressure control valve (PCV). Waste management systems are also self-contained in both configurations to permit operations while independent of the spacecraft waste management system.

2.2 FIELD OPTIONAL ITEMS

The items designated as crew/mission requirement deviations are shown in table 2-II. These items may be altered at the option of the individual crewman. Certain items are also adjustable as necessary to satisfy crewman comfort requirements. The deviations are determined as much as possible during the initial fit check; however, field modifications are accomplished when they are within the capability of the applicable support activity.

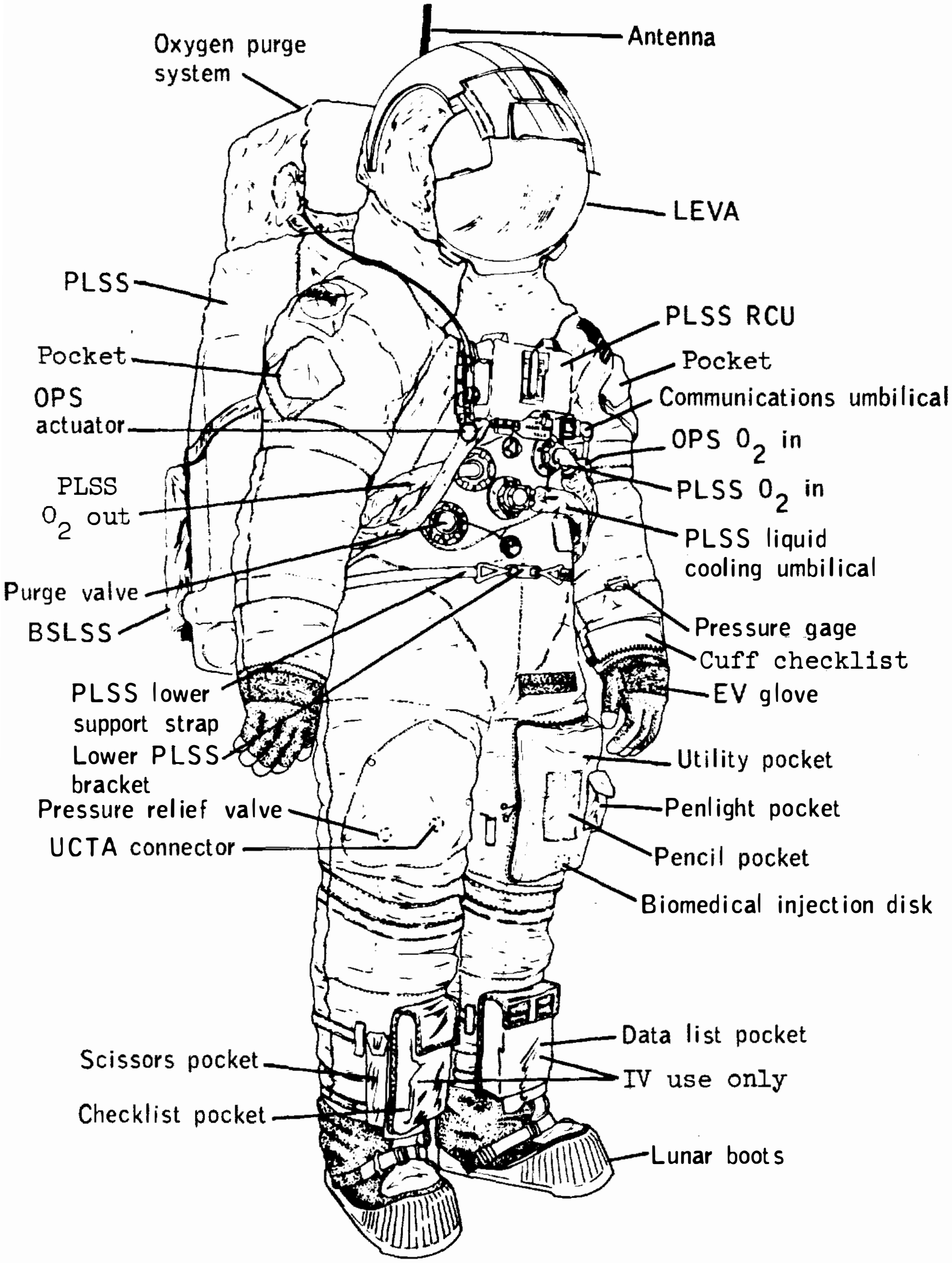


Figure 2-1.- Lunar surface configuration of the extravehicular mobility unit.

TABLE 2-I.- EMU OPERATIONAL SPECIFICATIONS

Item	Value
Pressure garment assembly	
Operational temperature limitations	-290° to +300° F
Leak rate at 3.7 psia (max.)	180.00 scc/min (0.0315 lb/hr)
Operating pressure	3.75 ± 0.25 psid
Structural pressure	6.00 psid
Proof pressure	8.00 psid
Burst pressure	10.00 psid
Pressure drop	
12 acfm, 3.5 psia, 50° F, and inlet diverter valve open (IV position)	4.70 in water
6 acfm, 3.9 psia, 77° F, and inlet diverter valve closed (EV position)	1.80 in water
Pressure gage range	2.5 to 6.0 psid
Pressure relief valve	
Cracking pressure	5.00 to 5.75 psid
Reseat pressure	4.6 psid min.
Suit pressure	5.85 psid max.
Leak rate closed	4.0 scc/min max.
Flow rate open	12.2 lb/hr min. of O_2 at 5.85 psia

TABLE 2-I.- EMU OPERATIONAL SPECIFICATIONS - Concluded

Item	Value
Liquid cooling garment	
Operating pressure	4.20 to 23.0 psid
Structural pressure	31.50 ± 0.50 psid
Proof pressure	31.50 ± 0.50 psid
Burst pressure	47.50 psid
Pressure drop	
4.0 lb/min at 45° F inlet	3.35 psi including both halves of multiple water connector
Leak rate	
19.0 psid at 45° F	0.58 cc/hr
Multiple water connector	
Pressure drop	
4.0 lb/min at 45° F, both halves, both directions	1.45 psi
Portable life support system	
Oxygen quantity	145 to 1500 psia
Low oxygen flow	0.07 lb/hr
Low PGA pressure	3.10 to 3.40 psid
Low vent flow	4.0 acfm (min. at 15 mm Hg)
Carbon dioxide production	0.39 lb/hr
Low feedwater	1.2 to 1.7 psia

TABLE 2-II.- FIELD OPTIONAL ITEMS

Item	Action
Leg mobility straps	Leg mobility straps may be removed.
Location of strap-on pockets	Strap-on pockets may be located as preferred by individual crewman.
Liner comfort pads	Comfort pads may be positioned as necessary to decrease pressure points.
Custom length of palm restraint straps	Palm restraint strap length may be varied to correspond with hand size.
Pocket preference for neck dam lanyard attaching strap	The neck dam lanyard strap may be stored to suit the individual crewman.
Orientation of gas connector locks	Gas connectors may be rotated to locate the locking tabs at 60° intervals to accommodate interface or operational requirements.
Custom length PGA urine drain hose	Hose length can be varied as necessary to accommodate fit.
Orientation or length of PGA liner electrical harness keeper tabs	Electrical harness keeper tabs may be lengthened or reorientated as necessary.
Wristlets	Wristlets may be donned as necessary to enhance crew comfort in wrist disconnect area.
Valsalva device	The valsalva device may be deleted from the pressure helmet at the discretion of the crewman.
Comfort gloves	The comfort gloves may be deleted.
Contingency sample pocket	The data list pocket includes a removable wall stiffener and is used as a contingency sample pocket during lunar surface activities.
Chin comfort pad	Comfort pads may be installed in the ITLSA liner for crewman comfort.

TABLE 2-II.- FIELD OPTIONAL ITEMS - Concluded

Item	Action
Scissors pocket	The scissors pocket may be attached to the straps of the checklist pocket or the outer shell of the integrated thermal micrometeoroid garment (ITMG) adjacent to the utility pocket.
Limb adjustments	The arm and leg lengths may be adjusted to customize the lengths to the crewman.
Neck restraint guide	The neck restraint cable guide may be located in one of three positions to accommodate suit posture and crewman comfort.
Wrist disconnect comfort pads	Comfort pads may be installed within the wrist disconnect to preclude chafing and buffeting discomforts.
EVA checklist	A lunar surface EVA checklist may be attached to the EV glove gauntlet outer shell as a crew/mission requirement. The specific location, method of attachment, and orientation of the checklist on the glove gauntlet will be defined by the crewman to to satisfy his specific needs and mission objectives.
Vertical location of liquid cooling garment (LCG) manifold	The LCG manifold may be raised or lowered to provide maximum comfort.
Comfort pads for the LCG at shoulders and hips	Comfort pads may be installed on the LCG at the shoulders and/or hip areas as preferred by the crewman for his comfort.
LCG comfort modification	The LCG may be modified by adding or removing material to accommodate crewman size.
LCG turtleneck addition	A turtleneck collar may be donned with the LCG for additional comfort.

2.3 PRESSURE GARMENT ASSEMBLIES AND ACCESSORIES

The Apollo pressure garment assemblies are anthropomorphic, protective structures worn by the crewmen during EV phases of an Apollo mission, and during IV modes of spacecraft operations. The CMP A7LB pressure garment configuration (fig. 2-2) is worn by the CMP and is normally used for IV and free space EV operations. The EV A7LB configurations (fig. 2-3) are worn by the crew commander and the lunar module (LM) pilot for IV and free space operations and lunar explorations.

The EV A7LB pressure garment and accessory systems interface with the portable life support systems to provide life support during lunar exploratory missions. The spacecraft environmental control EVA umbilical assembly and communications systems interface with the CMP A7LB pressure garment and accessories for free space EVA. Both configurations interface with the spacecraft crew systems and perform life support functions during depressurized and emergency modes of IV operations. The pressure garments permit normal body movements for the operation of spacecraft controls and equipment and have specially constructed devices required for space exploration. The garments are designed to operate at 0.18-psi (vent) to 3.75-psi (regulated) differential pressure at gas (oxygen) flow rates of 6 to 12 cubic feet per minute. The pressure garments are operational in temperatures of -290° to +300° F and in micrometeoroid flux densities normally expected within the lunar orbit perimeter. They can be worn for 115 hours during pressurized modes of emergency operation or 14 days of unpressurized operation except for normal removals for hygiene requirements. The pressurizable portion of the PGA includes an integrated torso limb suit assembly (ITLSA), detachable gloves, and a pressure helmet assembly (PHA). Entry into the EV A7LB torso limb suit is made through slide fastener (zipper) openings in the waist area. Entry into the CMP A7LB torso limb suit is gained through pressure-sealing and restraint-slide-fastener closures mounted vertically along the back and through the crotch. The helmet and gloves are then mechanically locked in place to complete the airtight envelope. Figure 2-2 and table 2-III identify the components that are interfaced for CMP A7LB EV and IV use, and figure 2-3 and table 2-IV identify the components interfaced to comprise EV A7LB suit configurations for normal EV and IV use.

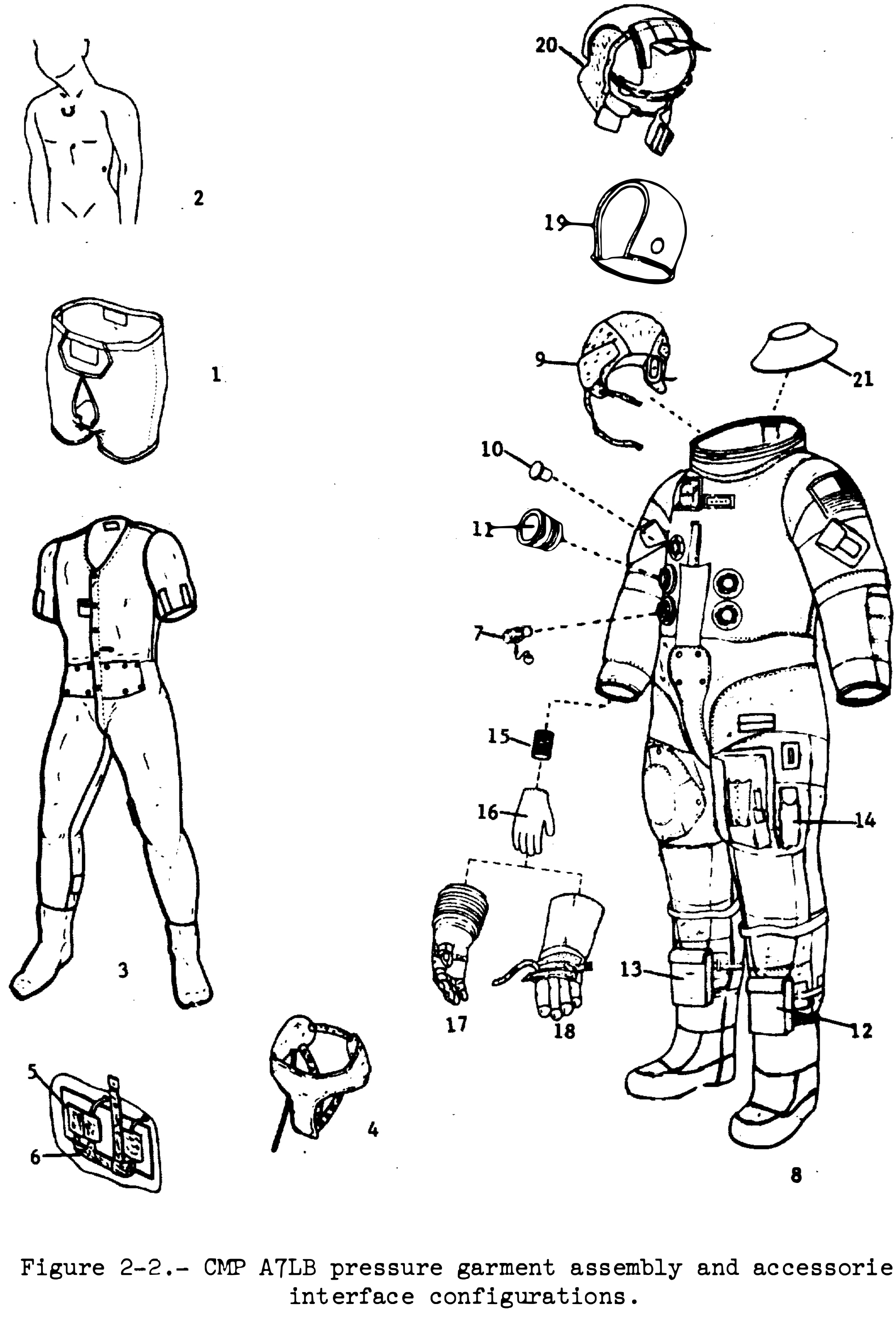


Figure 2-2.- CMP A7LB pressure garment assembly and accessories interface configurations.

TABLE 2-III.- CMP A7LB PRESSURE GARMENT ASSEMBLY AND ACCESSORIES INTERFACE CONFIGURATIONS

Components	Use	
	EV	IV
1. Fecal containment subsystem	X	X
2. Biomedical sensors	X	X
3. Constant wear garment		X
4. Urine collection and transfer assembly	X	X
5. Biomedical belt	X	X
6. Biomedical harness	X	X
7. Purge valve	X	
8. EV integrated torso limb suit assembly	X	X
9. Communications carrier	X	X
10. Electrical connector cap		X
11. Gas connector caps		X
12. Data list pocket		X
13. Checklist pocket		X
14. Scissors pocket (attached to strips of checklist pocket or cover layer assembly shell outboard of and adjacent to the utility pocket)	X	X
15. Wristlets	X	X
16. Comfort gloves	X	X
17. IV pressure gloves		X
18. EV glove assemblies (used in place of IV pressure gloves for EV use)	X	
19. Pressure helmet assembly	X	
20. Lunar extravehicular visor assembly	X	
21. Neck dam (for water egress)		

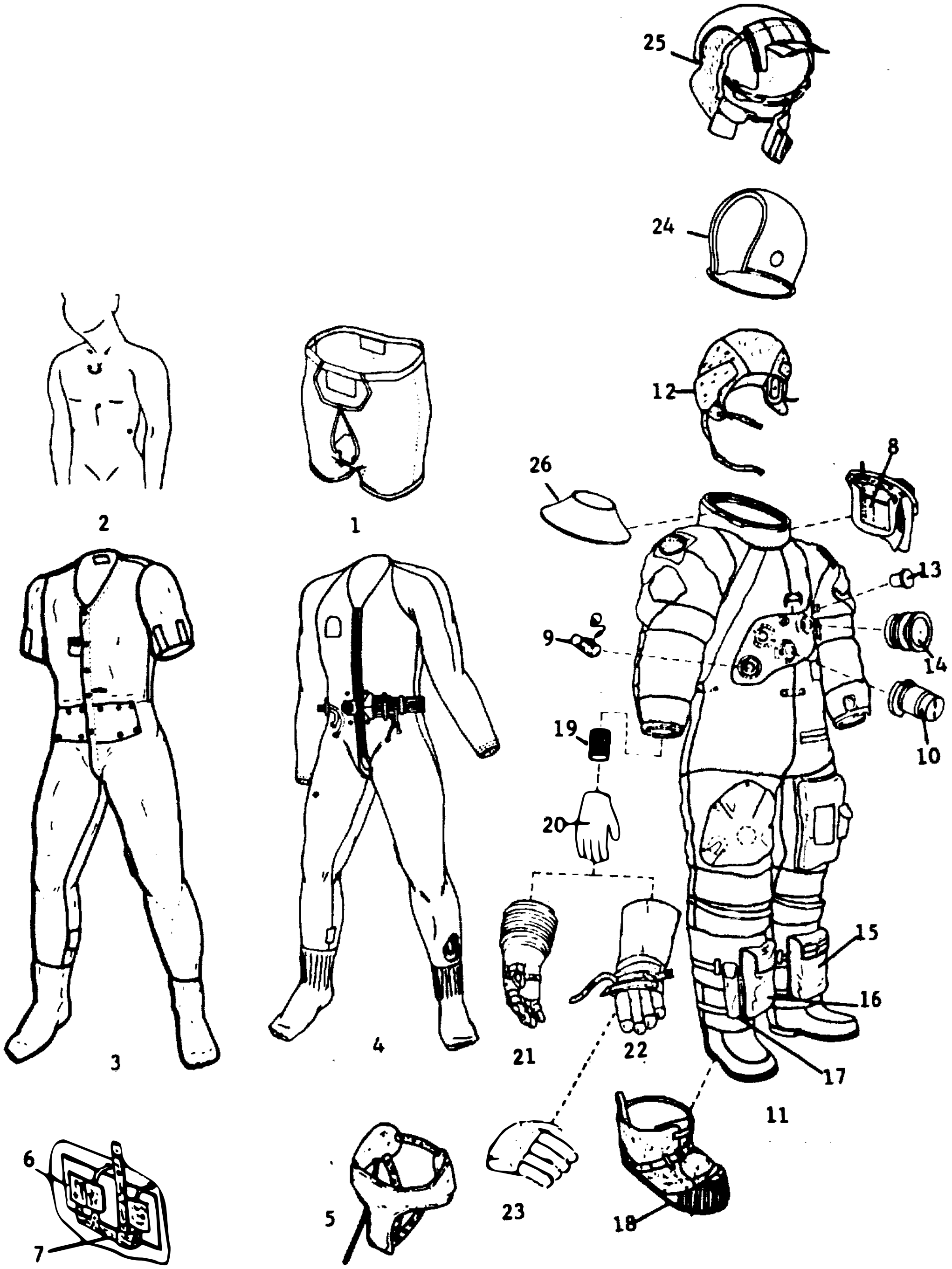


Figure 2-3.- EV A7LB pressure garment assembly and accessories interface configurations.

TABLE 2-IV.- EV A7LB PRESSURE GARMENT ASSEMBLY AND ACCESSORIES INTERFACE CONFIGURATIONS

Components	Use	
	EV	IV
1. Fecal containment subsystem	X	X
2. Biomedical sensors	X	X
3. Constant wear garment (CWG)		X
4. Liquid cooling garment (used in place of CWG for EV and IV LM use)	X	
5. Urine collection and transfer assembly	X	X
6. Biomedical belt	X	X
7. Biomedical harness	X	X
8. Insuit drinking device	X	
9. Purge valve	X	
10. LCG receptacle plug		X
11. EV integrated torso limb suit assembly	X	X
12. Communications carrier	X	X
13. Electrical connector cap		X
14. Gas connector caps		X
15. Data list pocket (used as an EV contingency sample pocket)	X	X
16. Checklist pocket		X
17. Scissors pocket (attached to straps of checklist pocket or ITMG shell outboard of and adjacent to the utility pocket)	X	X
18. Lunar boots	X	
19. Wristlets	X	X
20. Comfort gloves	X	X
21. IV pressure gloves		X
22. EV glove assemblies (used in place of IV pressure gloves for EV use)	X	
23. Abrasion cover gloves (integrated with EV glove at pre-installation acceptance testing and used to protect the EV glove)	X	
24. Pressure helmet assembly	X	
25. Lunar extravehicular visor assembly	X	
26. Neck dam (for water egress)		

The breathable gas used for respiration, pressurization, and ventilation is distributed within the pressurizable portion of the PGA through noncrushable ducts. Inlet and outlet connectors provide the interface between the suit ventilation distribution system and the spacecraft or PLSS environmental control system. A diverter valve (DV) directs the inlet gas flow to the helmet duct or diverts a portion of that flow to the torso duct as preferred by the crewman. The ventilating gas flows from the helmet down and over the body to the arm and leg extremities to remove body gas perspiration and heat. Outlet gas flows from the extremities through ducts to the exhaust connector. To preclude an accidental gas loss, a gas connector cap is provided for the unused connector port to prevent inadvertently depressing the poppet-type valve.

A manually operated purge valve may be fitted into the outlet gas connector. The purge valve is a part of the open-loop gas system that permits breathable gas from the oxygen purge system to flow through the PGA during emergency modes of pressurized suit operation.

An integrated thermal micrometeoroid garment (ITMG) is part of the EV torso limb suit. The assembly is a lightweight multilaminate unit designed to cover and conform to the contours of the torso limb suit assembly (TLSA). The cross section of materials for the ITMG affords protection against abrasion, thermal, and micrometeoroid hazards expected during free-space and lunar excursions. The outer layer is employed as a scuff and flame-impingement protective surface.

A receptacle on EV A7LB pressure garments connects the PLSS liquid cooling system to the liquid cooling garment (LCG) worn under the torso limb suit during EV excursions. The liquid cooling system removes metabolic heat from within the PGA. A plug is inserted into the multiple water connector receptacle when the LCG is not worn to preclude gas leakage from the pressurizable portion of the PGA.

A food and water port is provided in the side of the face area of the pressure helmet for emergency feeding and drinking.

Communications and biomedical data are transmitted through a suit electrical harness. The harness connector is mounted to the torso and provides an interface with the spacecraft or PLSS.

Biomedical instrumentation components employed within the PGA include electrocardiogram (ECG) and impedance pneumogram (ZPN) sensors that supply data to signal conditioners contained in a biomedical belt assembly, and a biomedical harness that provides an electrical interface between the signal conditioners and the suit electrical harness. The biomedical belt is snapped in place on the constant wear garment (CWG) or LCG.

The cotton fabric CWG is worn under the PGA next to the crewman's skin. The garment provides chafe protection and body cooling by perspiration wicking and evaporation. The CWG is worn as a comfort and cooling garment during IV modes of spacecraft operation.

The LCG replaces the CWG for lunar exploratory missions. The network of Tygon tubing within the LCG interfaces with the TLSA and PLSS to circulate water through the tubing network and transport metabolic heat from within the PGA.

To provide for emergency waste management, a fecal containment subsystem (FCS) is worn about the waist of the crewman next to the body for collecting and containing solid waste matter. A urine collection and transfer assembly (UCTA) collects waste liquids and provides an interface with the torso limb suit for transferring liquid from the UCTA to the spacecraft waste system.

The lunar extravehicular visor assembly (LEVA) fits over the pressure helmet to provide light and heat attenuation and to protect the crewman's eyes from harmful radiation during EV excursions.

A pair (one left and one right) of detachable EV glove abrasion covers fabricated from silicone-coated Nomex is integrated with the EV glove during preinstallation acceptance testing and permits handling of a core sample drill without damaging the EV gloves. The cover is installed over the EV glove with the access flap of the glove routed through the slot in the knuckle area of the cover. The Velcro hook patches inside the rear edge of the cover slot are engaged to the pile patches on the outside of the abrasion cover slot. The strap near the wrist area of the abrasion cover is engaged to the Velcro hook attachment point to secure the cover over the EV glove. The abrasion covers may be readily removed after the drilling operation.

An insuit drinking device is mounted between the TLSA liner and inner pressure wall and contains drinking water for the crewman while performing lunar surface activities.

Pockets are available as a part of the PGA for stowage of miscellaneous flight articles. Penlight and pencil pockets are located on the left-shoulder and left-thigh areas. A sunglasses pocket is provided on the right shoulder. For storage of large items, a utility pocket is attached to the left thigh of the ITMG. Detachable checklist and data list pockets may be located below the knee of either leg or about the thigh of the left leg over the utility pocket. A scissors pocket is sewn to the straps of the detachable checklist pocket or secured to the ITMG shell outboard of and adjacent to the utility pocket.

To accommodate stowage of the equipment, provide for inflight maintenance, and protect equipment during an Apollo mission, the following flight support accessories are provided: an inflight helmet stowage bag (IHSB) for storing the LEVA, IV gloves, or EV gloves; an EMU maintenance kit that provides a lubricant for seals and "O" rings, helmet LEVA visors cleaning pads, replacement seals and emergency repair patches for the PGA; a helmet shield that fits over the PHA for scuff and abrasion protection during tunnel transfer; an inflight HSB for stowage and protection of the helmet shield and/or PHA; and an LCG adapter interconnect for connecting the LCG and the LM liquid cooling system during in-LM rest periods with the PGA removed.

2.3.1 EV A7LB Pressure Garment Assembly

The EV A7LB PGA functions as a part of the EMU and the spacecraft environmental control system. The PGA is worn by the crew commander and LM pilot. The PGA contains a habitable environment and protects the astronaut from exposure to thermal and micrometeoroid conditions while he performs EV activites on the lunar surface or in free space.

The components comprising the PGA include:

a. EV A7LB TLSA
b. Pressure helmet assembly
c. Wristlets
d. Comfort gloves
e. IV pressure gloves
f. EV gloves
g. Data list pocket
h. Checklist pocket
i. Scissors pocket
j. Biomedical harness
k. Lunar boots
l. Neck dam

2.3.1.1 EV A7LB Integrated Torso Limb Suit Assembly

The EV ITLSA is a restrained, gas-retaining bladder structure integrated with a thermal micrometeoroid protective assembly and encompasses the crewman exclusive of the head and hands. The PHA and EV or IV pressure gloves are mated with the EV TLSA to complete a pressurizable envelope that protects the crewman in a depressurized spacecraft, free space, or the lunar environment. The assembly is composed of the following subassemblies as numbered in figure 2-4.

1. Gas connectors
2. Diverter valve
3. PLSS attachment (upper)
4. Outer electrical flange
5. Suit electrical harness
6. Multiple water connector
7. PLSS attachment (lower)
8. Pressure gage
9. Pressure gage cover
10. Liner
11. Ventilation ducts
12. Torso
13. Upper arms (r.h. and l.h.)
14. Pressure sealing slide fastener lock
15. Restraint cables
16. Boots (l.h. and r.h.)
17. Pressure relief valve
18. Legs (l.h. and r.h.)
19. Lower arms (r.h. and l.h.)
20. Restraint lock slide fastener
21. ITMG boots (l.h. and r.h.)
22. ITMG urine collection device clamp
23. ITMG arms (l.h. and r.h.)
24. ITMG torso
25. Water connector mounting ring
26. Core yarn and wrist ring
27. Lacing cord

The torso, upper and lower arms, legs, boots, and restraint cables are integrated to form the TLSA pressurizable vessel. This vessel includes convoluted joints which permit low-torque body movements and a near-constant-volume gas displacement within the PGA during normal joint flexure. Longitudinal cables extend across each convolute and sustain the axial loads. The neck, waist, shoulder cone, and ankle convolutes are of the constricted-restraint type, and the shoulder, elbow, knee, waist, and thigh joints are single-walled, integrated-restraint-and-bladder, bellows-like structures.

A textured nylon fabric is bonded to the inner surface of the pressure vessel to protect the bladder from scuffs, abrasions, and snags.

An inner comfort liner within the TLSA is removable for cleaning and inspection. The assembly offers scuff protection to the wearer and covers the ventilation ducting to preclude accidental damage during suit-donning operations.

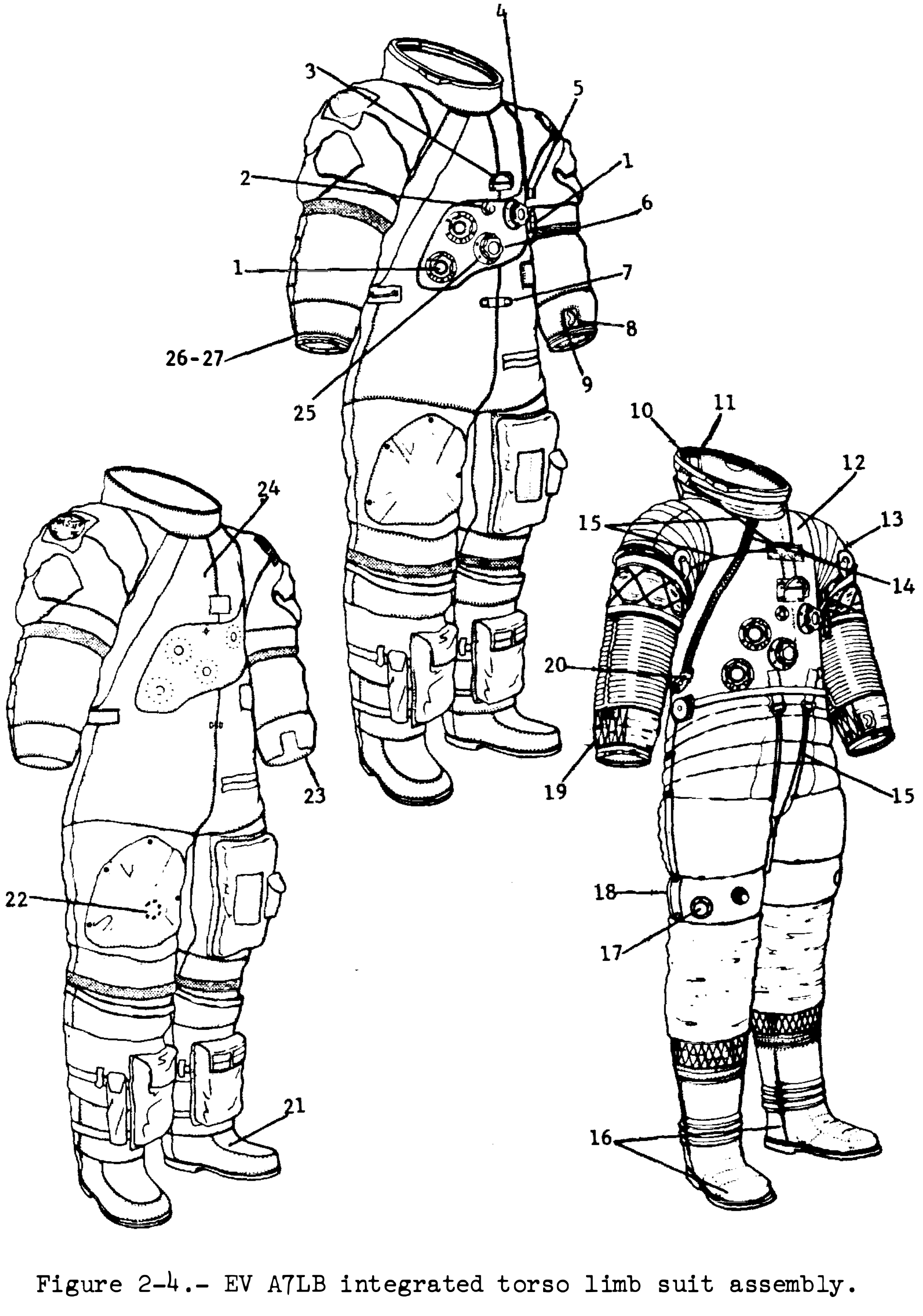


Figure 2-4.- EV A7LB integrated torso limb suit assembly.

Entry into the TLSA is made through restraint-and-pressure slide fasteners mounted in the waist area of the torso restraint-and-bladder layers. To preclude accidental opening, lock assemblies are provided to hold the slide fasteners closed.

A network of noncrushable ducting laced to the inner TLSA surface, two sets of inlet and exhaust gas connectors, and a diverter valve comprise the ventilation distribution system within the TLSA. The TLSA and the ventilation distribution system interface with the pressure gloves and helmet to complete the PGA pressurization and ventilation system.

A pressure gage is mounted on the left-arm wrist cone, and a pressure relief valve is mounted on the right-leg thigh cone. The pressure gage indicates differential pressures of from 2.5 to 6.0 psid, and the pressure relief valve relieves pressures in excess of 5.0 psid.

The suit electrical harness provides signal paths for biomedical instrumentation data and communications transmissions. The suit-mounted connector permits an electrical and mechanical interface with the spacecraft or PLSS communications umbilical.

A flange-mounted multiple water connector secured to the torso provides a mechanical mate between the LCG and PLSS or LM liquid cooling systems. When the LCG is not worn, a plug is locked into the connector opening to provide a gas seal.

The ITMG torso, arms, boots, and pressure gage cover afford flame impingement, thermal, and micrometeoroid protection to the pressurizable portion of the TLSA and to the crewman. The assemblies employ a multilayered cross section as shown in table 2-V.

The water connector mounting ring, outer electrical flange, ITMG urine collection device (UCD) clamp, core yarn, wrist ring, and lacing cord secure the thermal and micrometeoroid protective assemblies to the torso limb suit.

TABLE 2-V.- EV A7LB ITMG MATERIALS CROSS SECTION

(LISTED FROM THE INSIDE OUT)

Nomenclature	Function
Rubber-coated nylon (ripstop)	Inner liner and micrometeoroid protection
Nonwoven Dacron	Thermal spacer layer
Aluminized Mylar film	Thermal radiation protection
Nonwoven Dacron	Thermal spacer layer
Aluminized Mylar film	Thermal radiation protection
Nonwoven Dacron	Thermal spacer layer
Aluminized Mylar film	Thermal radiation protection
Nonwoven Dacron	Thermal spacer layer
Aluminized Mylar film	Thermal radiation protection
Nonwoven Dacron	Thermal spacer layer
Aluminized Mylar film	Thermal radiation protection
Beta marquisette	Thermal spacer layer
Gridded[a] aluminized Kapton film	Thermal radiation protection
Beta marquisette	Thermal spacer layer
Gridded aluminized Kapton film	Thermal radiation protection
Beta marquisette	Thermal spacer layer
Teflon-coated yarn Beta cloth	Flame impingement layer
Teflon fabric	Abrasion layer

[a] A 2-inch gridding with Polyemite tape is employed in the arm and knee areas; 4-inch gridding is provided in all other areas.

2.3.1.1.1 EV A7LB torso limb suit assembly.- The TLSA is sized to fit a specific crewman. To further customize the fit of a torso limb suit, to optimize mobility in the suit, and to provide maximum comfort, the following adjustments may be made.

a. Neck height
b. Neck angle
c. Shoulder width
d. Elbow convolute height
e. Arm length
f. Crotch height
g. Crotch and limb angle
h. Leg length

The torso section and shoulder, wrist, thigh, and lower leg cones employ a bilayered cross section, an inner gas retention layer, and an outer structural restraint layer to maintain the optimum shape and size of the torso limb suit during pressurized and depressurized modes of suit operation. The inner bladder layer is loosely fitted to the restraint layer and is attached to the restraint layer at strategic points for support and alinement. The convolutes provided at the shoulder, elbow, thigh, and knee areas are flexible, single-walled structures or joints to satisfy suit mobility requirements. Movements in the joint areas cause little change in the volume of gas within the PGA, but displace the gas within the joint area.

The TLSA boot assembly includes an outer fabric restraint, a sole and heel assembly, and an inner rubber bladder. The heel and sole assemblies employ an inner core of aluminum honeycomb in the heel and arch areas and a stainless steel truss core in the front sole area. The areas where honeycomb is used are rigid, and the truss area permits longitudinal flexibility to accommodate normal foot movements.

Nylon webbings at cable attachment points evenly distribute restraint loads. Metal eyelets and grommets line and reinforce the holes provided for cable attachment points.

An abrasion layer secured to the inner bladder wall reduces wear normally caused by direct contact between the body and the bladder.

Noncollapsible ducts along the inner wall of the TLSA make up the ventilation distribution system. Each duct is constructed of parallel lengths of nylon spacer coils wrapped with a nylon mesh cloth. The nylon mesh cloth and spacer construction are dipped in a rubber compound which promotes rigidity of the cloth and adds a nonslip characteristic between the cloth and the coil spacers. The assembled unit is then wrapped with bladder material to form a noncrushable duct with an airtight wall. These ducts are secured to the TLSA by a system of loop-type and lacing cord.

A comfort liner in the interior of the TLSA facilitates donning and promotes comfort. The leg of the liner assembly is zipped to the boot liner at the lower leg area. The assembly is secured to the torso limb suit with hook and pile fastener tape and snap fasteners at the neck opening, around the wrists, and along each side of the entry closure. Synthetic elastomer foam pads over each shoulder and at the biceps area of the arm promote comfort. Reinforced openings through the liner provide passages for the suit electrical harness communications branch, biomedical instrumentation branch, and urine transfer hose. A communications snap-flap at the front of the neck opening holds the communications branch in place to facilitate donning. The front-knee panels and the rear-elbow panels of the liner are pleated along each side to form semipockets which afford relief during limb flexation.

2.3.1.1.2 Lunar integrated thermal micrometeoroid garment.- The ITMG is sized to fit and conforms to the contours of the torso limb suit. The ITMG may be removed from the torso limb suit for inspection and maintenance. The multilaminate cross section of the ITMG prevents thermal damage to, and punctures in, the torso limb suit, and protects the crewman from the extreme temperatures and micrometeoroid flux densities normally expected on the lunar surface and in the free space within the lunar orbit perimeter. To protect against fire and exposed surface abrasion, an outer layer of Teflon fabric and an inner layer of Teflon-coated yarn Beta cloth are provided.

For protection from the thermal environment of free space and the moon, seven layers of aluminized film are used to reflect radiant heat and to reduce heat conduction between the aluminized film layers. A low-heat-conducting fabric of nonwoven Dacron or Beta marquisette is used to separate each layer of film. An inner layer of ripstop fabric, the thermal protective layers, and the fire impingement and abrasion layers provide the mass needed to afford micrometeoroid protection to the TLSA and crewman.

2.3.1.2 Pressure Helmet Assembly

The PHA (fig. 2-5) is a transparent bubble which engages with the torso limb suit and encloses the crewman's head. The assembly consists of an anodized aluminum neck ring, a vent pad, a valsalva device, and a transparent polycarbonate shell.

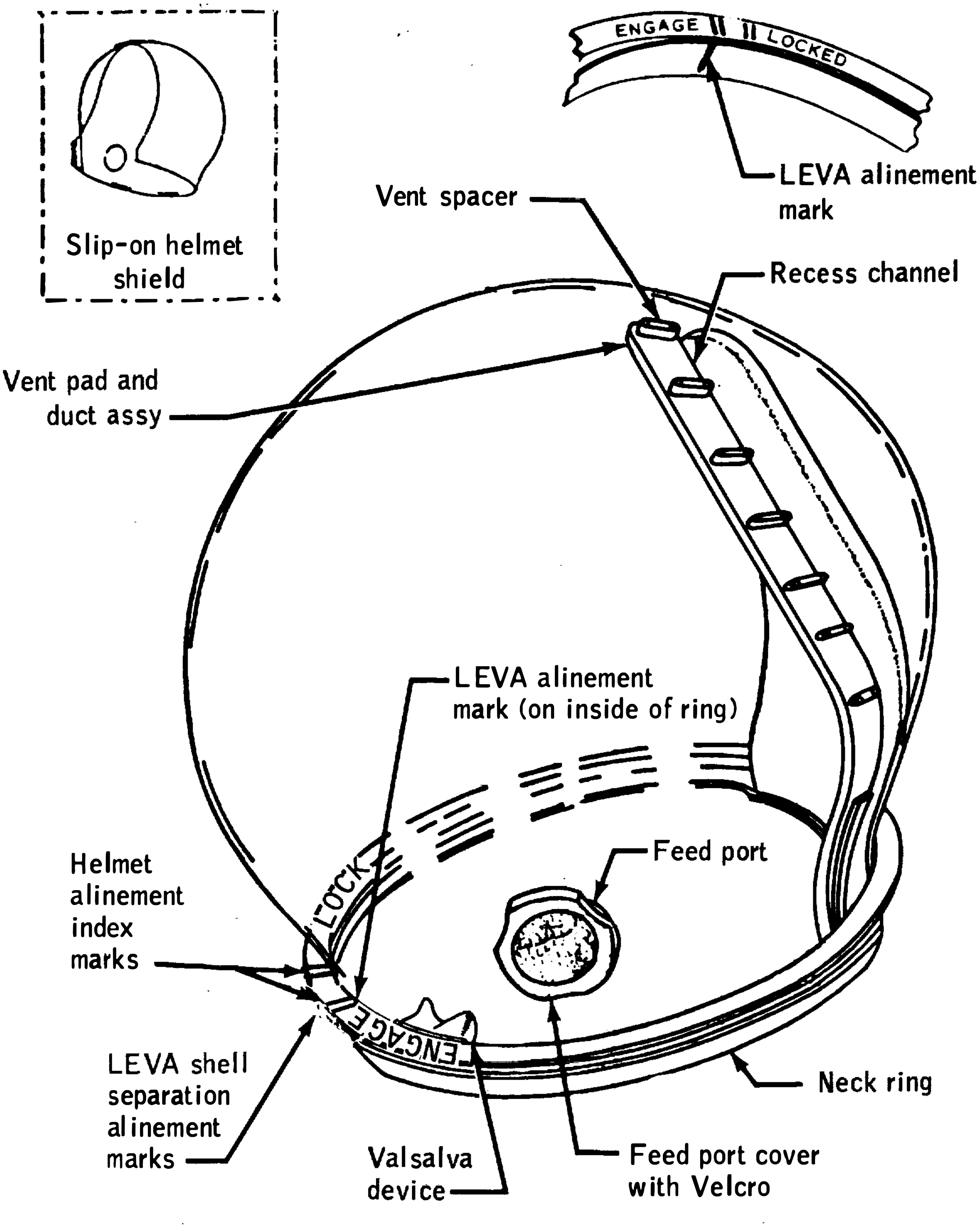


Figure 2-5.- Pressure helmet assembly and helmet shield.

The size of the polycarbonate shell permits normal neck flexion and rotation movements and provides an unobstructed field of vision in accordance with specified optical requirements.

The polycarbonate helmet shell is molded and has a machined bayonet base bonded to the helmet neck ring. The helmet neck ring is the male half of the suit neck ring assembly.

Index marks on each neck ring half are used for alinement during helmet donning operations, and a rigid airtight joint is assured when the two halves are joined.

A helmet shield is used with the helmet to afford scuff and abrasion protection during spacecraft tunnel transfers.

The helmet vent pad bonded to the back of the helmet shell provides shock protection and is used as a helmet ventilation flow manifold. Vent pad louvers guide a layer of gas along the inner surface of the helmet to the oronasal area. This flow of ventilation gas is then distributed through the oronasal area and causes an efficient exhaust of carbon dioxide from the helmet into the torso area.

The feed port is flange mounted to the pressure helmet and includes two metal halves, two beaded elastomer gaskets, and a metal cover. The inner half includes a port and gate valve that permits the insertion of a water or food probe. The valve is spring loaded to a closed position and provides an air-tight seal when the probe is removed. The outer feed port half provides a gas seal around the opening when the probe is inserted. A bayonet juncture holds the feed port cover to the outer feed port half. Beaded elastomer gaskets fit between the helmet and each feed port half to ensure a gas seal at the helmet/feed port mounting surfaces.

A valsalva maneuver device is attached to the pressure helmet neck ring assembly approximately 37° to the left of the sagittal plane. The helmet attaching plate is cemented to the inner circumferential surface of the helmet neck ring at this location and permits attaching and detaching the device. The device can be detached from the helmet by depressing the latch and sliding the device in either direction until free of the helmet attaching plate.

2.3.1.3 Wristlets

The wristlets (fig. 2-6) may or may not be selected for use by the crewman for comfort. The wristlets are cylindrically shaped and constructed of ribknit cotton material. The wristlets may be attached to the comfort glove to provide the wrist and lower arm with protection against wrist disconnect buffeting.

2.3.1.4 Comfort Gloves

The comfort gloves (fig. 2-6) may be used by the crewman for comfort. When used, they are worn beneath the EV or IV PGA pressure gloves to avoid chafe between the skin and the gloves. The comfort gloves are made of nylon tricot material and are available in either long or short lengths of standard small, medium, or large sizes. The long-length gloves are also available in custom sizes.

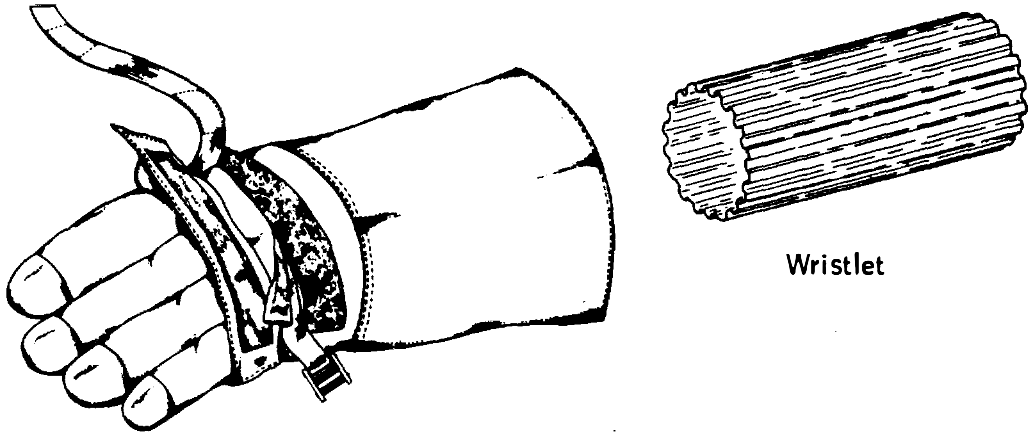
2.3.1.5 IV Pressure Glove Assembly

The pressure glove assembly (fig. 2-6) is a flexible, gas-retaining device which locks to the torso limb suit by means of a quick-disconnect coupling (the wrist disconnect). The bladder assembly is dip molded from a hand cast of the individual's hand. The bladder is comprised of an inner restraint core of nylon tricot covered with a dipped rubber compound. The dexterity of the bladder is increased by built-in relief projections over the knuckle areas, and, to facilitate thumb extension, a gusset is provided in the thumb/forefinger crotch.

A standard convolute section is incorporated in the wrist area of the bladder to allow omnidirectional movement of the wrist. The convoluted section is restrained by a nylon restraint fabric layer and a system of sliding cables secured to a wrist restraint ring and the glove side-wrist disconnect. The cable restraint system accepts the axial load across the glove convolute.

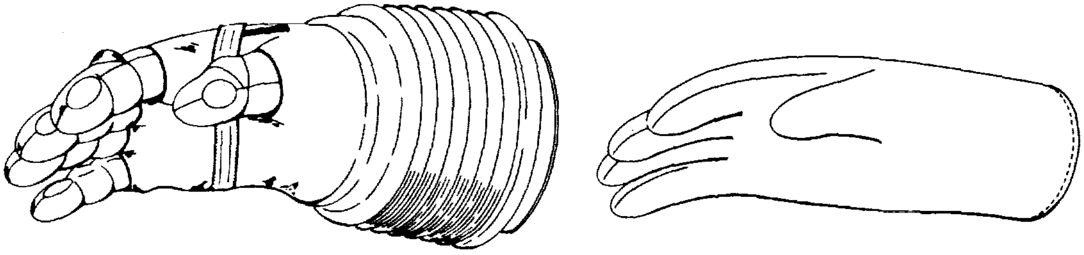
The glove side-wrist disconnect is the male portion of the wrist disconnect assembly and features a sealed bearing which permits 360° glove rotation.

The fingerless glove/outer convolute cover is a restraint assembly which is cemented onto the bladder at the wrist area and encloses the entire hand and wrist exclusive of the fingers and thumb. An external palm restraint assembly minimizes the ballooning effect when pressurized, thereby enhancing grip control. The convolute covers protect the bladder and convolute restraint system.



EV pressure glove

Wristlet



IV pressure glove

Comfort glove

Figure 2-6.- Glove assemblies with wristlets.

2.3.1.6 EV Pressure Gloves

The EV glove assembly (fig. 2-6) is a protective hand covering interfaced with the torso limb suit assembly prior to egress for extravehicular operations. The EV glove consists of a modified IV pressure glove assembly covered by the EV glove shell assembly. The assembly covers the entire hand and has an integral cuff or gauntlet which extends the protective covering well above the wrist disconnect.

A lunar surface EVA checklist is attached to the EV glove gauntlet outer shell as a crew/mission requirement. The specific location, method of attachment, and orientation of the checklist on the glove gauntlet will be defined by the crewman to satisfy specific needs and mission objectives.

The EV glove thermal shell is a multilayered assembly (table 2-VI) which provides scuff, abrasion, flame impingement, and thermal protection to the pressure glove and crewman. A woven metal (Chromel R) fabric is incorporated over the hand area for added protection from abrasion. The thumb and finger shells are made of high-strength silicone rubber which is reinforced with nylon cloth and provides improved tactility and strength. A silicone dispersion coating is applied to the palm, around the thumb, and to the inner side of each finger for increased gripping.

The outer cover is shaped to the inner pressure glove and does not appreciably restrict the dexterity of the inner pressure glove. A flap is sewn onto the back of the glove shell and provides access to the palm restraint flap. The flap is opened or closed by engaging or disengaging the hook-and-pile fastener tape. When the palm restraint flap and hook-and-pile tapes are disengaged, the glove shell can be removed by disengaging the cemented interfacing areas near the fingertips. The materials cross section of the cover layer of the EV glove assembly is identified in table 2-VI.

TABLE 2-VI.- MATERIALS CROSS SECTION FOR EV THERMAL GLOVE

Material	Function
Pressure glove	Pressure retention
Aluminized Mylar (7 layers)	Insulation film
Nonwoven Dacron (6 layers)	Insulation spacer
Teflon-coated Beta yarn (gauntlet only)	Fire resistant shell (gauntlet only)
Teflon cloth (gauntlet only)	Abrasion resistant (gauntlet only)
Chromel R metal fabric (hand only)	Abrasion, fire, heat resistant
Silicone rubber (finger tips only)	Increase friction.

2.3.1.7 Data List Pocket Assembly

The data list pocket assembly (fig. 2-7) is a strap-on assembly which is normally wrapped around the lower left or right leg of the ITMG. The pocket is attached to the leg by two straps held in place by belt loops. The pocket opens and closes by means of an overhanging flap secured by strips of hook-and-pile fastener tape. The data list pocket may be provided as an EV contingency sample pocket. The walls of the pocket include removable stiffeners which hold the pocket open to reduce interferences while inserting or removing articles.

The pocket may be secured to the left thigh in an upright or upside down attitude to attain maximum accessibility to the pocket. Hook-and-pile fastener tape is employed to hold the pocket flap in the open position when the pocket is upright and secured to the thigh.

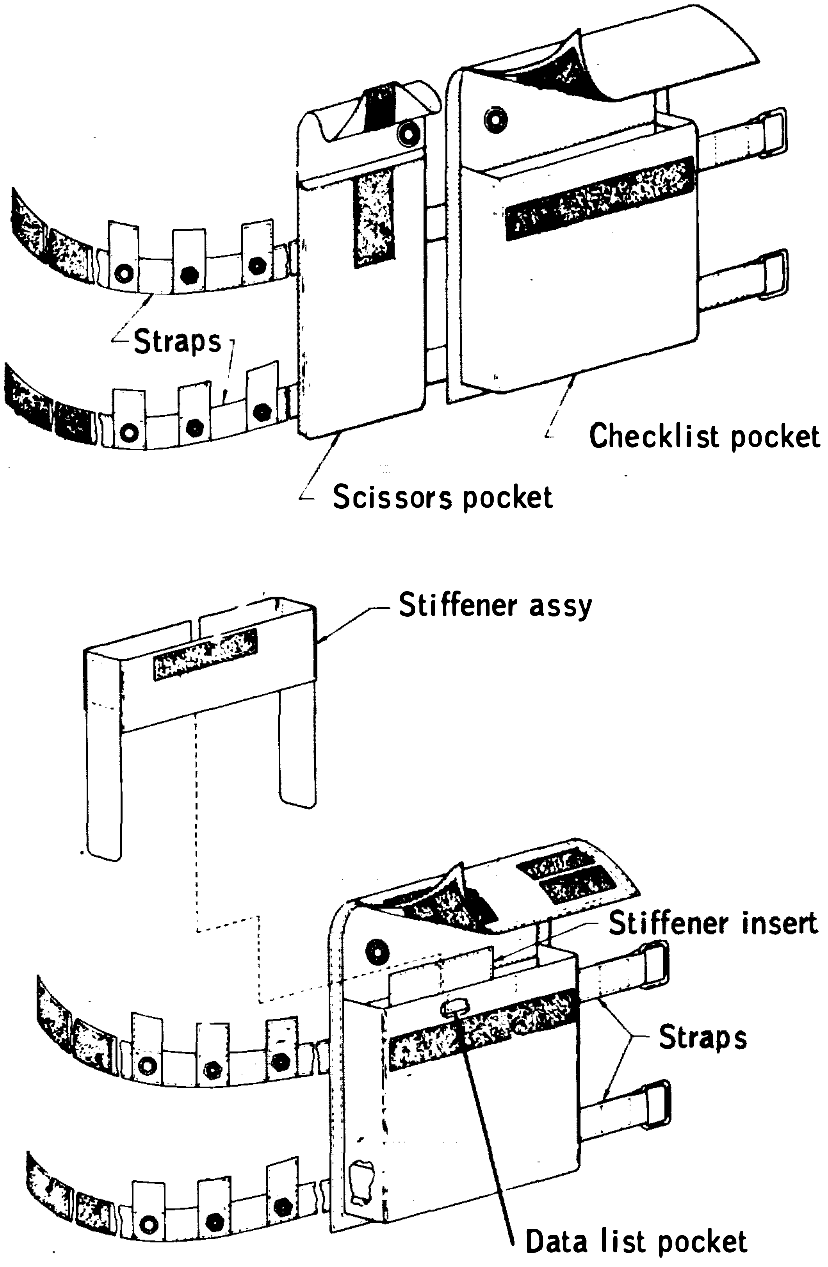


Figure 2-7.- Detachable pocket assemblies.

2.3.1.8 Checklist Pocket Assembly

The checklist pocket assembly (fig. 2-7) is a strap-on assembly consisting of a checklist pocket and belt assemblies. The entire assembly straps onto the lower right or left leg of the ITMG. Belt loops on the legs of the ITMG hold the pocket in position.

2.3.1.9 Scissors Pocket Assembly

The scissors pocket (fig. 2-7) may be attached to the straps of the checklist pocket assembly or secured to the ITMG as a crew/mission requirement. The exact location on the ITMG shell is defined by the crewman and specific mission objectives.

2.3.1.10 Biomedical Harness

The biomedical harness (fig. 2-8) is an electrical cable assembly which interconnects the signal conditioners and dc-to-dc converter within the biomedical belt and interfaces with the suit electrical harness.

2.3.1.11 Lunar Boots

The lunar boot (fig. 2-9) is a thermal and abrasion protective device worn over the ITMG and PGA boot assemblies during lunar extravehicular operations. It permits free articulation of the foot and does not restrict mobility of the PGA boot. Donning is accomplished by inserting the PGA boot into the enlarged upper portion of the lunar boot. A donning strap assembly (located at top rear) facilitates positioning of the PGA boot within the lunar boot. The surplus material at the upper front edge folds over to overlap the tongue area and is held closed by engaging a snap fastener and retaining strap attached to each fold. Further security is provided by a strap assembly which extends from each side of the heel and crosses the instep. The strap incorporates a latching mechanism which is easily actuated even while wearing EV gloves. Table 2-VII defines the material cross section of the lunar boot assembly.

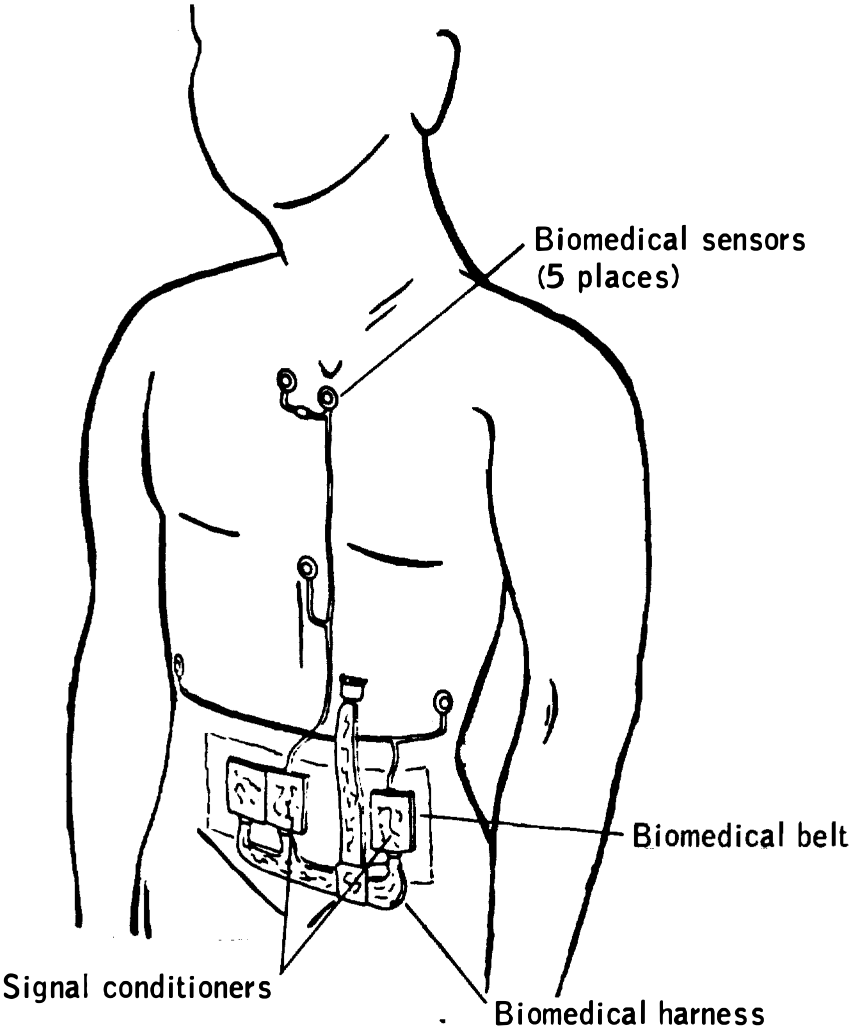


Figure 2-8.- Biomedical harness and sensors.

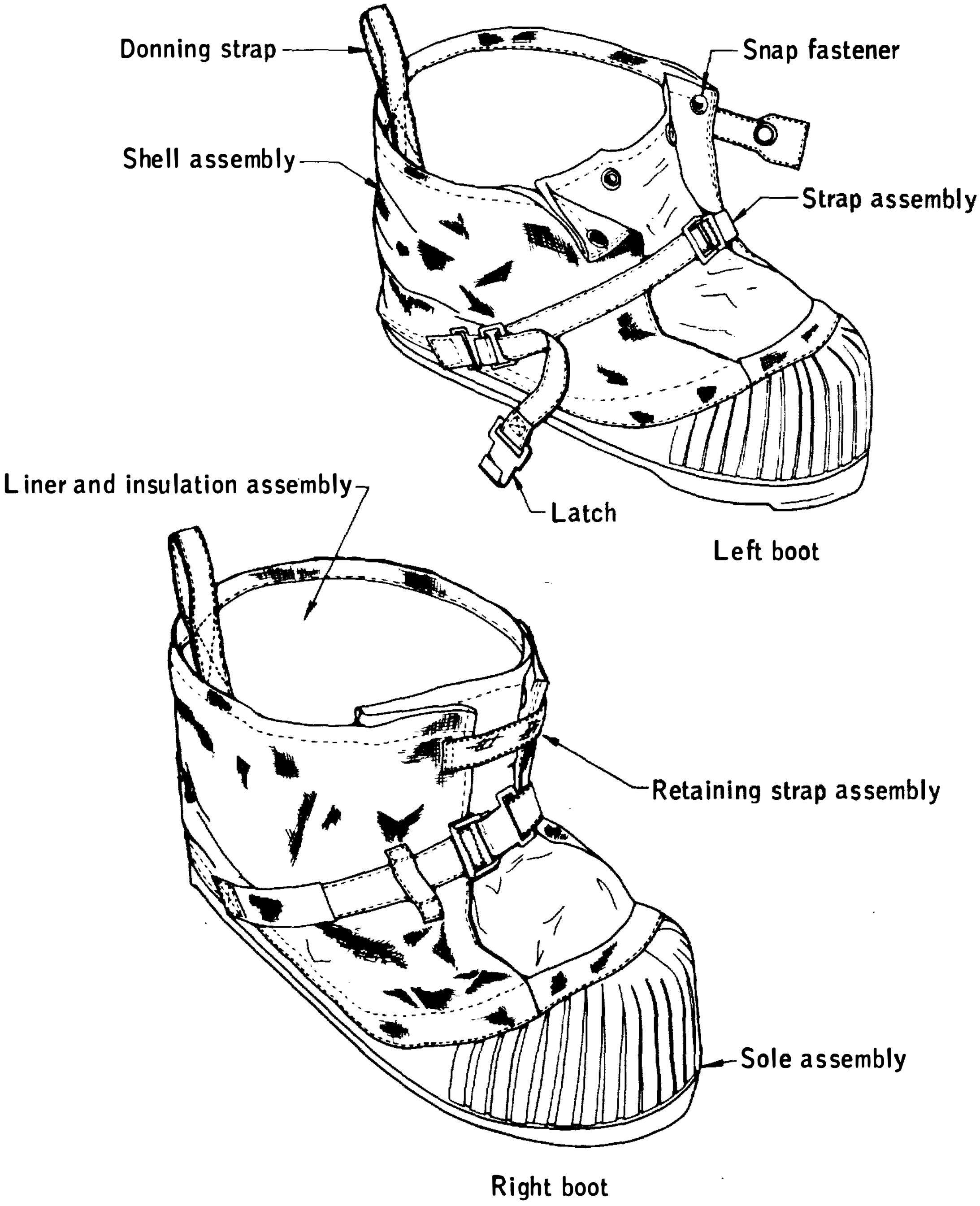


Figure 2-9.- Lunar boots.

TABLE 2-VII.- MATERIALS CROSS SECTION FOR LUNAR BOOT

Material	Function
Teflon-coated Beta cloth	Boot liner
Aluminized Mylar	Insulation film
Nomex felt	Thermal boot pad
Aluminized Mylar (9 layers)	Insulation film
Nonwoven Dacron (9 layers)	Insulation spacer
Beta marquisette Kapton laminate (2 layers)	Outer insulation
Teflon-coated Beta cloth	Fire resistant shell
High-strength silicone rubber	Lunar boot sole
Chromel R metal fabric	Abrasion, fire, heat resistant

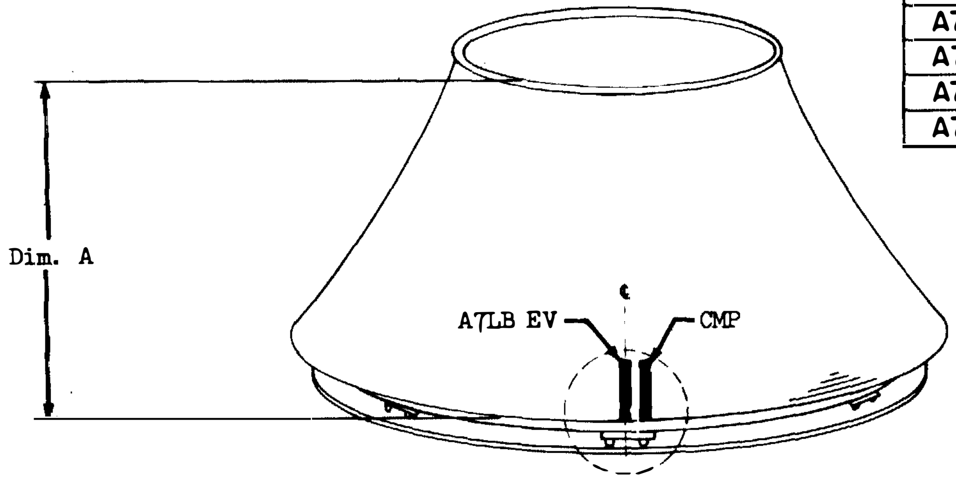
2.3.1.12 Neck Dam

The neck dam assembly (fig. 2-10) is a sealing device to prevent water seepage into the TLSA through the neck opening during suited operations in the water. The assembly consists of a neck dam seal constructed of rubber, a neck dam ring assembly made of flexible metal, and a storage lanyard. The neck dam assembly is conically shaped with a sized opening for the head and neck. The neck dam is donned after reentry and just prior to spacecraft egress operations. The size of the neck dam is determined by the circumference of the head and neck opening in the neck dam seal. The size can be identified by the part number suffix (-1400, neck size 14; -1450, neck size 14-1/2; etc.), and it is available in sizes 13-1/2 to 16-1/2.

2.3.2 CMP A7LB Pressure Garment Assembly

The CMP A7LB PGA functions as a part of the spacecraft environmental control system or the EMU. The PGA contains a habitable environment and protects the astronaut from exposure

Size designation	Size, in.	Dim. A, in.
A7L-1Z1036-02-1350	13-1/2	5-3/4
A7L-1Z1036-02-1400	14	5-1/2
A7L-1Z1036-02-1450	14-1/2	5-1/4
A7L-1Z1036-02-1500	15	5
A7L-1Z1036-02-1550	15-1/2	4-3/4
A7L-1Z1036-02-1600	16	4-1/2
A7L-1Z1036-02-1650	16-1/2	4-1/4



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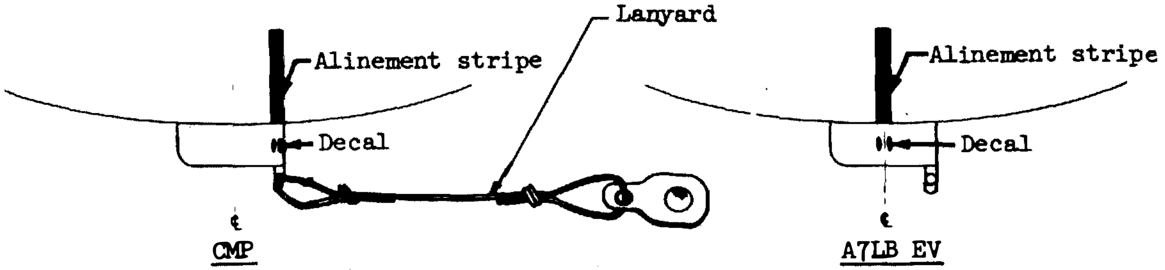


Neck dam alinement

Figure 2-10.- Neck dam.

to thermal and micrometeoroid conditions during EV activities in the free space within the lunar orbit perimeter. The components of the PGA include:

a. CMP A7LB ITLSA
b. PHA
c. Wristlets
d. Comfort gloves
e. IV pressure gloves
f. EV gloves
g. Data list pocket
h. Checklist pocket
i. Scissors pocket
j. Biomedical harness
k. Neck dam

2.3.2.1 CMP A7LB Integrated Torso Limb Suit Assembly

The CMP ITLSA is a restrained, gas-retaining bladder structure integrated with a thermal micrometeoroid protective assembly. The CMP ITLSA encompasses the crewman exclusive of the head and hands. The PHA and EV or IV pressure gloves are mated with the CMP TLSA to complete a PGA for protecting the crewman in a depressurized spacecraft or free space environment. The ITLSA consists of the following subassemblies as numbered in figure 2-11.

1. Torso
2. Pressure gage
3. Torso adjusting strap
4. Restraint cables
5. Pressure sealing slide fastener
6. Boots (r.h. and l.h.)
7. Legs (r.h. and l.h.)
8. Pressure relief valve
9. Gas connectors with diverter valves
10. Arm assembly
11. Suit electrical harness
12. Upper arms (r.h. and l.h.)
13. Liner
14. Core yarn, wrist ring and lacing cord
15. Cover layer assembly boots (r.h. and l.h.)
16. UCD and medical injection access flap
17. Cover layer assembly arms (r.h. and l.h.)
18. Pressure gage cover
19. Cover layer assembly torso
20. Ventilation ducts (not shown)
21. Outer electrical flange (not shown)
22. ITMG UCD clamp (not shown)

The torso, upper and lower arms, legs, boots, and restraint cables are integrated to form the CMP TLSA pressurizable vessel. This vessel includes convoluted joints for low-torque body movements and a near-constant volume displacement during normal joint movements. Longitudinal cables extend across each convolute and sustain the axial loads. The shoulder cone and ankle convolutes are of the constricted-restraint type; and the shoulder, elbow, knee, waist, and thigh joints are single-walled, integrated restraint and bladder, bellows-like structures.

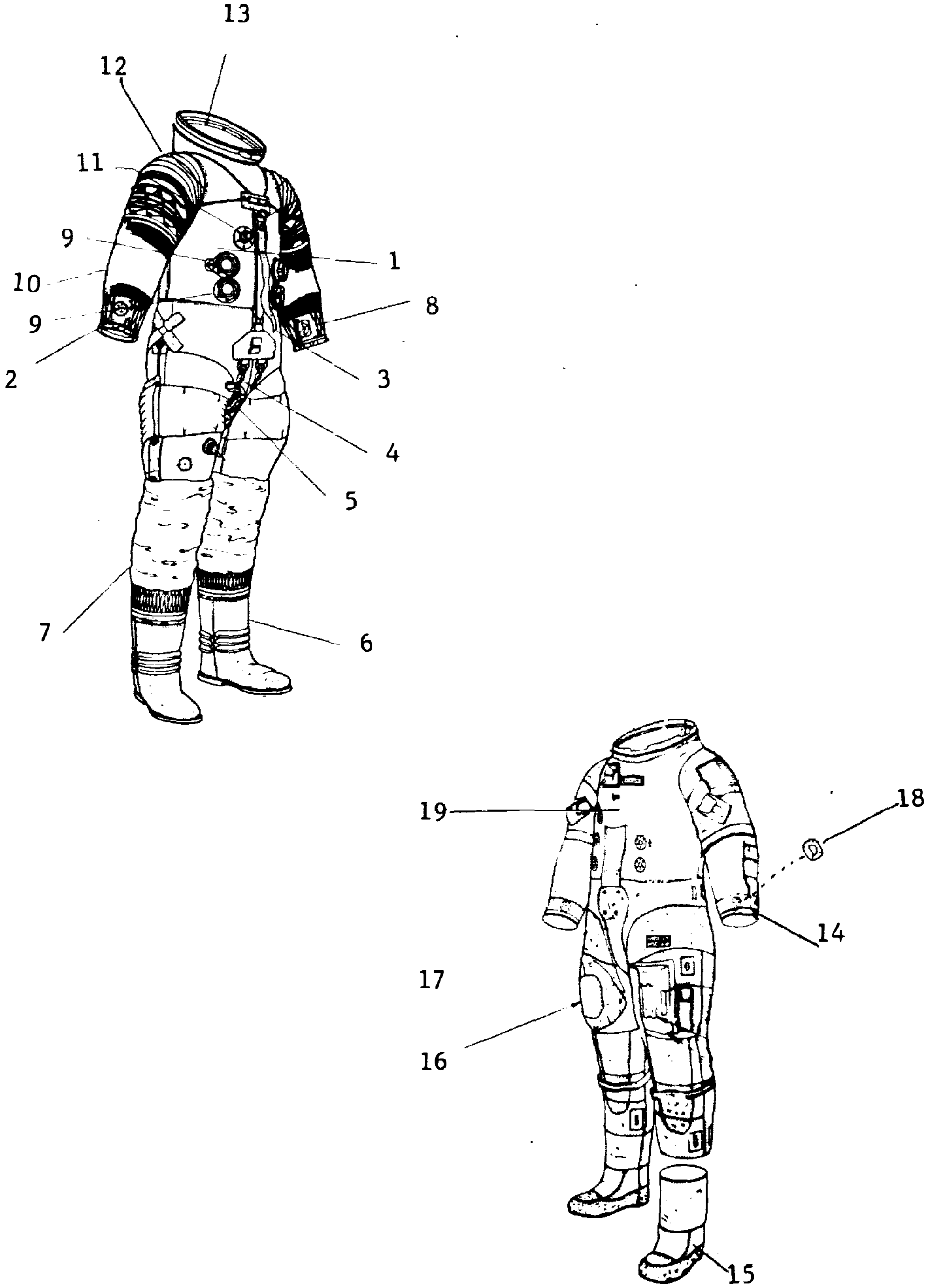


Figure 2-11.- CMP A7LB integrated torso limb suit.

An inner comfort liner within the TLSA is removable for cleaning and inspection. The assembly offers scuff protection to the wearer and covers the ventilation ducting to preclude accidental damage during suit-donning operations.

Entry into the TLSA is made through an integrated restraint and pressure slide fastener assembly mounted vertically along the spinal column and through the crotch area. To preclude accidental opening, a lock assembly for the pressure sealing slide fastener holds it in the closed position.

A network of noncrushable ducting secured to the inner TLSA surface, two sets of inlet and exhaust gas connectors, and a diverter valve for each inlet connector comprise the ventilation distribution system within the TLSA. The TLSA and a ventilation distribution system interface with the pressure gloves and helmet to complete the PGA pressurization and ventilation system. A pressure gage is mounted on the left-arm wrist cone, and a pressure relief valve is mounted on the left arm. The pressure gage indicates differencial pressures of from 2.5 to 6.0 psid, and the pressure relief valve relieves pressures in excess of 5.0 psid.

The suit electrical harness provides a signal path for biomedical instrumentation data and communications transmissions. The suit-mounted connector permits an electrical and mechanical interface with the spacecraft or PLSS communications umbilical.

The cover layer assembly (CLA) torso, arms, boots, and pressure gage cover afford flame impingement, thermal, and micrometeoroid protection to the pressurizable portion of the TLSA and to the crewman. The assemblies employ a multilayered cross section as shown in table 2-VIII.

The outer electrical flange, ITMG UCD clamp, core yarn, wrist ring, and lacing cord secure the thermal and micrometeoroid protective assemblies to the torso limb suit.

TABLE 2-VIII.- CMP A7LB CLA MATERIALS CROSS SECTION

(LISTED FROM THE INSIDE OUT)

Nomenclature	Function
Rubber-coated nylon (ripstop)	Inner liner
Aluminized Mylar film	Thermal radiation protection
Nonwoven Dacron	Thermal spacer layer
Aluminized Mylar film	Thermal radiation protection
Nonwoven Dacron	Thermal spacer layer
Aluminized Mylar film	Thermal radiation protection
Nonwoven Dacron	Thermal spacer layer
Aluminized Mylar film	Thermal radiation protection
Nonwoven Dacron	Thermal spacer layer
Aluminized Mylar film	Thermal radiation protection
Aluminized Kapton film/ Beta marquisette laminate	Fire and thermal radiation protection
Aluminized Kapton film/Beta marquisette laminate	Fire and thermal radiation protection
Teflon-coated yarn Beta cloth	Fire protection
Teflon fabric	Abrasion protection

2.3.2.1.1 CMP A7LB torso limb suit assembly.- The CMP TLSA is similar to the EV TLSA described in paragraph 2.3.1.1.1 except for the following details.

a. The ventilation distribution system ducts are secured to the TLSA in the EV configuration by a system of loops and lacing cord and, in the CMP configuration, by hook and pile fastener tape and bonding strips.

b. The semipockets at the knees of the comfort liner are formed by front panel pleats in the EV configuration and by rear panel pleats in the CMP configuration.

2.3.2.1.2 CMP cover layer assembly.- The CLA is identical to the lunar ITMG described in table 2-VIII.

2.3.2.2 Pressure Helmet Assembly

The CMP PHA is identical to the EV PHA described in paragraph 2.3.1.2 and figure 2-5.

2.3.2.3 Wristlets

The CMP wristlets are identical to the EV wristlets described in paragraph 2.3.1.3 and figure 2-6.

2.3.2.4 Comfort Gloves

The CMP comfort gloves are identical to the EV comfort gloves described in paragraph 2.3.1.4 and figure 2-6.

2.3.2.5 IV Pressure Gloves

The CMP pressure glove assembly is identical in all respects to the EV pressure glove assembly described in paragraph 2.3.1.5 and figure 2-6.

2.3.2.6 EV Gloves

Refer to paragraph 2.3.1.6 and figure 2-6.

2.3.2.7 Data List Pocket

Refer to paragraph 2.3.1.7 and figure 2-7.

2.3.2.8 Checklist Pocket

Refer to paragraph 2.3.1.8 and figure 2-7.

2.3.2.9 Scissors Pocket

Refer to paragraph 2.3.1.9 and figure 2-7.

2.3.2.10 Biomedical Harness

Refer to paragraph 2.3.1.10 and figure 2-8.

2.3.2.11 Neck Dam

Refer to paragraph 2.3.1.12 and figure 2-10.

2.3.3 Interface Components

This paragraph contains descriptions of the components which interface the torso limb suit with other components of the EMU or with the spacecraft, and those which are provided as accessories to the suit. The interface and accessory components are as follows.

a. PLSS attachments
b. Tether attachments
c. Helmet attaching ring
d. Wrist disconnects
e. Gas connectors
f. Diverter valve
g. Multiple water connector
h. Urine transfer connector
i. Medical injection patch
j. Zipper lock assemblies
k. Pressure relief valve
l. Biomedical belt
m. Biomedical harness
n. Suit electrical harness

2.3.3.1 PLSS Attachments

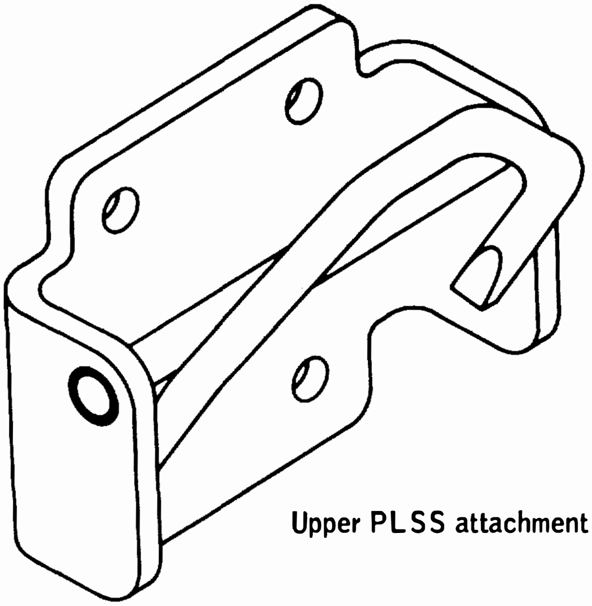
Two attachment brackets (fig. 2-12) on the EV A7LB PGA anchor the shoulder and waist PLSS support straps in place. The upper bracket is fixed to the torso sternum area. The lower PLSS attachment is fitted over the ITMG and snapped to the front torso crotch cable "D" rings located in the abdominal area.

2.3.3.2 Tether Attachment

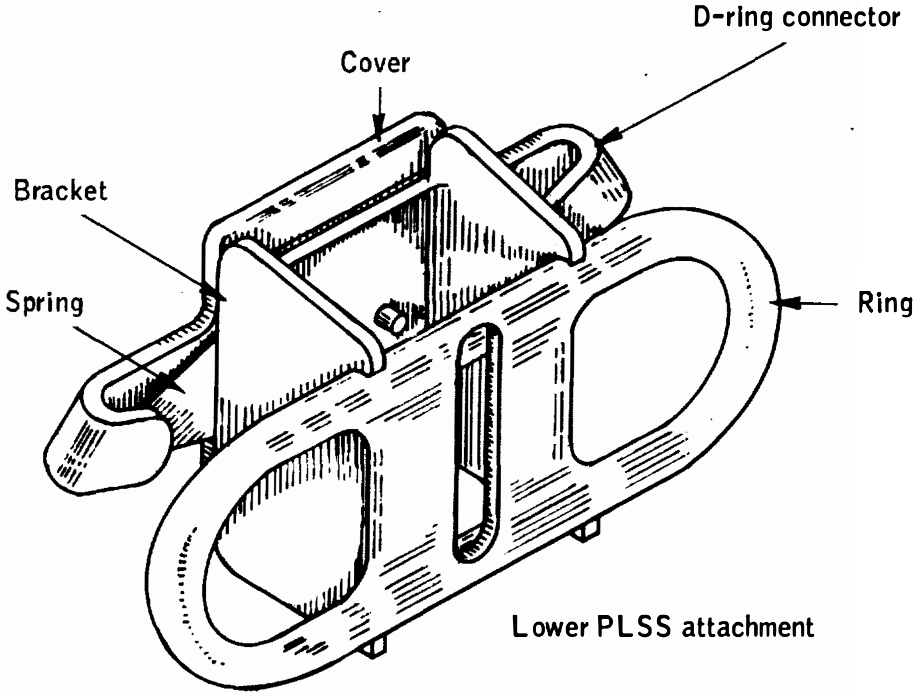
Tether attachments (fig. 2-13) are available at the left and right sides of the EV PGA. The attachment interfaces with and becomes a part of the LM tether system. The LM tether system with the PGA tether attachments provide an artificial gravity to assist the crewman in maintaining stability within the LM.

2.3.3.3 Helmet Attaching Ring Assembly

The helmet is attached to the TLSA by a self-latching, self-sealing, quick-disconnect coupling (fig. 2-14). The TLSA side of the coupling consists of a neckring housing, eight latch assemblies, a rotating locking ring, and a pushbutton lock subassembly on the locking ring. Index marks and



Upper PLSS attachment



Lower PLSS attachment

Figure 2-12.- PLSS attachments.

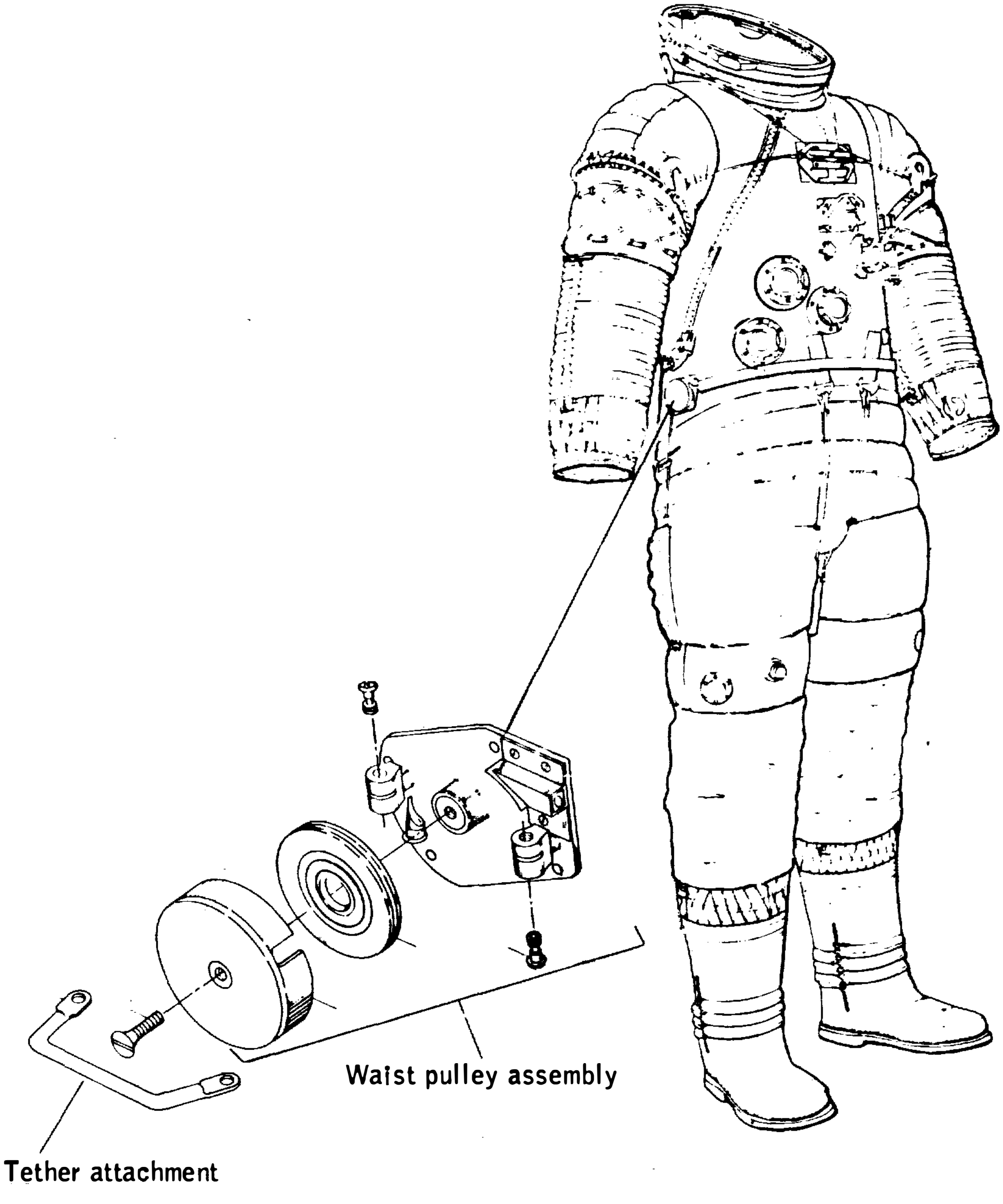
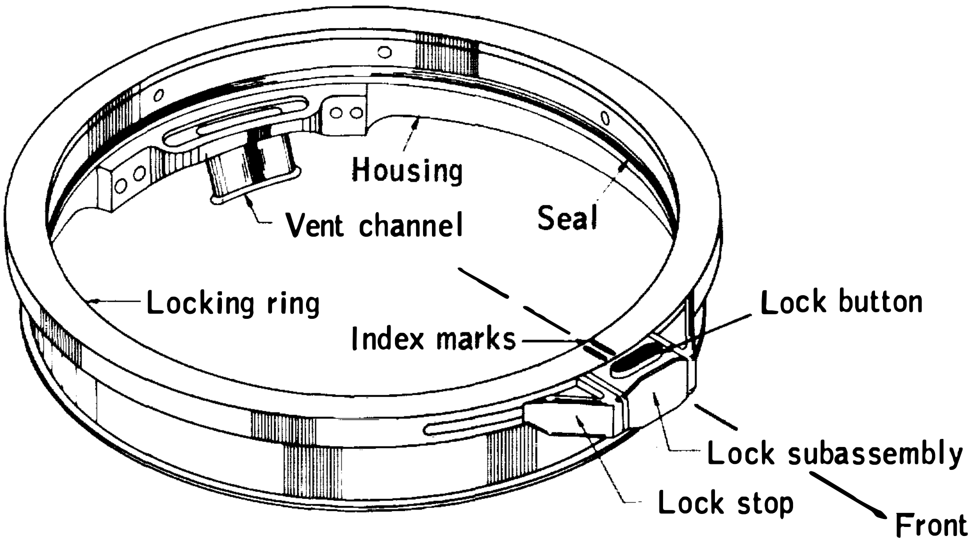
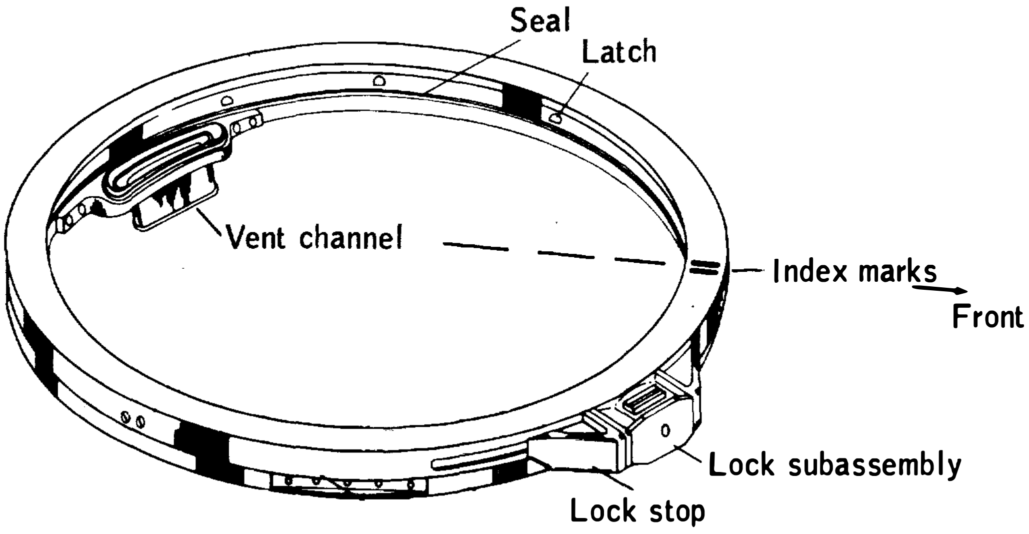


Figure 2-13.- Lunar module tether attachments (A7LB EV).

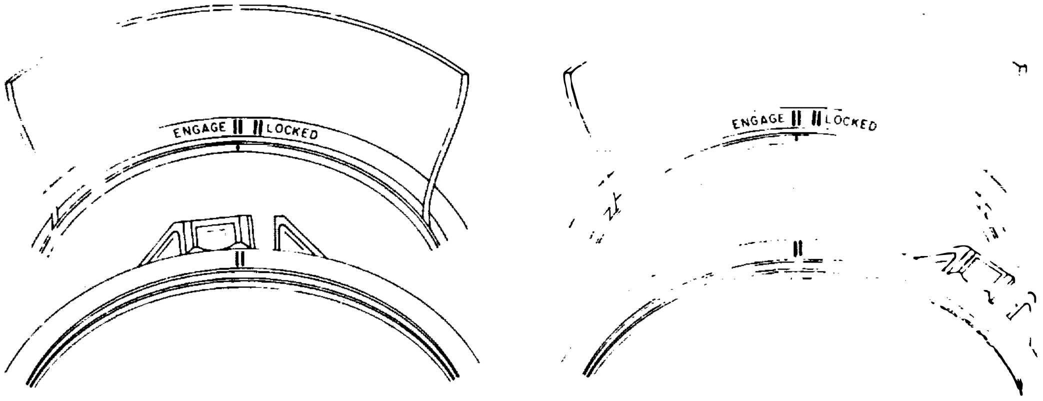


CMP A7LB

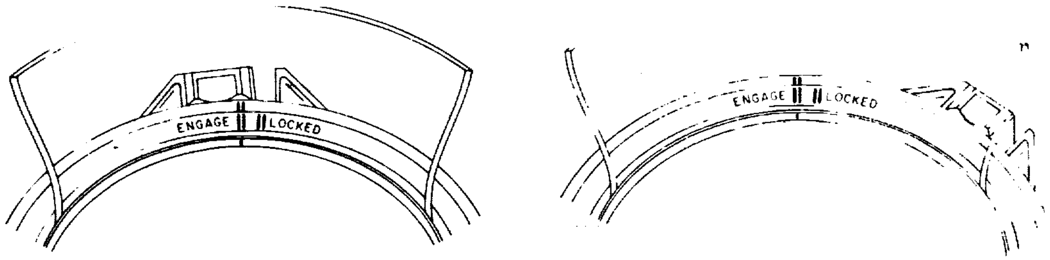


EV A7LB

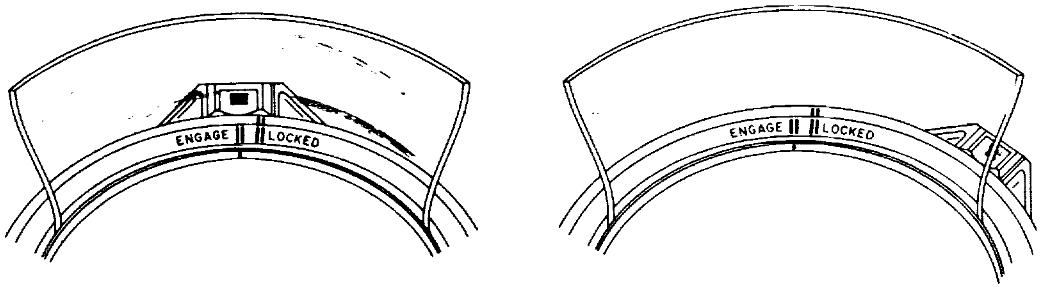
Figure 2-14.- Helmet attaching neck ring.



Helmet alinement for donning



Helmet/suit neck ring engaged



Neck ring locked

A7LB CMP

A7LB EV

Figure 2-14.- Concluded.

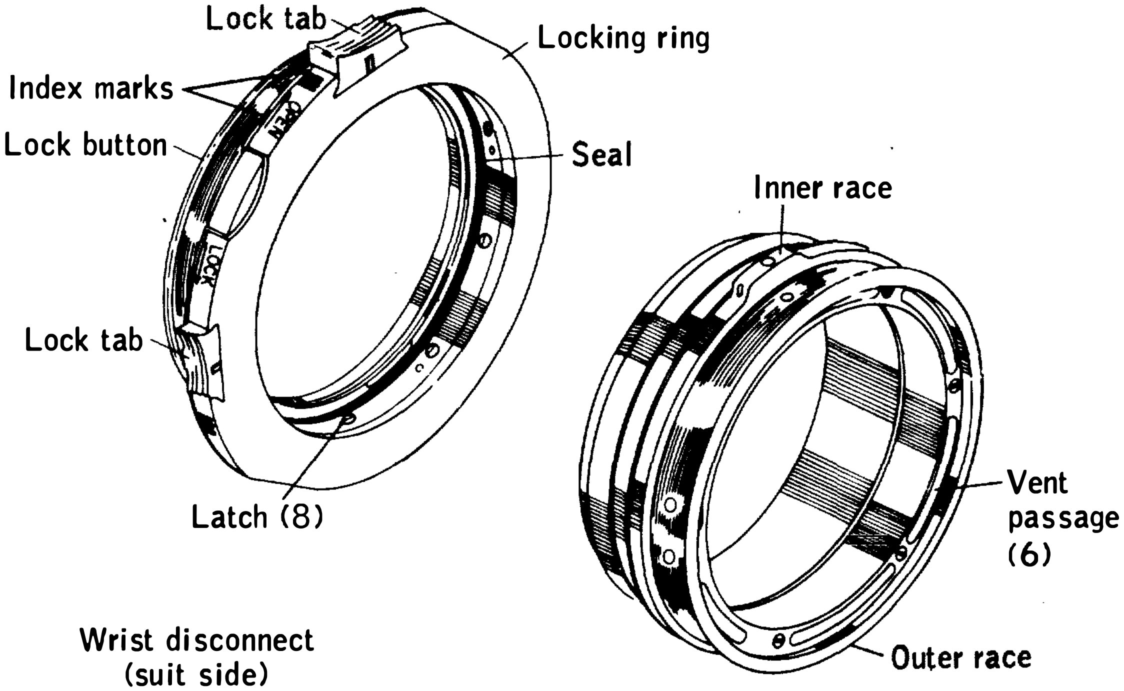
printed labels on the helmet neckring identify the ENGAGE and LOCKED positions and facilitate alinement and engagement with the TLSA neckring. Positive locking of the helmet-to-TLSA coupling is ensured by a TLSA-mounted locking ring which is rotated by hand to the engaged, locked, or release positions. A pushbutton lock on the TLSA locking ring permits rotation of the locking ring to the LOCKED position and prevents accidental unlocking. The helmet is donned with the TLSA locking ring in the ENGAGE position by alining and pressing the helmet into place until the latches catch. The helmet is then locked into place by pressing the pushbutton on the TLSA locking ring, sliding the pushbutton lock outward, and rotating the TLSA locking ring to the LOCKED position. The helmet is removed by pressing the pushbutton on the TLSA locking ring, sliding the pushbutton lock outward, and rotating the TLSA locking ring past the ENGAGE position to the release position. When the TLSA locking ring is released at the helmet release position, it returns automatically to the ENGAGE position.

2.3.3.4 Wrist Disconnects

The PGA wrist disconnect (fig. 2-15) coupling includes a suit (female) half and a glove (male) half. The female coupling incorporates a manually actuated lock and unlock mechanism, which has three positions, ENGAGE, LOCK, and UNLOCK. The male half incorporates a sealed bearing which permits 360° glove rotation. The male half of the disconnect is engaged to the female half by alining the glove-half coupling and placing it into the suit-half coupling with the locking ring in the ENGAGE position, then rotating the locking ring to the LOCK position. The glove-half coupling is disengaged or removed from the suit-half coupling by depressing the lock-lock button with the index finger, and with the thumb and second finger, pulling the two locking tabs from the LOCK position and rotating the locking ring to the open (UNLOCK) position.

2.3.3.5 Gas Connectors

Two inlet and two outlet gas connectors (fig. 2-16) permit the exchange of vent system umbilicals without interrupting the flow of gases to and from the suit. All inlet gas connectors and mating umbilical connectors are anodized blue, and all outlet connectors and mating umbilical connectors are anodized red to preclude reversed connections.



Wrist disconnect
(suit side)

Wrist disconnect
(glove side)

Figure 2-15.- Wrist disconnects.

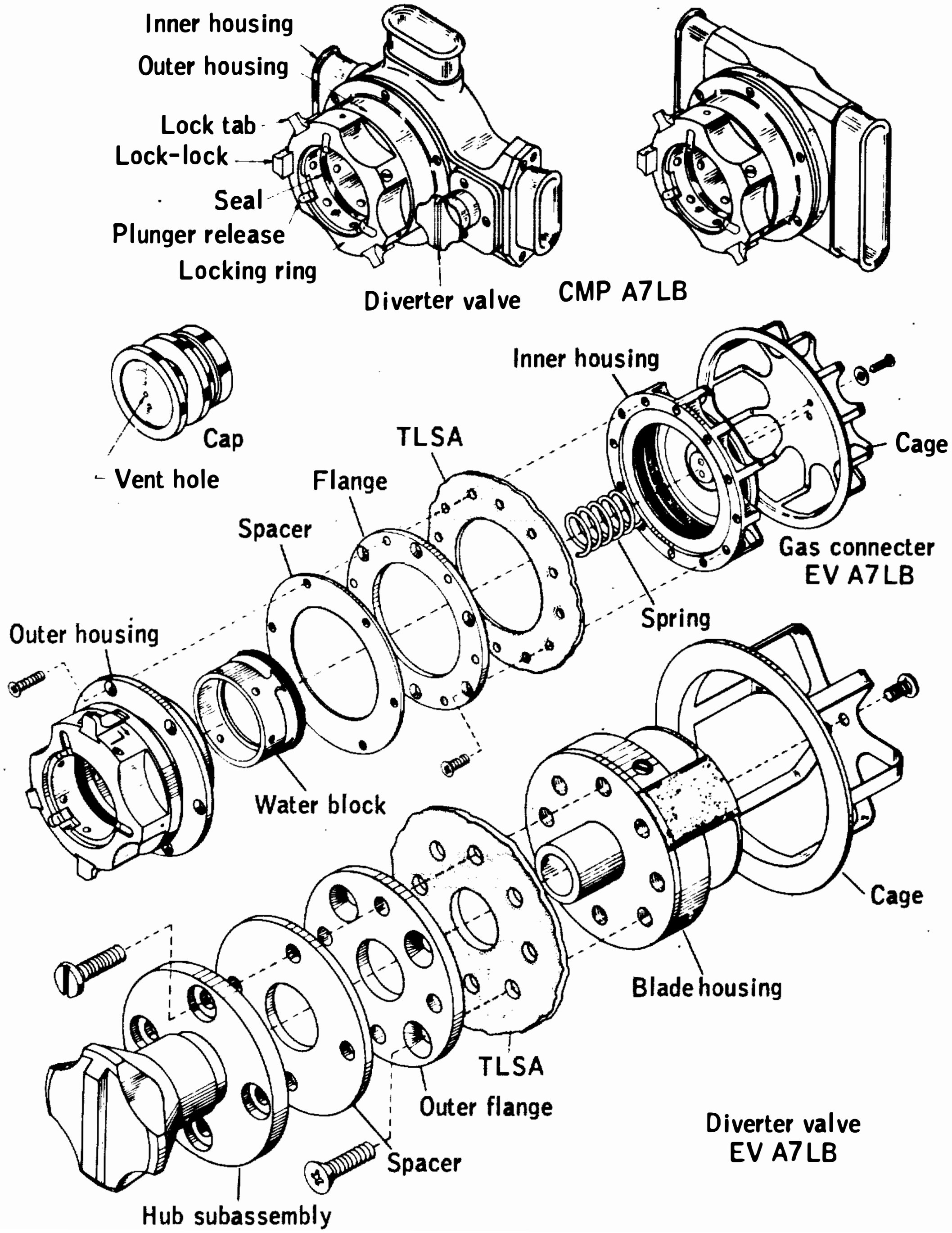


Figure 2-16.- Gas connectors and diverter valve.

The connectors (inlet and outlet) are ball-lock devices and have automatic locking and manual unlocking features. A spring-loaded-closed, mechanically-opened check valve or water block is an integral part of each gas connector. When the umbilicals are disconnected, the check valve or water block prevents pressure loss through the connector. Should the PGA become submerged, the check valve will also prevent water flow through the valves. The check valves are held open by the gas umbilicals when connected. Gas connector caps block the unused connector ports to prevent inadvertent opening of the valve or water block when the umbilicals are not installed. A vent hole through the cap prevents a pressure buildup under the cap when it is inserted into the connector.

The ventilation umbilicals are engaged by inserting the umbilical connectors into the PGA gas connector openings and pressing them firmly into place (the engaging force does not exceed 20 pounds). The umbilicals must be inserted straight into the gas connectors to prevent side loading and damage to the "O" ring seals. The redundant lock is engaged by sliding the tab toward the connector base and into the recess of the upper housing.

The umbilicals are disengaged by releasing the redundant lock and then pulling outward with the forefinger until the tab is clear of the recess in the upper housing. The umbilical may then be released by pulling the locking tabs outward with the thumb and forefinger, thus disengaging them and enabling the locking ring to be rotated to the OPEN position. The gas connector locking ring will automatically lock in the open position to permit immediate or subsequent reengagement of the umbilical.

2.3.3.6 Diverter Valve

A DV (fig. 2-16) to direct the flow of air into the suit is mounted in the central chest area of the EV PGA near the gas connectors. The DV has two functional positions, CLOSE and OPEN. In the CLOSE position, all inlet gas flow is directed to the helmet by the blade on the DV. In the OPEN position, the blade divides the inlet gas flow and diverts a part of it through the torso duct and to the helmet.

A ridged projection on the DV control knob identifies the position of the valve blade. When the ridged projection is vertical (CLOSE position), the blade blocks the passage to the torso duct; when it is horizontal (OPEN position), the blade opens the torso duct passage.

The DV may be rotated 360° in either direction, and spring-loaded, positive (locking) detents are provided at 90° intervals. The valve is operated by pulling out the control knob and rotating it in either direction to the desired position until the locking detent engages.

2.3.3.7 Multiple Water Connector

The multiple water connector (MWC) receptacle (fig. 2-17) includes a double-ball-lock system to engage an LCG dual-passage connector to the inner ball-lock mechanism and a PLSS dual-passage connector to the outer ball-lock mechanism. A plug inserted into the receptacle and locked in place replaces the LCG connector when the LCG is not worn. The plug extends through the receptacle to aline it with the outer surface of the suit.

The inner mechanism is a manually actuated locking and unlocking device. With the locking ring in the OPEN position, the LCG connector is alined with the receptacle port, positioned with the thumb and forefinger, and rotated to the LOCKED position.

The LCG connector is disengaged by pulling out the two locking tabs with the thumb and forefinger and rotating the locking ring to the OPEN position. The LCG connector may then be extracted from the receptacle.

To engage the PLSS connector, the connector must be alined with the port of the receptacle and placed into the receptacle (engaging force should not exceed 20 pounds). The locking mechanism will automatically lock the connector in place. The connector position may be engaged in 180° increments to facilitate convenient connection in the LM.

The PLSS connector may be disengaged by pulling the two locking tabs out and rotating the locking ring to the OPEN position. The locking mechanism will then remain in the OPEN position, ready for immediate or subsequent reengagement.

2.3.3.8 Urine Transfer Connector

The urine transfer connector assembly (fig. 2-18) consists of a PGA-mounted, ball-lock connector and a sized length of interconnecting hose. The connector is flange mounted to the right-leg thigh cone of the PGA where it mates with the urine transfer umbilical of the spacecraft management system. The hose assembly is mounted to the connector on the inside of

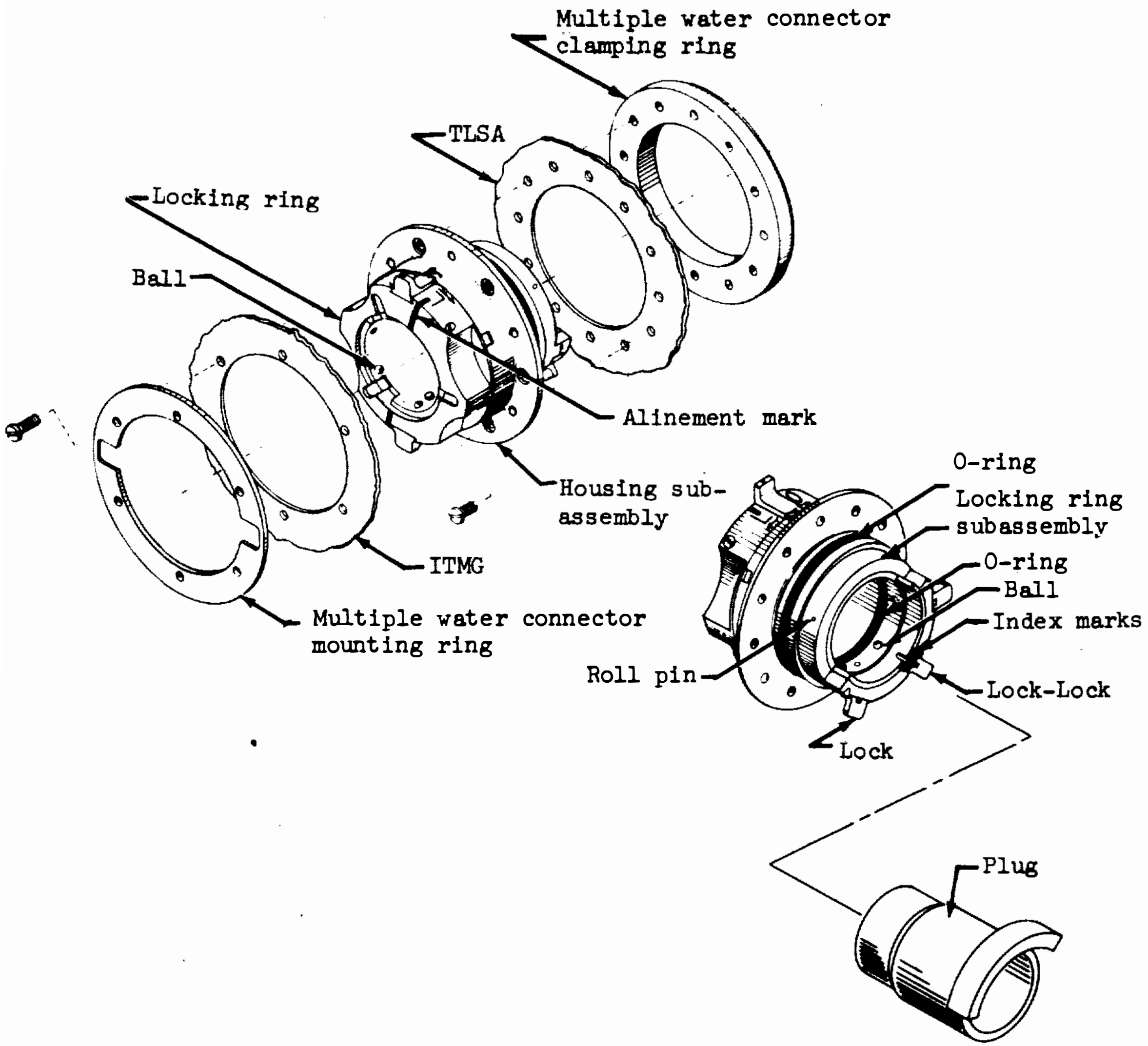


Figure 2-17.- Multiple water connector.

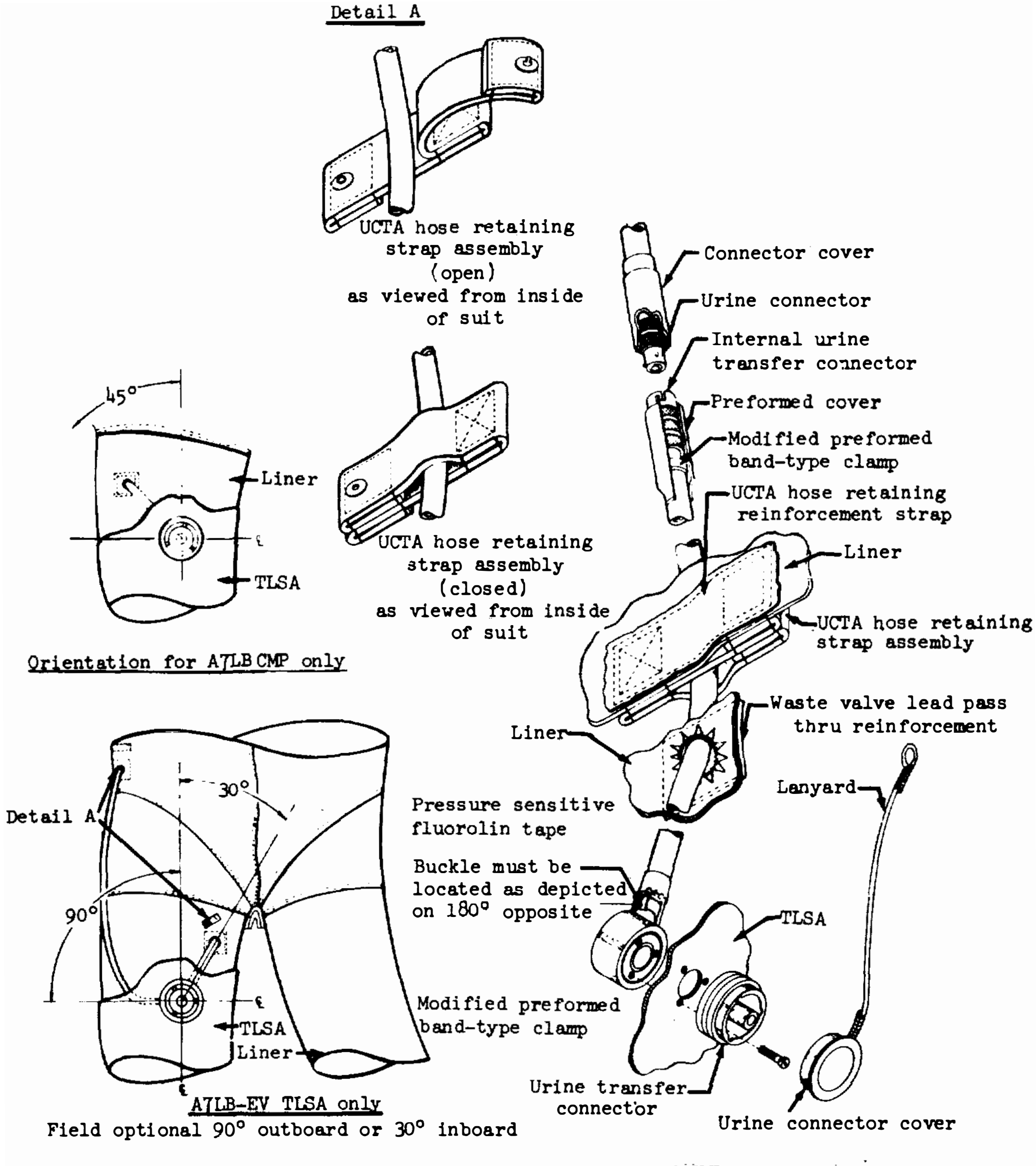


Figure 2-18.- Urine transfer connector.

the PGA, and it extends to a male adapter which mates with the UCTA connector. The assembly transfers urine from the UCTA to the spacecraft waste management system. A preformed rubber connector cover is fitted over the mated UCTA/TLSA urine transfer hose connector to improve comfort and to preclude possible abrasion to the TLSA bladder.

2.3.3.9 Biomedical Injection Patch

A circular biomedical injection patch (fig. 2-19) is sewn to the left-thigh cone of the PGA. The patch is made from a silicone rubber disk which is self-sealing to permit a crewman to inject a hypodermic in a vacuum environment without jeopardizing the pressure integrity of the PGA. The patch is placed at approximately the midpoint of the PGA thigh cone and is identified by a red zigzag stitch line around the perimeter.

2.3.3.10 Zipper Lock Assemblies

A separate zipper lock assembly (fig. 2-20) is provided for the PGA restraint and pressure-sealing slide fasteners (zippers) on the EV A7LB PGA, and a single lock is provided for the pressure-sealing slide fastener on the CMP A7LB PGA. The lock assemblies are of different configurations. The locks engage and hold the zipper sliders when they are at the fully closed positions on the zipper. The zipper lock assemblies include additional or redundant lock features to prevent inadvertent release of the lock.

The EV A7LB restraint zipper lock assembly (fig. 2-20) is mounted on the slider of the horizontal restraint zipper and engages the slider on the vertical restraint zipper slider when both zippers are in the fully closed positions. The lock assembly is operated by fully engaging the slider of the vertical restraint zipper into the lock and squeezing the red striker until the lock-lock tab snaps into the lock position. To release the lock, the lock-lock tab is pulled out, and the zipper lock strike is moved out free of the vertical zipper slide.

The EV A7LB pressure zipper lock assembly (fig. 2-20) for the pressure sealing zipper is mounted on the CLOSE zipper stop. When the zipper is fully closed, the slider depresses the safety plunger which permits the lock to be actuated. The lock is actuated by pressing inward on the safety shaft while simultaneously turning it until the spring retaining pin is moved fully into the detent slot. To disengage the

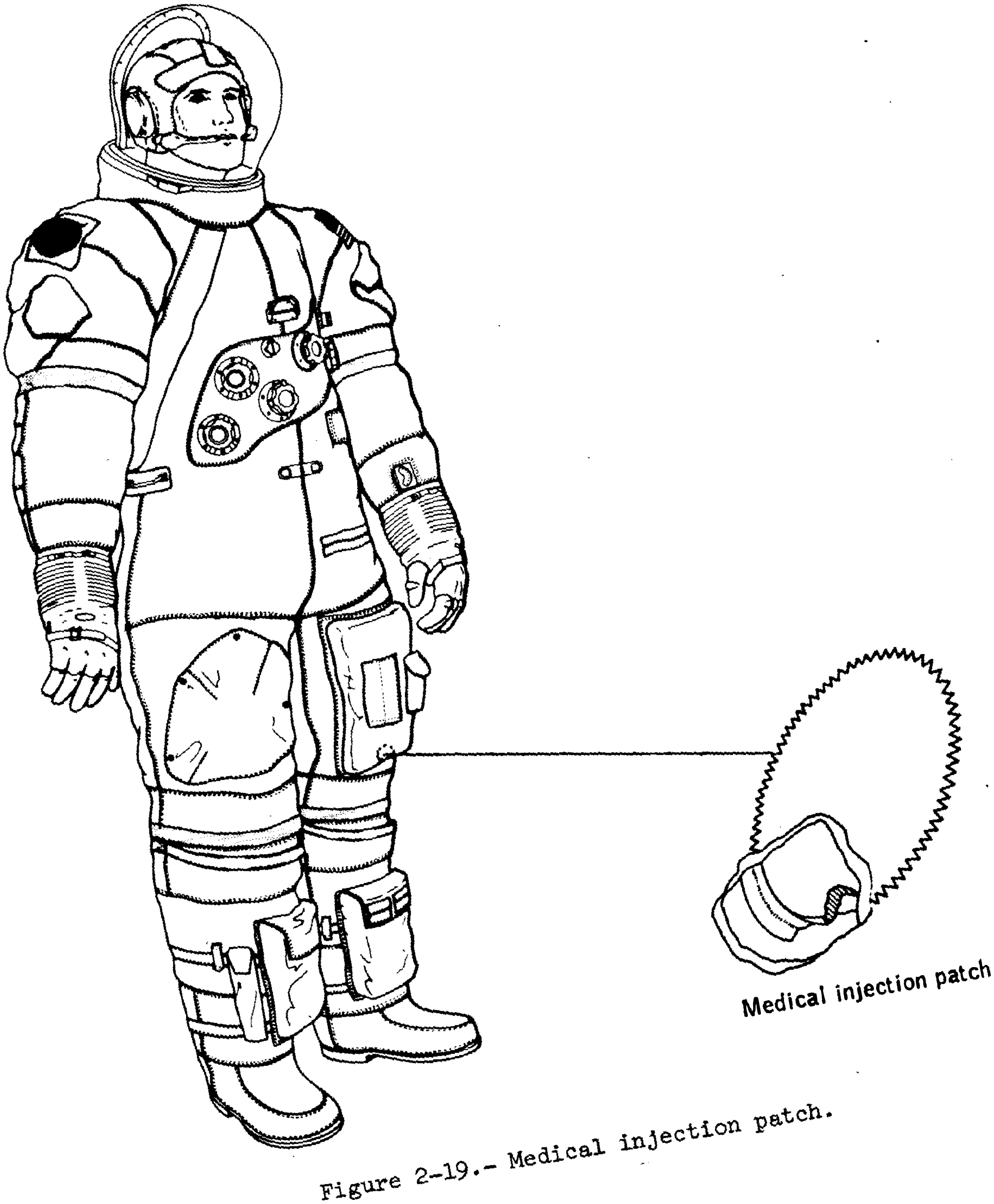


Figure 2-19.- Medical injection patch.

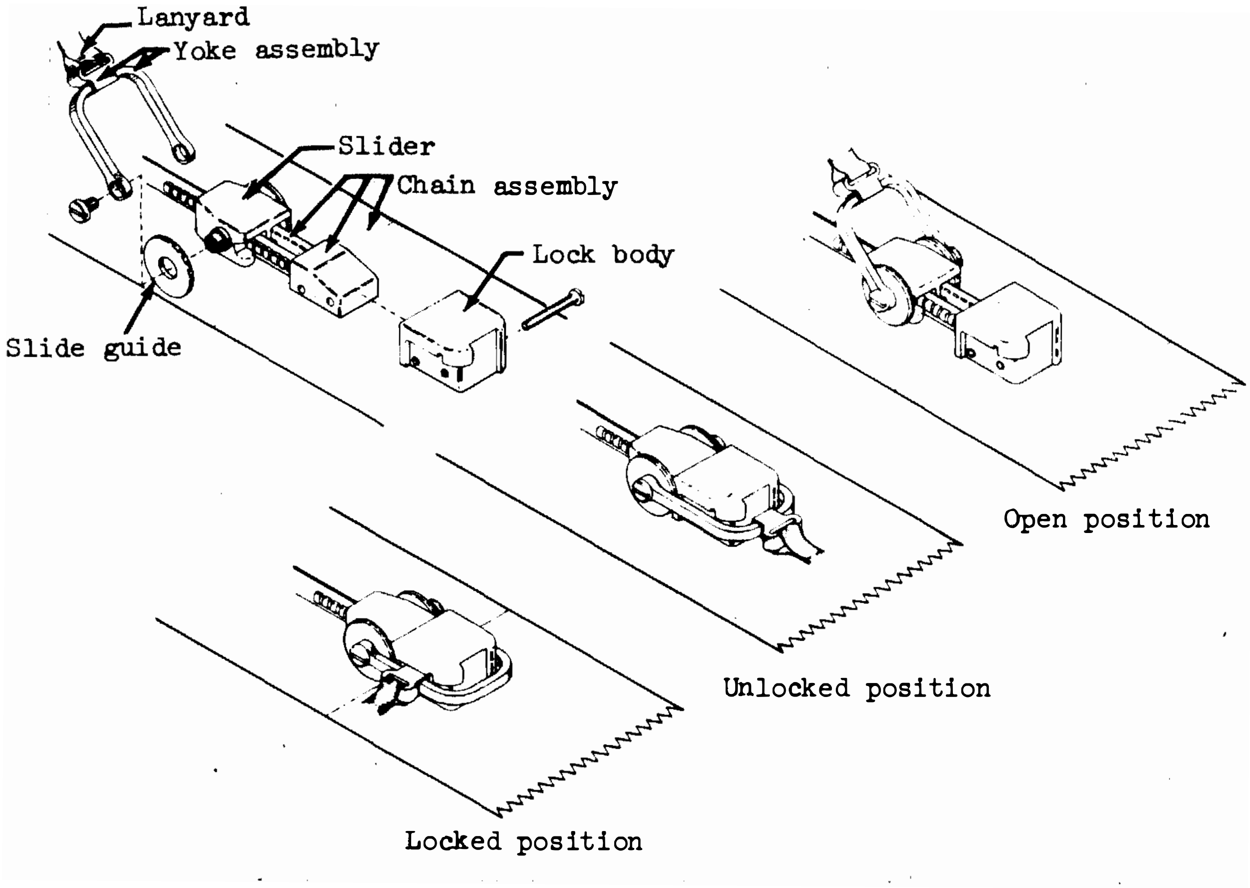
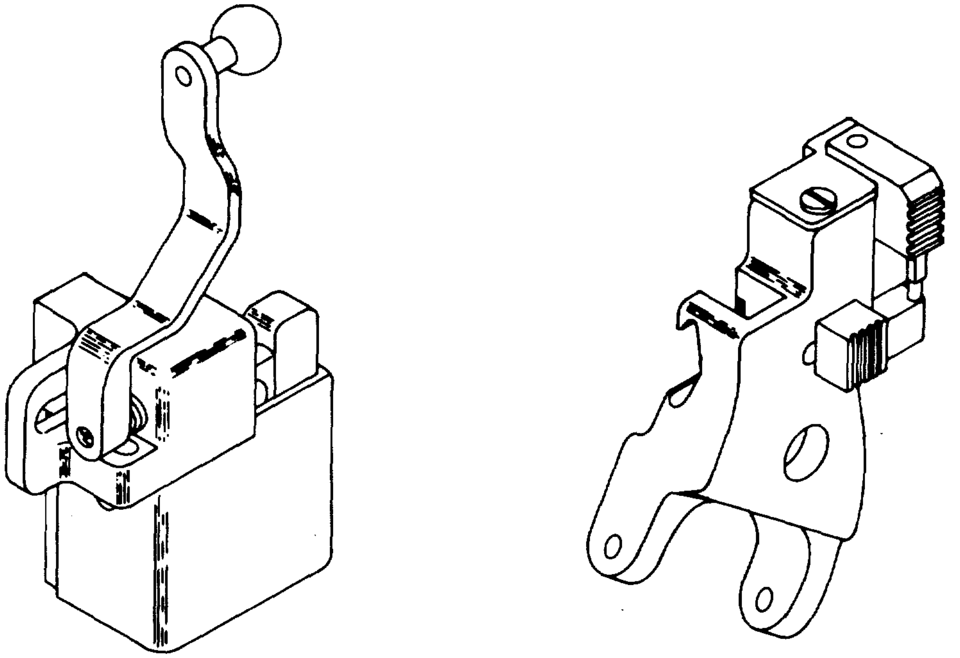
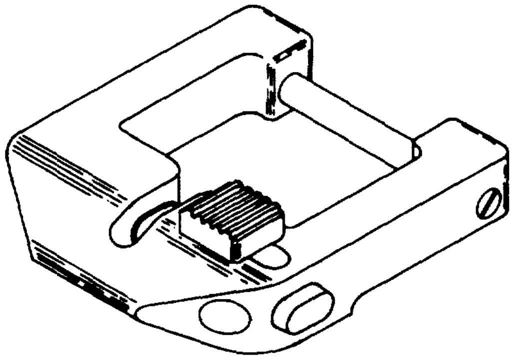


Figure 2-20.- Zipper lock assemblies.



EV A7LB pressure zipper lock assembly

EV A7LB restraint zipper lock assembly



CMP A7LB slide fastener lock assembly

Figure 2-20.- Zipper lock assemblies.

lock, the locking shaft is depressed and the safety arm is rotated out and away from the zipper allowing the locking shaft to disengage the zipper strike.

The CMP A7LB pressure-sealing slide fastener lock assembly (fig. 2-20) holds the slider of the pressure-sealing closure to prevent accidental opening. The lock assembly may be placed in two positions, LOCK and UNLOCK. The LOCK position is achieved by pushing the lock slider inboard to the stop using the thumb and forefinger. The red slider should not protrude beyond the body of the assembly when the slider is in the LOCK position. An OPEN position is achieved by pushing the lock assembly release button outboard of the stop using just the thumb. To engage the lock to the pressure-sealing closure slider, the lock assembly is firmly pulled over the slider and then the assembly is locked. The slide fastener closure is released by unlocking the lock assembly and lifting the lock assembly away from the pressure-sealing closure slider. A detent assembly holds the lock assembly slider in the LOCK and UNLOCK positions.

2.3.3.11 Pressure Relief Valve

The pressure relief valve (fig. 2-21) relieves suit pressures in excess of 5.0 psid. Relief cracking limits are 5.0 to 5.75 psid. The valve will reseat as suit pressure reduces to 4.6 psid and shall not leak more than 4.0 scc per minute when closed at 4.6 psid. The valve accommodates a relief flow of 12.2 lb/hr minimum at 5.85 psia in the event of a faulted-open primary oxygen pressure regulation in the PLSS.

The pressure relief valve may be blocked to preclude the relief of suit pressure or to stop leakage through the valve. A cap fitted over the valve and locked in place by a cam lock system blocks the exhaust ports to prevent pressure relief through the valve.

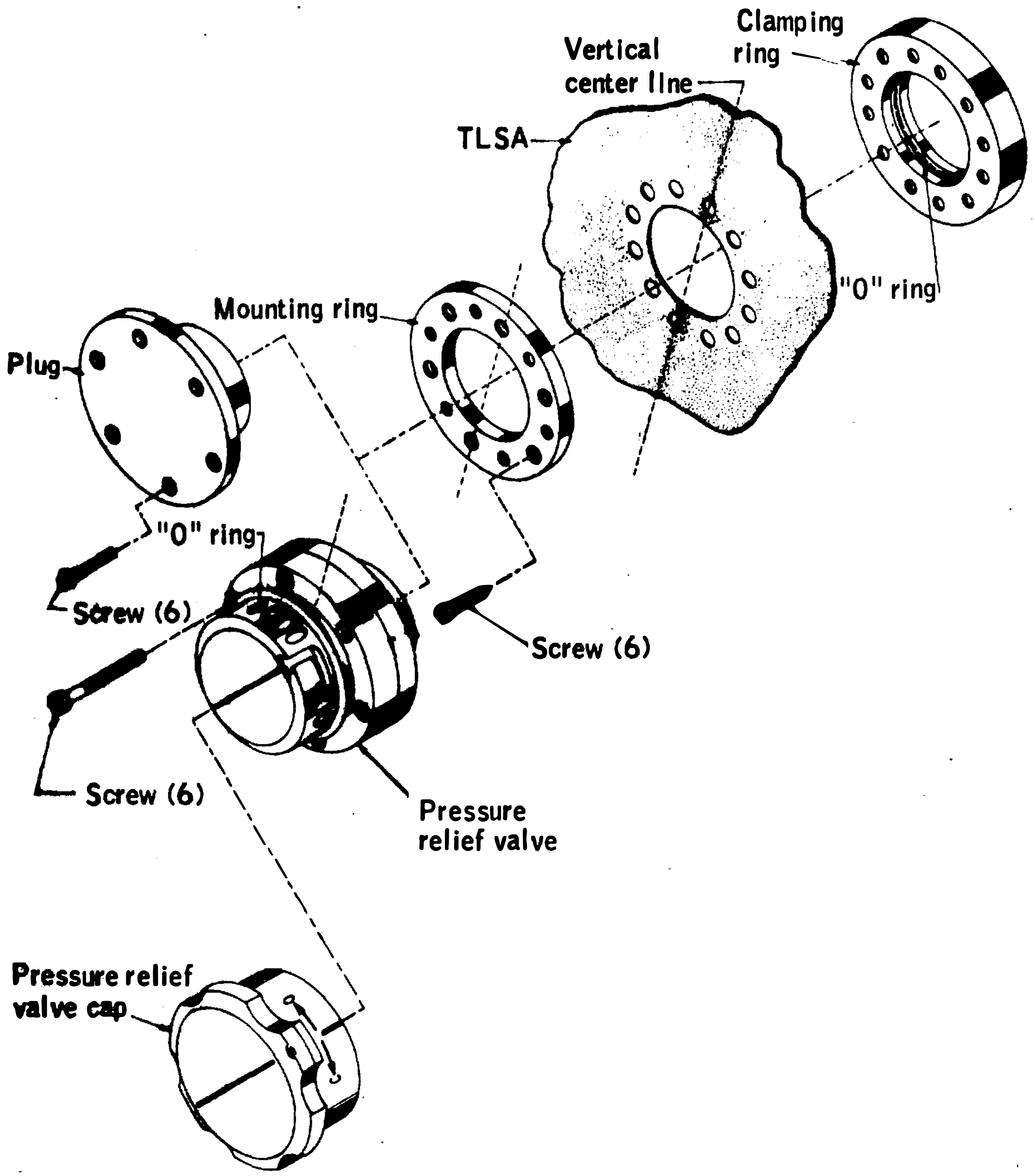


Figure 2-21.- Pressure relief valve.

2.3.3.12 Biomedical Belt

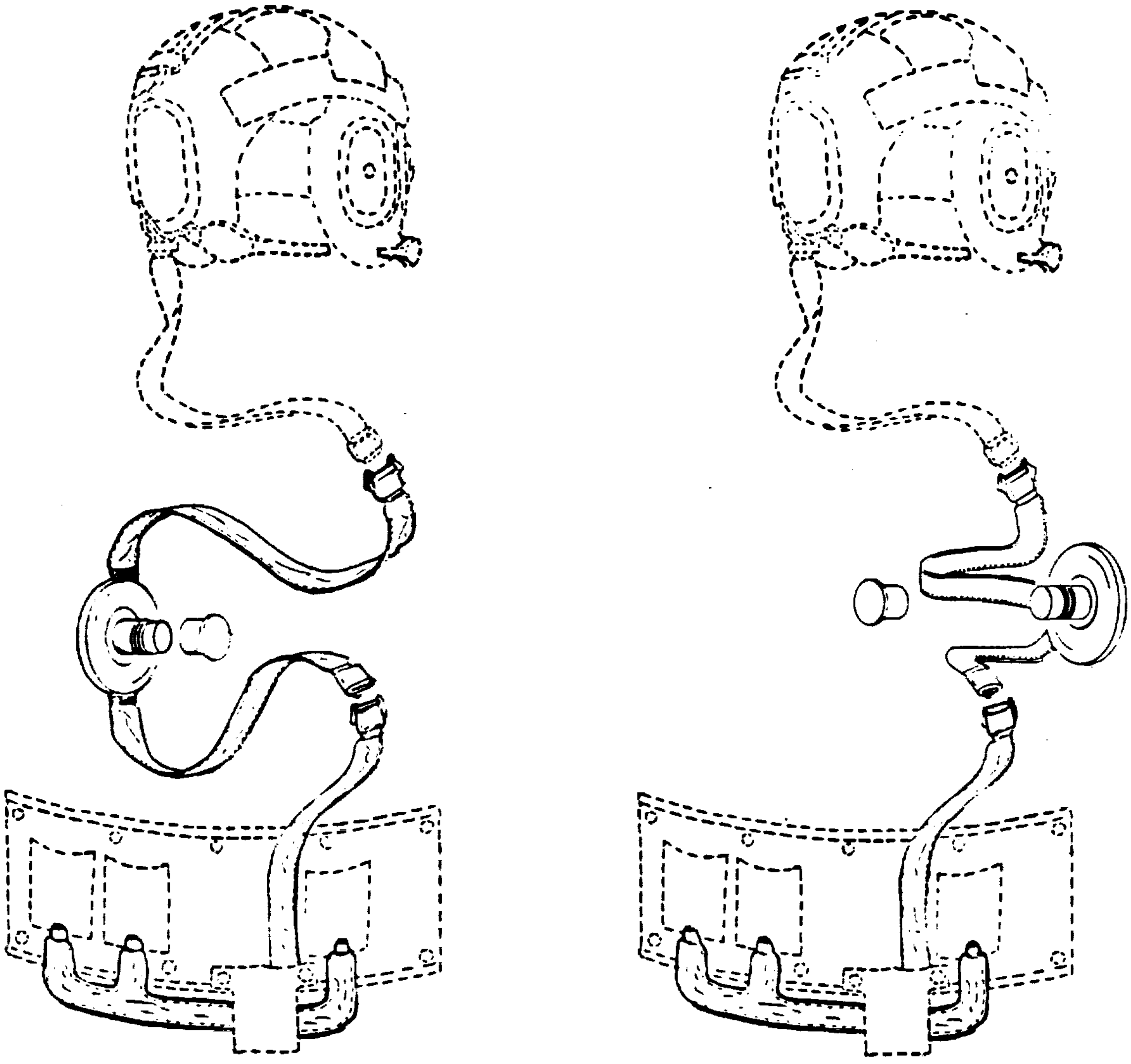
The biomedical belt (fig. 2-22) supports the signal conditioners and power converter as a part of the biomedical instrumentation system. The power converter is located in the right-hand pocket (as worn), the ECG signal conditioner in the center pocket, and the impedance pneumogram (ZPN) signal conditioner in the left-hand pocket. The connector ends of these units are colored red, blue, and yellow, respectively. When installing or reinstalling the units, the above order is maintained to assure that proper signal path connections are made. When the belt is transferred between the LCG and CWG, the color-coded electrode harnesses are disconnected at the units, and the units are retained in the belt. The biomedical harness need not be disconnected from the belt. The electrodes are not removed to change garments.

2.3.3.13 Biomedical Harness

The biomedical harness (fig. 2-22) is a four-branch assembly that interfaces with the two biomedical instrumentation signal conditioners (ECG and ZPN), the dc-dc power converter, and the main branch which mates with the suit electrical harness. The wires are covered with a sheath of Teflon fabric anchored to each connector by nylon wrapping cord. The harness is held in place by the biomedical belt and, through its mechanical connectors, with the dc-dc converter and the signal conditioner.

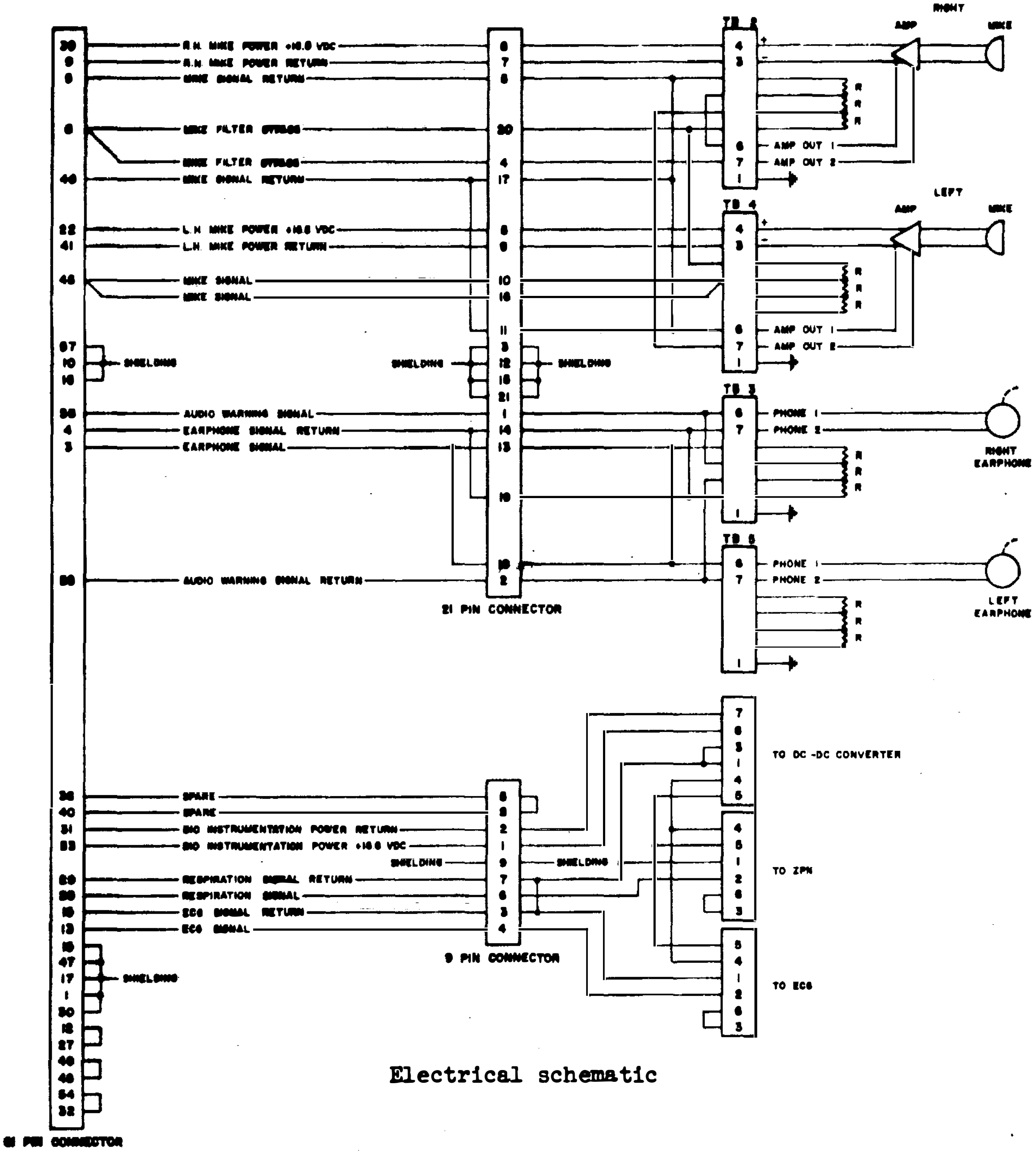
2.3.3.14 Suit Electrical Harness

The suit electrical harness (fig. 2-22) has a central 61-pin connector from which two branches extend. One branch connects to the communications cap or carrier, while the second, shorter branch connects to the biomedical harness. The communications branch has a 21-pin connector, and the biomedical instrumentation branch has a 9-pin connector. A groove machined into the mounting face of the central 61-pin connector uses an O ring to provide a seal when the electrical harness is mounted to the TLSA. Each branch is covered with a Teflon fabric sheath. The Teflon fabric sheaths are attached to each connector with wrapping cord and an adhesive. The central 61-pin connector receives the ball/lock engagement mechanism of the communications and biomedical instrumentation umbilical of the spacecraft or the PLSS. The 9- and 21-pin connectors employ a dual-pawl or latch-engaging mechanism.



CMP A7LB **EV A7LB**

Figure 2-22.- Biomedical and suit electrical harness and biomedical belt.



Electrical schematic

Figure 2-22.- Concluded.

2.3.4 Controls and Displays

The PGA controls and displays control and monitor the internal pressure and ventilation. The pressure controls provide automatic and manual control of the suit pressure. The ventilation control is manually operated. The controls and displays consist of an automatic pressure relief valve mounted on the right-thigh cone, manual purge and diverter valves mounted on the chest area, and a pressure indicating gage on the left-wrist cone. The pressure relief and diverter valves are described in paragraphs 2.3.3.11 or 3.1, the pressure gage in paragraphs 2.3.3.6 and 3.1, and the purge valve in paragraphs 3.1 and 2.3.5.10.

2.3.5 Pressure Garment Accessories

2.3.5.1 Fecal Containment Subsystem

The FCS (fig. 2-23) consists of a pair of elasticized underwear shorts with an absorbent liner material added in the buttocks area and with an opening for the genitals in the front. Foam rubber is placed around the leg opening, under the scrotal area, and at the spinal furrow. This system is worn under the CWG or LCG to permit emergency defecation during the periods when the PGA is pressurized. The FCS collects and prevents the escape of fecal matter into the pressure garment. The moisture contained in the fecal matter is absorbed by the FCS liner and is evaporated from the liner into the suit atmosphere where it is expelled through the PGA ventilation system. The system has a capacity of approximately 1000 cc of solids.

2.3.5.2 Urine Collection and Transfer Assembly

The UCTA (fig. 2-23) collects and provides intermediate storage of liquid waste during launch, EVA, or emergency modes when the spacecraft waste management system cannot be used. The UCTA will accept fluids at rates to 30 cc/sec with a maximum stored volume of 950 cc. No manual adjustment or operation by the crewman is required for operation of the UCTA. A flapper check valve prevents reverse flow from the collection bag. When feasible, the stored urine can be transferred

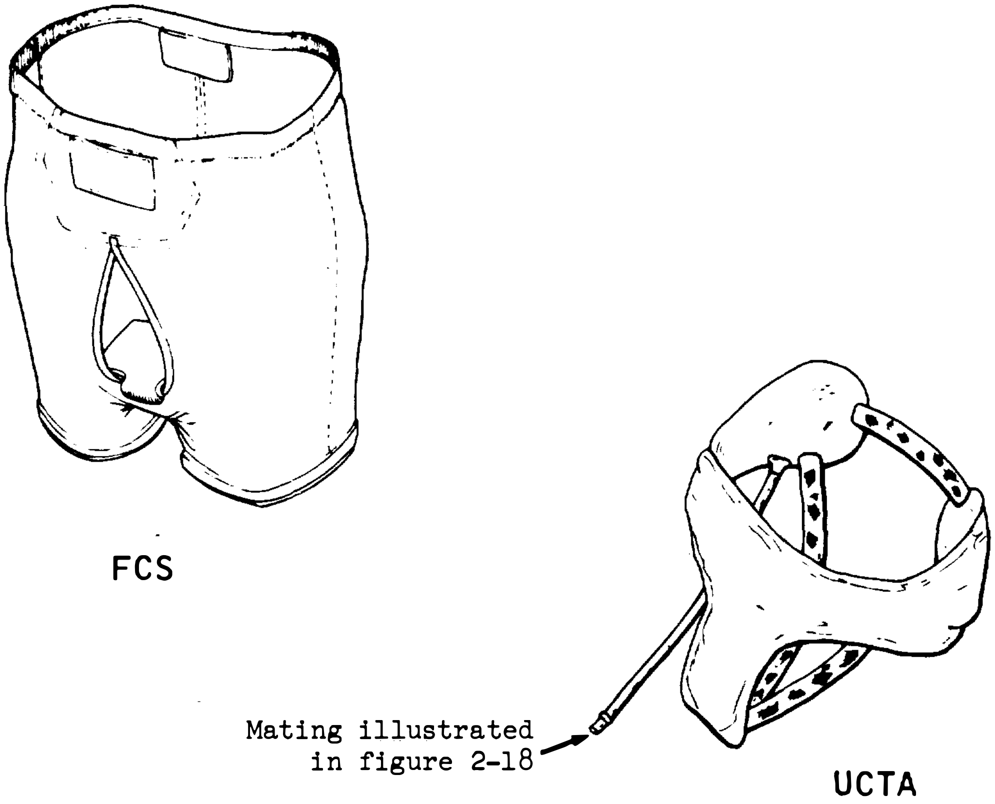


Figure 2-23.- Fecal containment subsystem and urine collection and transfer assembly.

through the suit wall by hose to the CM or LM during pressurized or depressurized cabin operation.

The UCTA is worn over or under the CWG or the LCG and is connected by hose to the urine transfer connector on the PGA. The urine transfer connector is a quick-disconnect fitting used to transfer urine from the UCTA to the spacecraft waste management system. A UCTA transfer adapter is provided on board the CM for use by the crewman to dump the liquid waste after the PGA has been doffed.

2.3.5.3 Constant Wear Garment

The CWG (fig. 2-24) is a one-piece cotton undergarment which is worn next to the skin and encompasses the entire body exclusive of the head and hands. It is worn during IV CM operations for general comfort, to absorb perspiration, and to hold the biomedical instrumentation system. It absorbs excessive body moisture and prevents the crewman's skin from becoming chafed by the pressure garment. The CWG is donned and doffed through the front opening which is kept closed by five buttons. The feet are covered by socks sewn to the legs of the CWG.

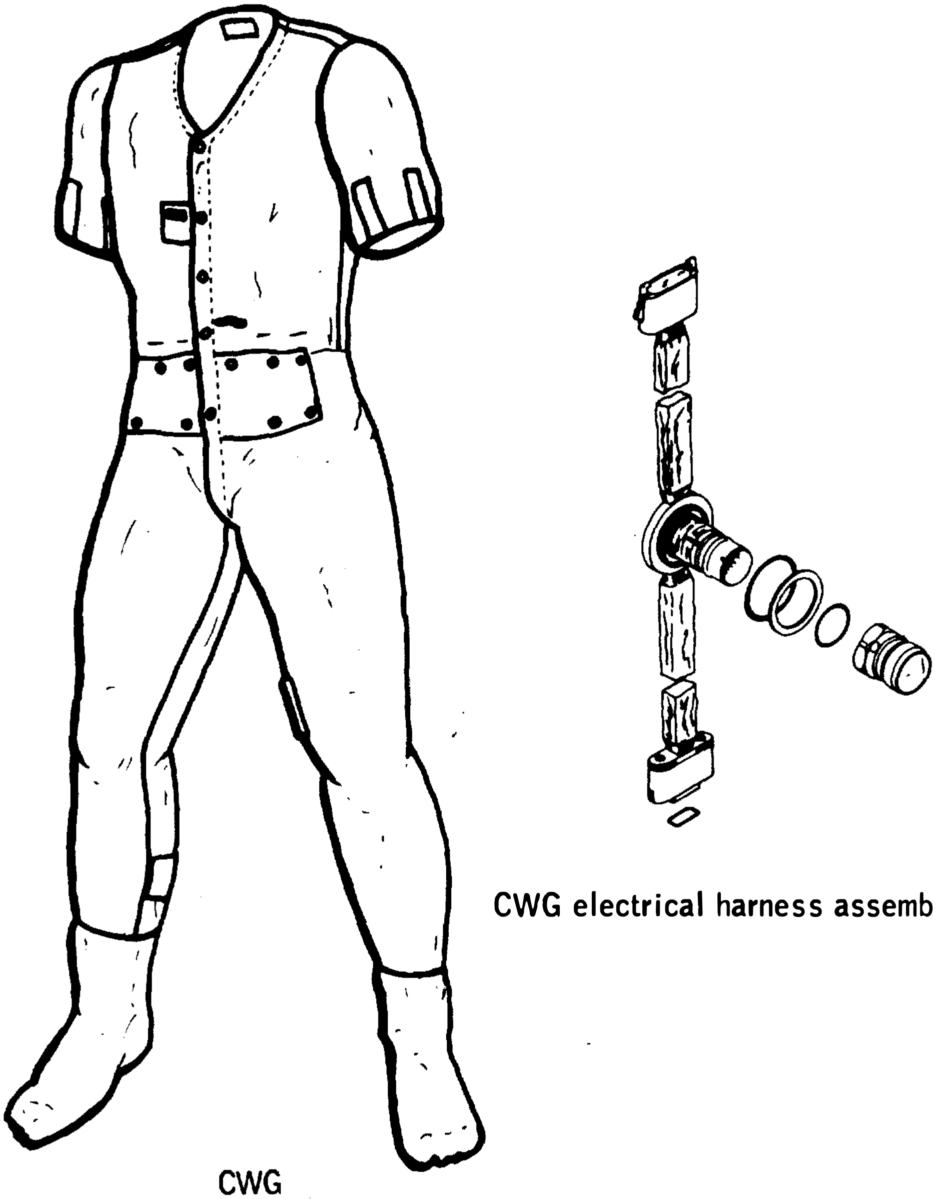
Waste management is accommodated without removing the CWG by a fly opening in the front and a buttock port in the rear. Snap fasteners attach the biomedical instrumentation belt.

Although the CWG may be worn under either the CMP or EV pressure garments, it is normally used during IV phases of the mission or during EVA work from the CM.

2.3.5.4 CWG Electrical Harness

The CWG electrical harness (fig. 2-24) is used with the CWG or inflight coverall garment and provides a mechanical and electrical interface with the communications carrier, biomedical harness assembly, and the spacecraft communications umbilical. It replaces the suit electrical harness when the PGA is doffed and the CWG is worn.

The CWG electrical harness consists of a central 61-pin connector from which two branches extend. One branch conducts communications signals while the second, shorter branch connects to the biomedical harness. The communications branch includes a 21-pin connector which interfaces with the communications carrier or lightweight headset. The biomedical instrumentation branch has a 9-pin connector which interfaces



CWG electrical harness assembly

CWG

Figure 2-24.- Constant wear garment and electrical harness.

with the biomedical harness. The 61-pin connector protrudes through the inflight coverall garment at the upper chest area to engage with the electrical umbilical. An aluminum washer spacer positions the 61-pin connector housing and ensures proper depth of engagement when the ball-lock mechanism of the electrical umbilical is interfaced with the 61-pin connector. Each branch of the harness is covered with a Teflon fabric sheath, and the branches are secured in place by two snap tabs on the front of the CWG. White reflective tape attached to the shell of the 61-pin connector helps aline the spacecraft umbilical connector with the 61-pin connector.

2.3.5.5 Liquid Cooling Garment

The liquid cooling garment (fig. 2-25) cools the body by circulating water at a controlled temperature through a network of tubing. The LCG is worn next to the skin. When it is interfaced with the liquid cooling system of the PLSS or LM, it is the primary means by which the crewman is cooled. The garment covers the torso, legs, and arms and is donned through the slide fastener opening in the front of the torso. An additional slide fastener opening in the rear accommodates waste management needs.

The LCG consists of an outer layer of nylon spandex material, a multiple connector for water inlet and outlet connections, inlet and outlet manifolds, a network of polyvinylchloride distribution tubing, and an inner nylon chiffon comfort liner. The network of tubing is distributed evenly over the body, excluding stress points such as the elbow and knee, and is stitched to the nylon spandex outer restraint garment at approximately 1-inch intervals. Even spacing of the tubing network and parallel flow paths permit the efficient transfer of body heat to the cooling liquid as it circulates through the network. The dual-passage (inlet and outlet) water connector is attached to the tubing network and interfaces with the PLSS water and LM environmental control system (ECS) umbilicals. The water is warmed by heat transferred from the crewman's body. The warmed water returns to the PLSS through the outlet channel of the multiple water connector.

The nylon chiffon liner separates the tubing network from the body and also contributes to body comfort by absorbing and evaporating perspiration into the PLSS or ECS oxygen systems. Comfort pads are installed at strategic points on the LCG. Custom-sized socks are physically attached to the LCG; however, the socks do not incorporate cooling tubes. There are eight snap fasteners located in the abdominal area of the

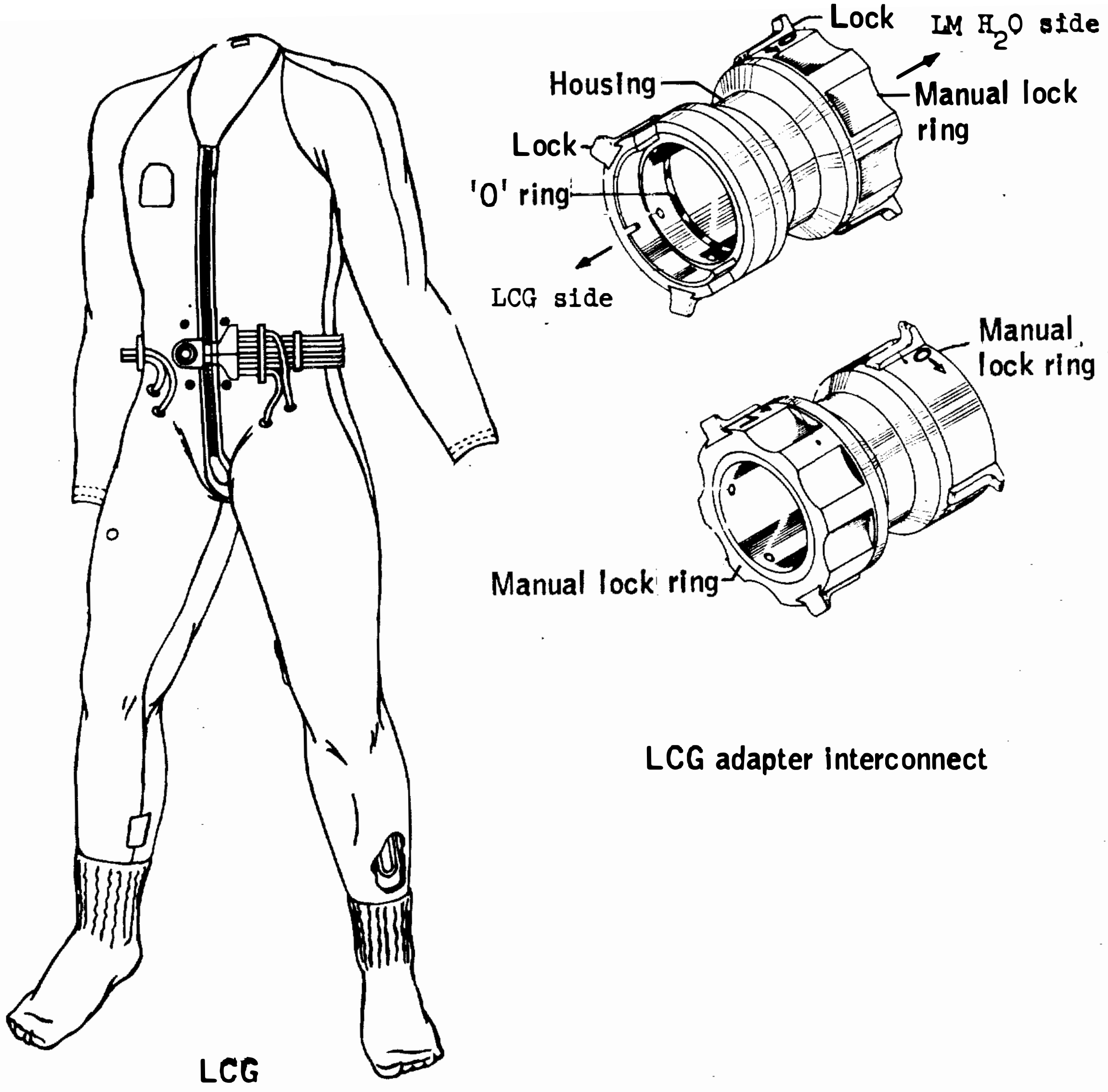


Figure 2-25.- Liquid cooling garment and LCG adapter interconnect.

garment to secure the biomedical belt. Three passive dosimeter pockets are placed at strategic points about the garment.

Table 2-IX lists the main characteristics of the LCG and the multiple water connector.

TABLE 2-IX.- PERFORMANCE CHARACTERISTICS OF THE LIQUID COOLING GARMENT AND MULTIPLE WATER CONNECTOR

Item	Value
Liquid cooling garment	
Weight (charged)	7.00 lb[a]
Operating pressure	4.20 to 23.0 psid
Structural pressure	31.50 ± 0.50 psid
Proof pressure	31.50 ± 0.50 psid
Burst pressure	47.50 psid
Pressure drop (4.0 lb/min at 70° ± 10° F inlet)	3.35 psi[b]
Leak rate for 19.0 psid at 45° F	0.58 cc/hr
Multiple water connector	
Pressure drop (4.0 lb/min at 70° ± 10° F, both halves, both directions)	1.45 psi

[a] Design value.

[b] Includes both halves of connector.

2.3.5.6 LCG Adapter Interconnect

The LCG connector adapter interconnect (fig. 2-25) is a dual-ball lock adapter which permits an interface between the LCG and LM liquid cooling systems when the PGA is removed. The assembly employs manual locking and unlocking mechanisms for engaging and disengaging both liquid cooling system connectors. The inflight coverall garment is normally worn over the LCG during IV activity, supports the LCG LM umbilical, and precludes kinks and water restrictions in the tubing.

2.3.5.7 Insuit Drinking Device (ISDD)

The insuit drinking device (fig. 2-26) provides approximately 32 ounces of potable water within the PGA during lunar surface extravehicular activities. The ISDD consists of a flexible film bag with an inlet valve for filling and an outlet tube and tilt valve for drinking. The bag is attached between the PGA bladder and liner at the neck ring by means of hook and pile Velcro. The bag is filled with potable water from the spacecraft water system by means of the water dispenser/fire extinguisher.

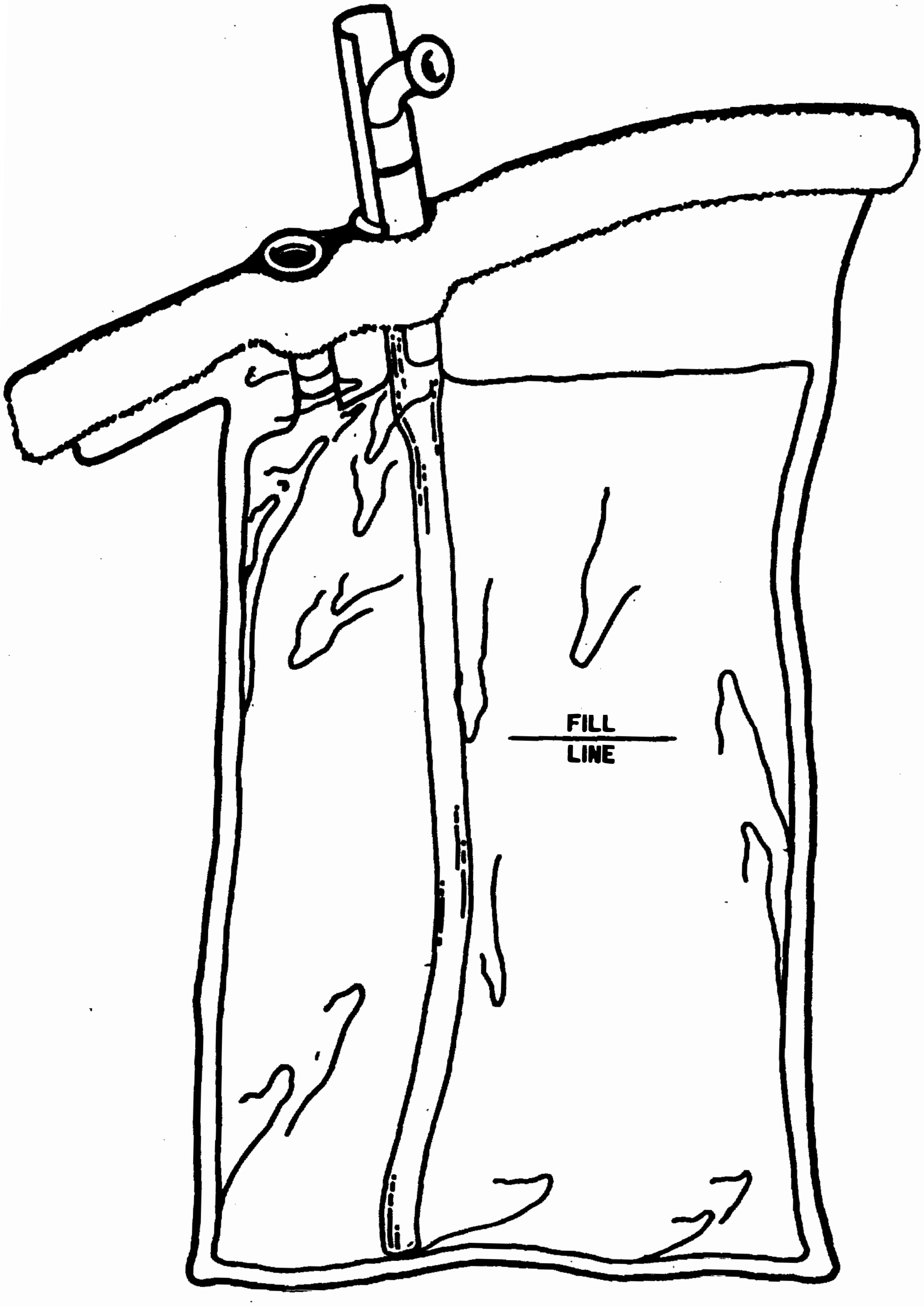


Figure 2-26.- Insuit drinking device.

2.3.5.8 Communications Carrier

The communications carrier (fig. 2-27) provides microphones and earphones in a soft-suspension skull cap. Acoustic isolation between earphone and microphone is achieved when the carrier is properly fitted to the wearer. The connection may be made directly to the spacecraft communications system or through the PGA internal communication harness. The wiring from the earphones and microphones is connected by a flat pigtail to a 21-pin connector in the electrical harness assembly. The electrical umbilicals, in turn, connect the communications system to the PLSS or spacecraft.

2.3.5.9 Lunar Extravehicular Visor Assembly

The LEVA (fig. 2-28) is a light and heat attenuating assembly which fits over the clamps around the base of the PHA. It provides additional protection from micrometeoroids and accidental damage to the PHA. The LEVA consists of the following subassemblies.

a. Shell assembly
b. Shell cover assembly
c. Protective visor
d. Sun visor
e. Hub assemblies (2)
f. Latching mechanism
g. Side eyeshade assemblies (2)
h. Center eyeshade assembly

An elastomer light seal located on the protective visor stiffener prevents direct light leakage between the protective visor and the sun visor. The protective visor, when lowered to the full-DOWN position, extends over a light and thermal seal arrangement at the frontal area of the shell cover assembly. The position of the visors within the shell assembly and about the light seal is adjustable. The radial position of visor support cams determines the position of the visors with respect to the shell assembly. The shell cover assembly is attached over the polycarbonate shell and extends below the helmet attaching hardware to provide thermal and micrometeoroid protection for the LEVA/ITMG or LEVA/CLA interface area. When secured in place over the PHA, and with both visors lowered, adequate protection is provided for the thermal and light conditions anticipated on the lunar surface. The eyeshades can also be lowered to reduce low-angle solar glare. When facing toward the sun, the center eyeshade assembly may be lowered and the viewport door adjusted to provide additional solar glare protection.

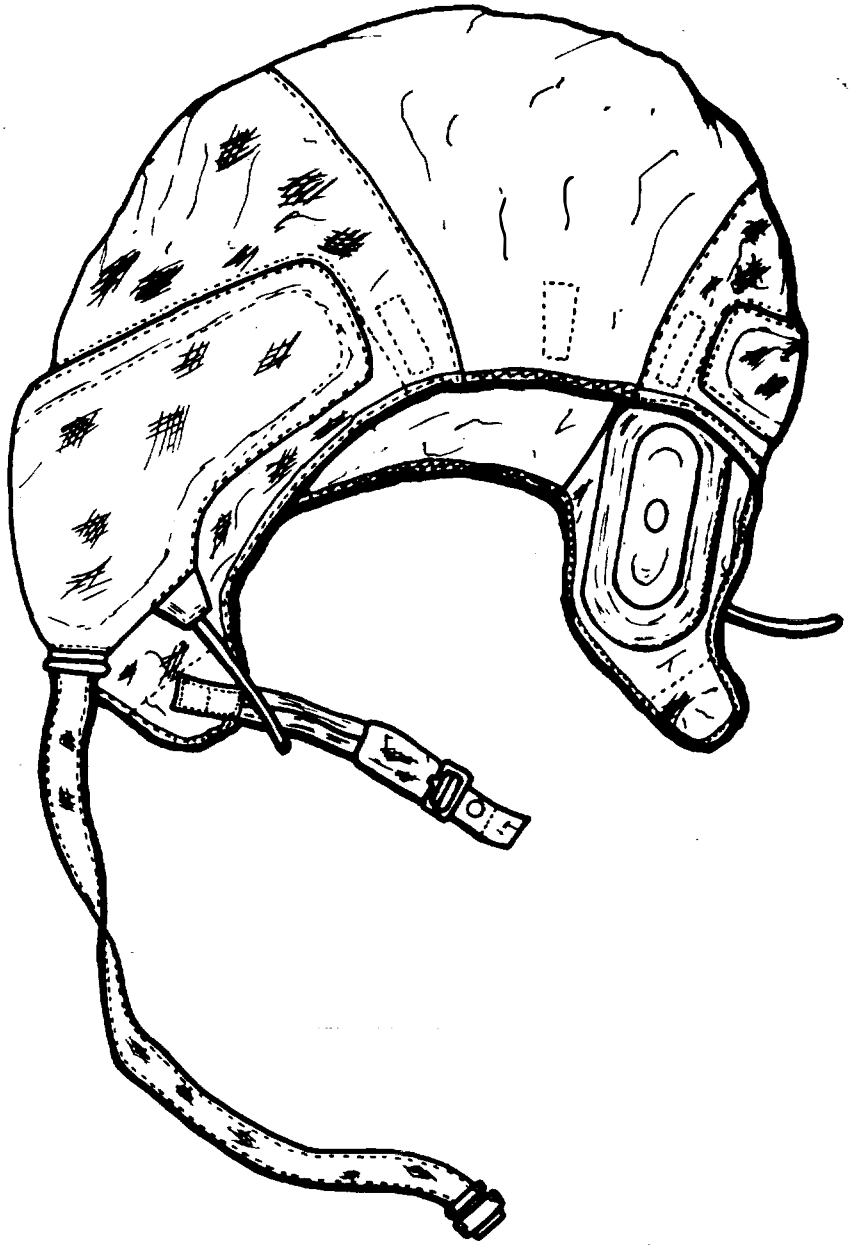


Figure 2-27.- Communications carrier.

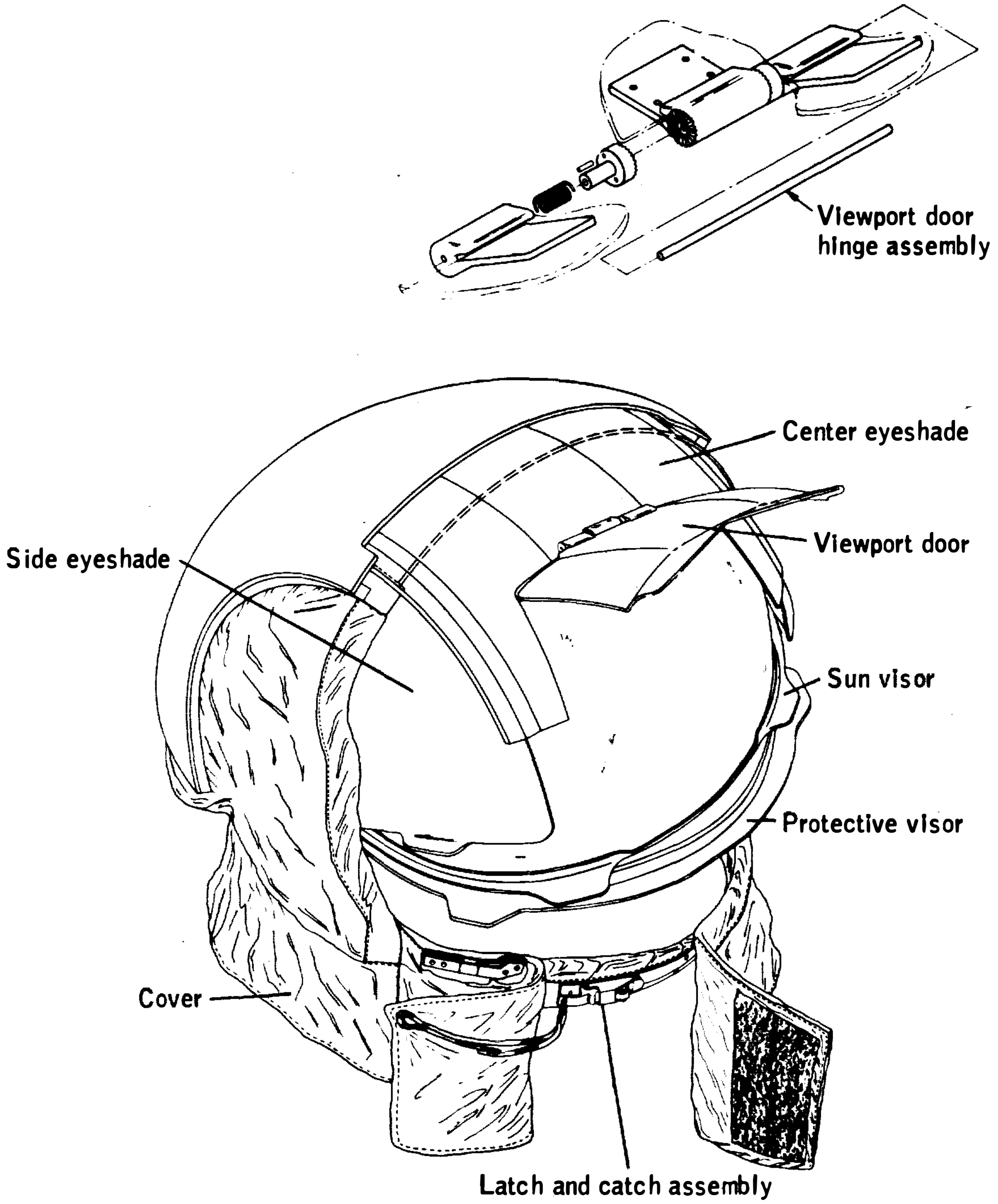
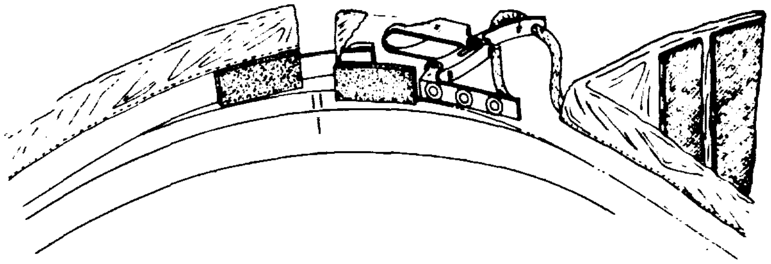
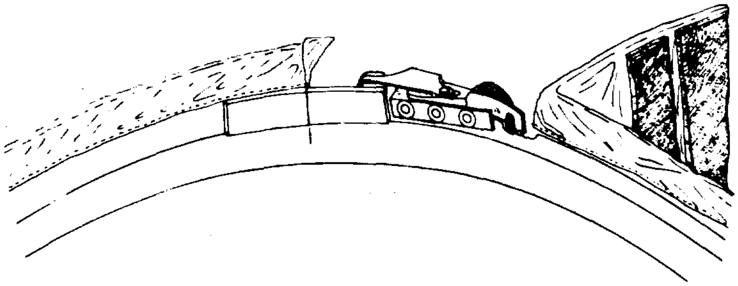


Figure 2-28.- Lunar extravehicular visor assembly.



LEVA to neck ring before latching



LEVA to neck ring after latching

Figure 2-28.- Concluded.

The shell assembly is a formed polycarbonate structure to which the visors, hinge assemblies, eyeshades, latch, and shell cover assembly are attached. The shell assembly latches around the pressure helmet at the neck ring, and, when the latch is secured, a rigid connection between the two assemblies is assured. Adjacent to the visor hinge, straps constructed of polypropylene are employed across the cut-out support portions of the visor shell to permit flexual durability and to allow ease in spreading the visor during LEVA donning.

The shell cover assembly is constructed of seven layers of perforated, aluminized Mylar and six layers of nonwoven Dacron. The layers are arranged alternately to reduce interlayer heat transfer. The outer layer or covering is made of Teflon-coated Beta yarn for additional thermal and fire protection. Potential scuff areas on the forward edge are reinforced with Teflon fabric. Flameproof hook-and-pile fastener tape (Velcro) is used to attach the collar over the LEVA/ITMG or LEVA/CLA interface area.

The protective visor is an ultraviolet-stabilized polycarbonate shield which affords impact, micrometeoroid, and ultraviolet ray protection. It can be positioned anywhere between the full-UP and full-DOWN positions and requires a force of 2 to 4 pounds for movement. A coating is added to the inner surface of this assembly. The elastomer seal on the upper surface of the stiffener prevents light passage between the two visors. The protective visor can be lowered independently of the sun visor, but cannot be raised independently with the sun visor in the DOWN position.

The inner surface of the polysulfone sun visor has a gold coating which provides protection against light and reduces heat gain within the helmet. The visor can be positioned anywhere between the full-UP and full-DOWN positions by exerting a force of 2 to 4 pounds on the pull tabs. The sun visor cannot be independently lowered unless the protective visor is in the DOWN position, but it can be raised or lowered independently when the center eyeshade is in the full-UP position and the protective visor is in the DOWN position.

The hinge assemblies located on each side of the LEVA shell are support and pivot devices for the two visors and eyeshades. The hinge positions adjust for a proper fit of the visors to the shell and helmet assemblies and to aid in achieving a good light seal. Each hinge assembly is comprised of a bolt extending through a two-piece hub arrangement which supports dissimilar-material washers, the spacers, and a spring. Tension on the spring is adjustable and determines the force necessary for visor and side eyeshade movements. After adjustment, the hinge bolt is safe-tied with lock wire.

The latching mechanism is constructed of stainless steel and is used to secure the base of the LEVA shell around the PHA above the helmet neck ring. The over-center feature of the latch pulls the two sides of the front portion of the LEVA shell structure together and tightens it around the PHA. A lanyard attached to the actuating tab of the latch and the shell cover assembly permits easy actuation of the latch with a gloved hand. The lanyard is visible when the collar is held open.

The eyeshade assemblies are constructed of fiberglass and are coated with white epoxy paint on the outer surfaces. The inner surfaces are coated with black epoxy paint. The side eyeshades are attached to the hinge assemblies and can be lowered independently of the sun visor and each other to prevent light penetration of the side viewing areas, thereby reducing low-angle solar glare.

The center eyeshade (fig. 2-28) is attached to the LEVA shell assembly over the shell thermal cover and can be lowered independently of the side eyeshade assemblies. When sufficiently lowered, the viewport door may be positioned as required to reduce solar glare. The viewport door is held in the desired position by a ratchet mechanism integral with the hinge assembly. The center eyeshade assembly cannot be independently lowered unless the protective visor and the sun visor are in the down positions.

2.3.5.10 Dual-Position Purge Valve

The purge valve (fig. 2-29) interfaces with the lower right exhaust (red) gas connector of the PGA. During contingency modes of EMU operation, the purge valve is operated in conjunction with the oxygen purge system (OPS) to complete an open-loop gas pressurization and ventilation system. When activated, the breathable gas flows from the oxygen purge bottle, through the PGA, and through the open purge valve to the outside atmosphere. Within the PGA, carbon dioxide is purged from the oronasal area and passes from the helmet down through the PGA ventilation distribution system to the purge valve. One of two purge flow-rate selections is available to the astronaut. High flow permits a normal 8.1-lb/hr flow of gas through the PGA with a 4.0-psia differential suit pressure.

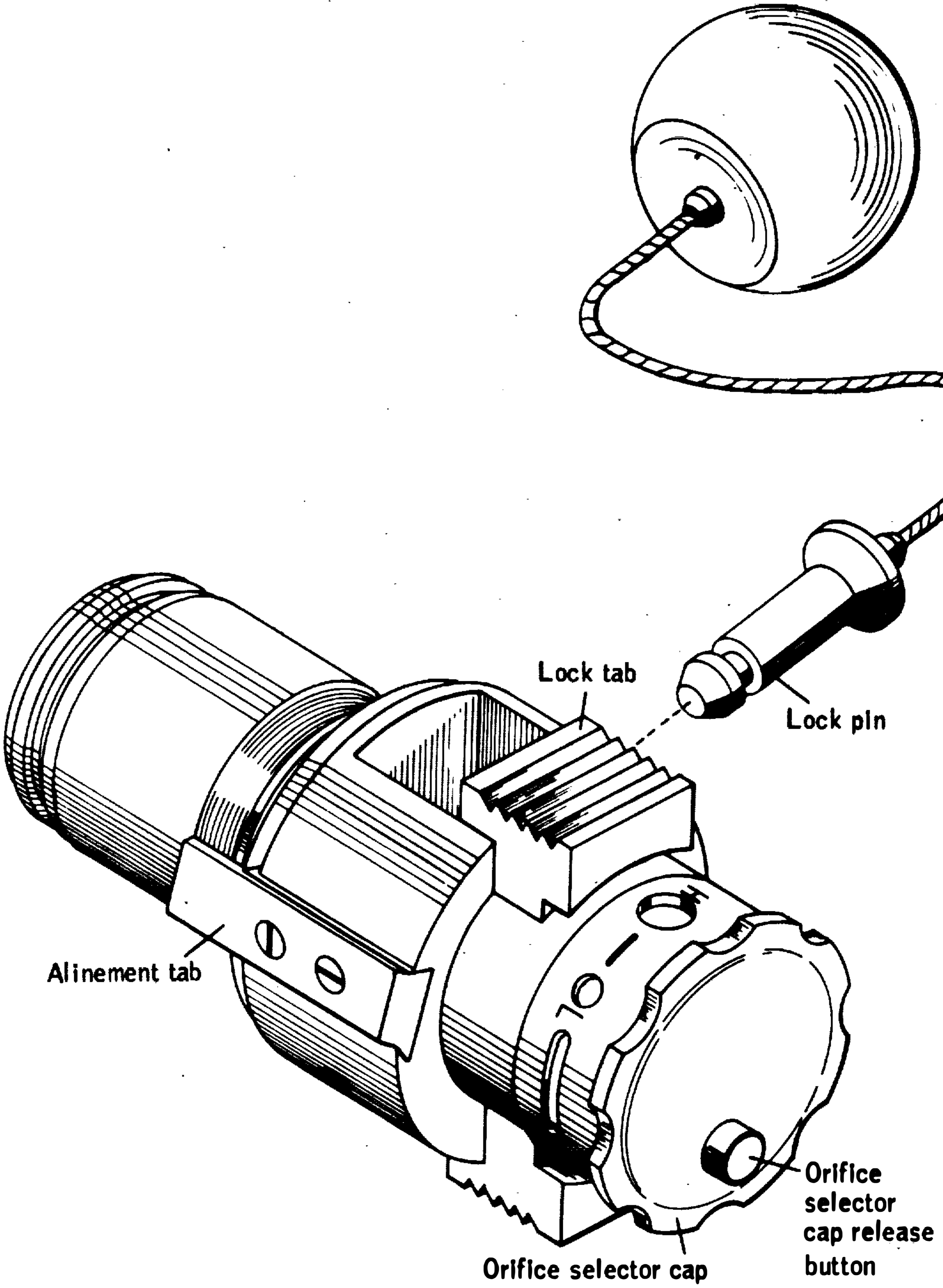


Figure 2-29.- Dual-position purge valve.

Low flow permits a normal 4.0-lb/hr flow. A lanyard unlocks the valve, and the valve is opened by depressing two lock tabs simultaneously. A rotating cap held by a release button provides the selection of low-flow-rate or high-flow-rate orifices.

2.3.5.11 Inflight Helmet Stowage Bag

The inflight helmet stowage bag (IHSB) (fig. 2-30) is used for temporary helmet stowage in the CM. It is constructed of a Teflon-coated Beta fabric and conforms to the helmet size.

2.3.5.12 LEVA Helmet Stowage Bag

The LEVA helmet stowage bag (fig. 2-31) consists of a formed polycarbonate base, shell assembly, and the necessary straps and components for attachment of the items to be stowed. The two-ply shell assembly and the polycarbonate base covering are made of Teflon-coated Beta cloth. Velcro strips are attached to the cover of the polycarbonate base to secure the LEVA stowage bag within the LM. The shell assembly is secured to the base assembly at the rear by two snaps and a tapered zipper closure (gusset) which draws the cover in snugly around the base. Additional security is provided around the bottom edge on each side of the gusset by Velcro strips. Polycabonate rings formed to the shape of the wrist disconnects are bonded to the polycarbonate base and provide stowage for the EV gloves. A polycarbonate retainer is also bonded to the base for stowage of the EMU maintenance kit. Straps with hook-and-pile fastener tape on the ends secure the EV gloves and EMU maintenance kit in position.

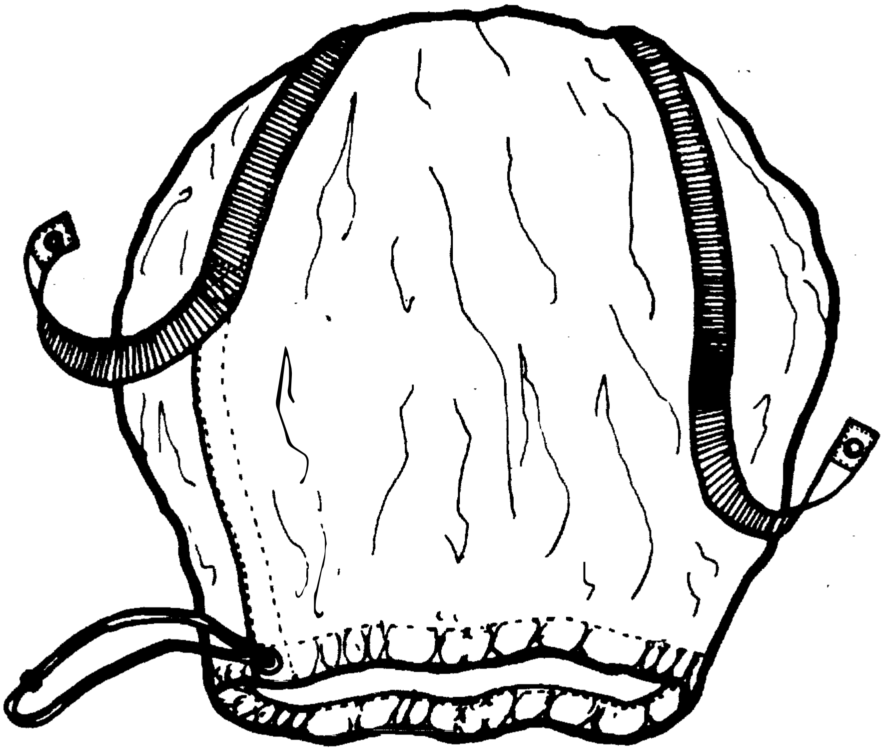


Figure 2-30.- Inflight helmet stowage bag.

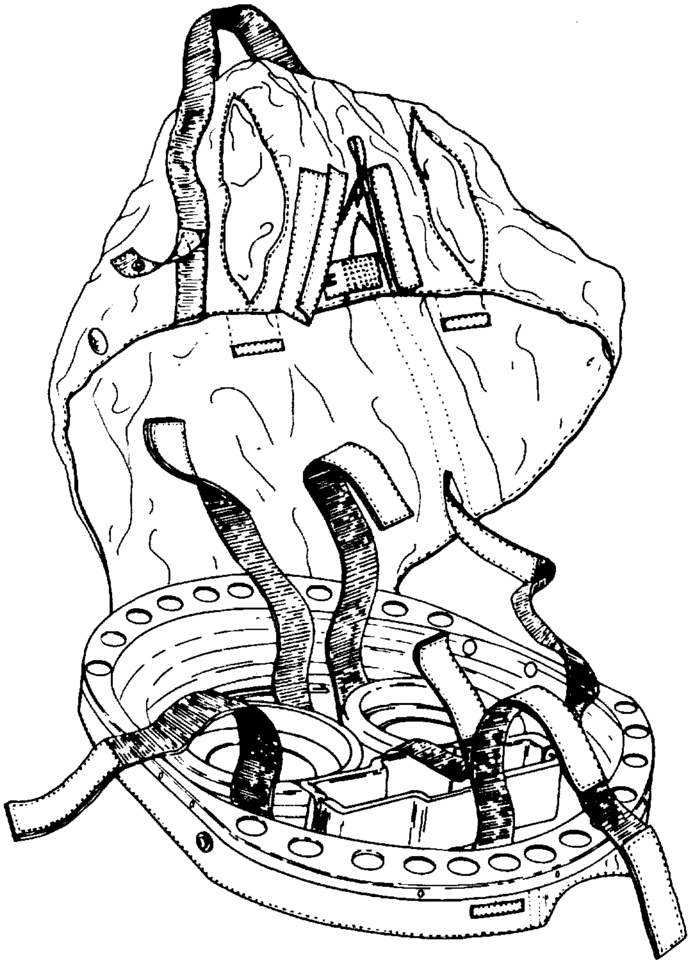


Figure 2-31.- LEVA helmet stowage bag.

2.3.5.13 EMU Maintenance Kit

The EMU maintenance kit (fig. 2-32) is a compact, lightweight assembly containing cleaning, replacement, and repair parts for inflight maintenance of the A7LB pressure garment assembly and the extravehicular visor assembly. The EMU maintenance kit consists of the following items each defined in subparagraphs:

a. Pocket assembly
b. Seal removal tool
c. Lubricant pouch assembly
d. Pouch assembly
e. Fabric repair patch
f. Fabric repair assembly

The pocket assembly, held closed by hook and pile fastener strips, folds out to reveal four underlying flaps. The six items are encased within the flaps.

The seal removal tool is a nylon rod with a preformed tip which facilitates the removal of the "O" ring seals. A lanyard with a pile fastener strip is attached to the tools. Temporary stowage is accomplished by engaging the pile strip with any hook strip.

The lubricant pouch assembly contains eight fluorinated, oil-saturated pads which are used to lubricate pressure sealing slide fasteners, seals, and "O" rings. The pads are held in place in the center pouch of the pocket assembly by whip-stitched Beta thread.

Two 5- by 5-inch sheets of Teflon-coated-yarn Beta cloth are rolled individually and placed in the pouch provided.

Two lengths of fiber-glass fabric tape (1 by 36 inches), wrapped individually to a nylon rod and a Beta-cord lanyard that connects a strip of fastener tape (hook) to the rod, comprise the fabric repair assembly. This assembly is stowed in a pocket provided in the EMU maintenance kit. The tape may be employed to complete small repairs to layers of the ITMG or CLA or used in conjunction with the Teflon-coated Beta cloth when repairs to abraded, cut, or torn areas of the ITMG or CLA are required.

The pouch assembly consists of six transparent, heat-sealed pouches. Each pouch is clearly labeled as to its contents. The entire pouch assembly is attached to the pocket assembly by snap fasteners.

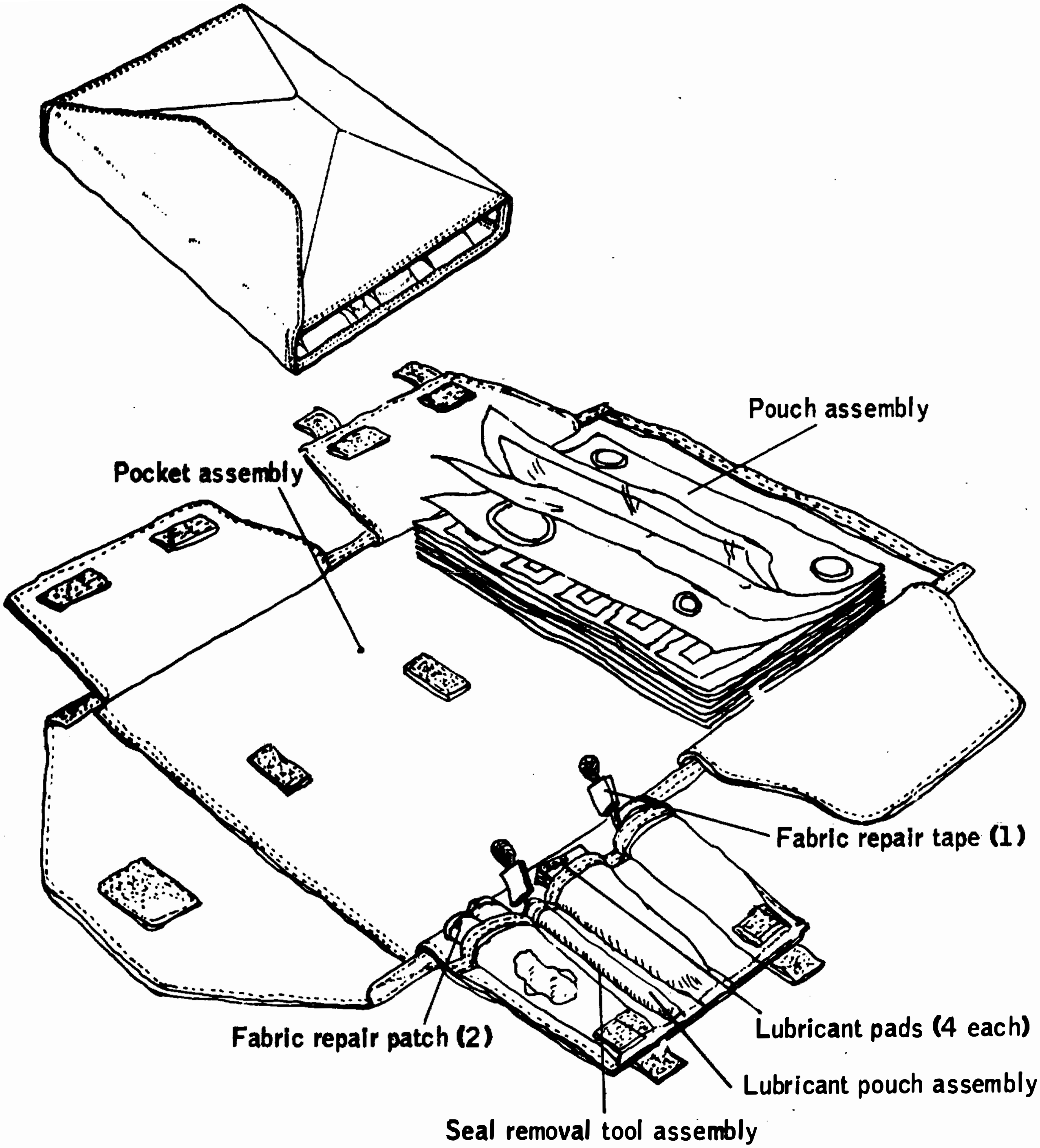


Figure 2-32.- EMU maintenance kit.

The first pouch contains three repair patches made of pressure-sensitive tape. The second pouch contains five pockets of sealant which are used in conjunction with the repair patches to seal accidental punctures in the primary bladder of the PCG. The third pouch contains a replacement seal for a large wrist disconnect. The fourth pouch contains three compartments, one for a spare PRV "O" ring, one for a spare feedport "O" ring, and one for a spare gas/water connector "O" ring. The fifth pouch contains three applicator pad pockets each of which contains two applicator pads. The sixth pouch contains instructions for use of the maintenance kit contents.

2.3.5.14 Helmet Shield

The helmet shield (fig. 2-5) is a transparent, slip-on, protective cover for the outer, exposed portions of the pressure helmet assembly. The shield is molded of clear polycarbonate material and conforms to the outer frontal area of the pressure helmet. A hole in the lower left facial area permits the feed-port cover to protrude through the shield. The helmet shield protects the pressure helmet from impact or abrasion damage during crewman transfer operations between the command and lunar modules.

2.4 INFLIGHT COVERALL GARMENT

The inflight coverall garment (fig. 2-33) is a three-piece suit consisting of a jacket, trousers, and boots. The garment is worn over the CWG during flight in the CM or LM when the PGA is not required. The inflight coverall garment is fabricated entirely from 100-percent woven Teflon fabric. The detachable pockets of the PGA can be used also on the coverall garment for stowage of various pieces of equipment. Restraint tabs hold the CM communications adapter cable in place. The LM configuration of the coverall garment includes provisions to pass the LCG adapter through the garment.

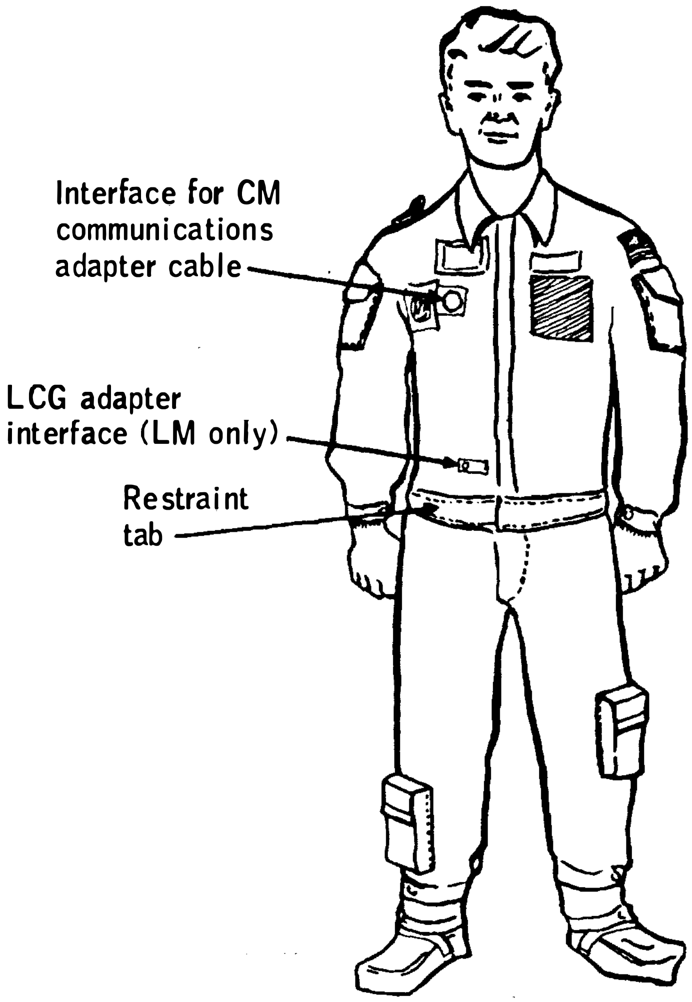


Figure 2-33.- Inflight coverall garment.

2.5 PORTABLE LIFE SUPPORT SYSTEM

The PLSS (fig. 2-34) provides life support for EV EMU activity, including expendables for metabolic consumption, communications, telemetry, operating controls, and displays. Although the -7 PLSS used for Apollo 15 and subsequent missions is similar to the -6 PLSS used on previous missions, the -7 PLSS has increased expendables capacity for longer duration missions (fig. 2-35). The PLSS supplies oxygen to the PGA and cooling water to the LCG. The PLSS also removes solid and gaseous contaminants and water vapor from returning oxygen and thus maintains a clean, dehumidified supply of oxygen. The PLSS is worn on the back of a suited astronaut in knapsack fashion and is attached to the PGA with harnesses.

The major subsystems of the PLSS are the oxygen ventilation circuit, the feedwater loop, the liquid-transport loop, the primary oxygen subsystem, the electrical power subsystem, the extravehicular communications system (EVCS), and the remote control unit (RCU). The subsystem controls are the main and auxiliary feedwater tank shutoff valves, the primary oxygen supply shutoff valve, the water diverter valve, the gas-separator actuation button, the fan and pump actuation switches, the communications volume control, the communications mode-selector switch, and the push-to-talk switch. Subsystem displays include the oxygen quantity indicator and warning flags and tones for low suit pressure, low feedwater pressure, high oxygen flow, and low vent flow. A system schematic of the -7 PLSS is shown in figure 2-36.

All PLSS components are mounted on the main feedwater reservoir and LiOH canister assembly. A hard cover fitted over the assembled unit supports the OPS mounting plate on top of the PLSS and the conformal pads. A thermal insulation jacket covers the PLSS, except for that portion which is exposed to the crewman's back. Hard-point mounting holes in the PLSS sides are used to stow the PLSS in the LM during flight and may be used to mount the buddy secondary life support system (BSLSS) during EVA.

2.5.1 Oxygen Ventilating Circuit

The oxygen ventilating circuit supplies fresh, cooled oxygen at 3.5 to 4.0 psia through the PGA. A fan motor assembly forces the oxygen into the PGA at a flow rate of 5.5 acfm with a minimum pressure rise of 1.5 inches of water. Suit

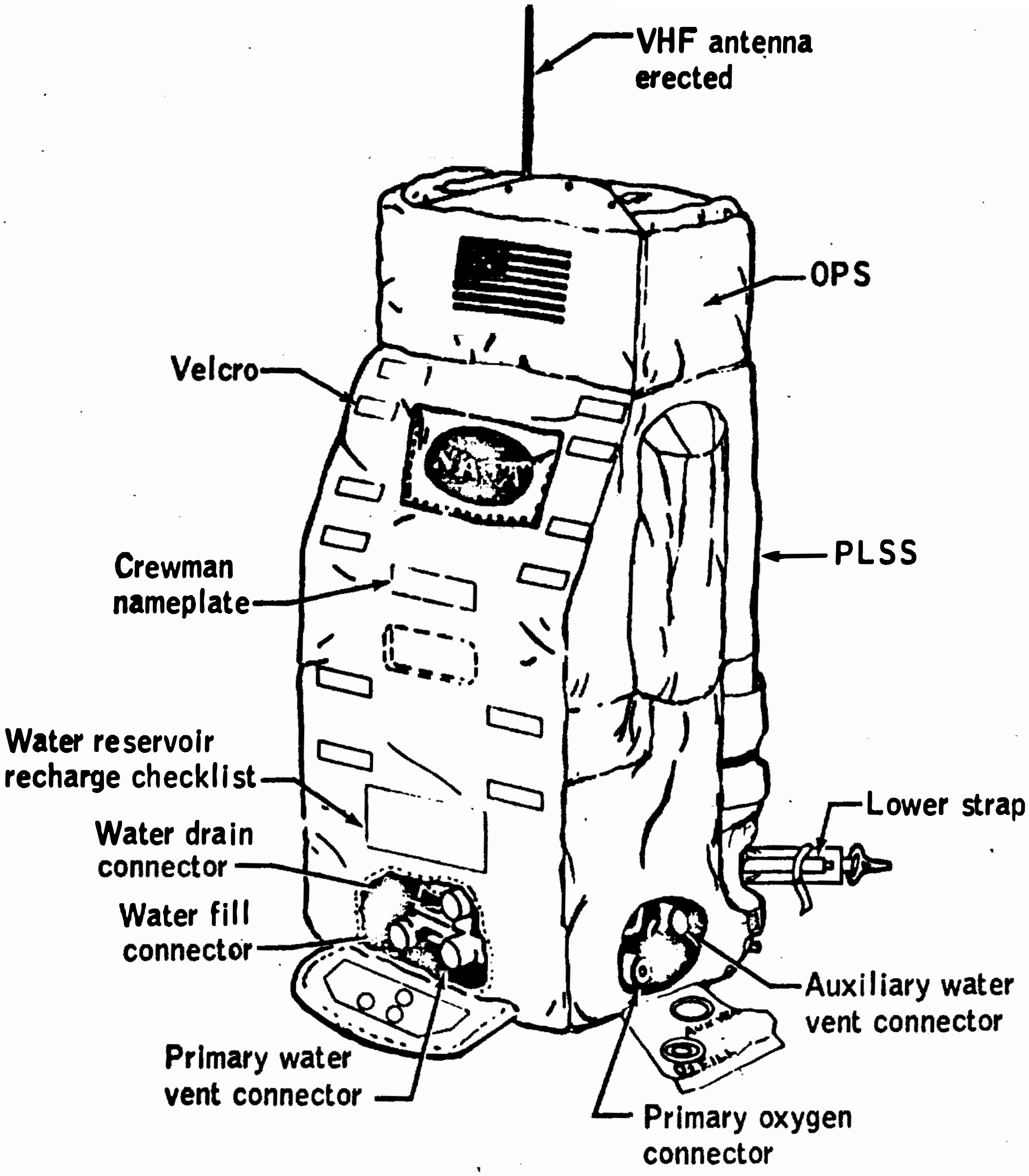
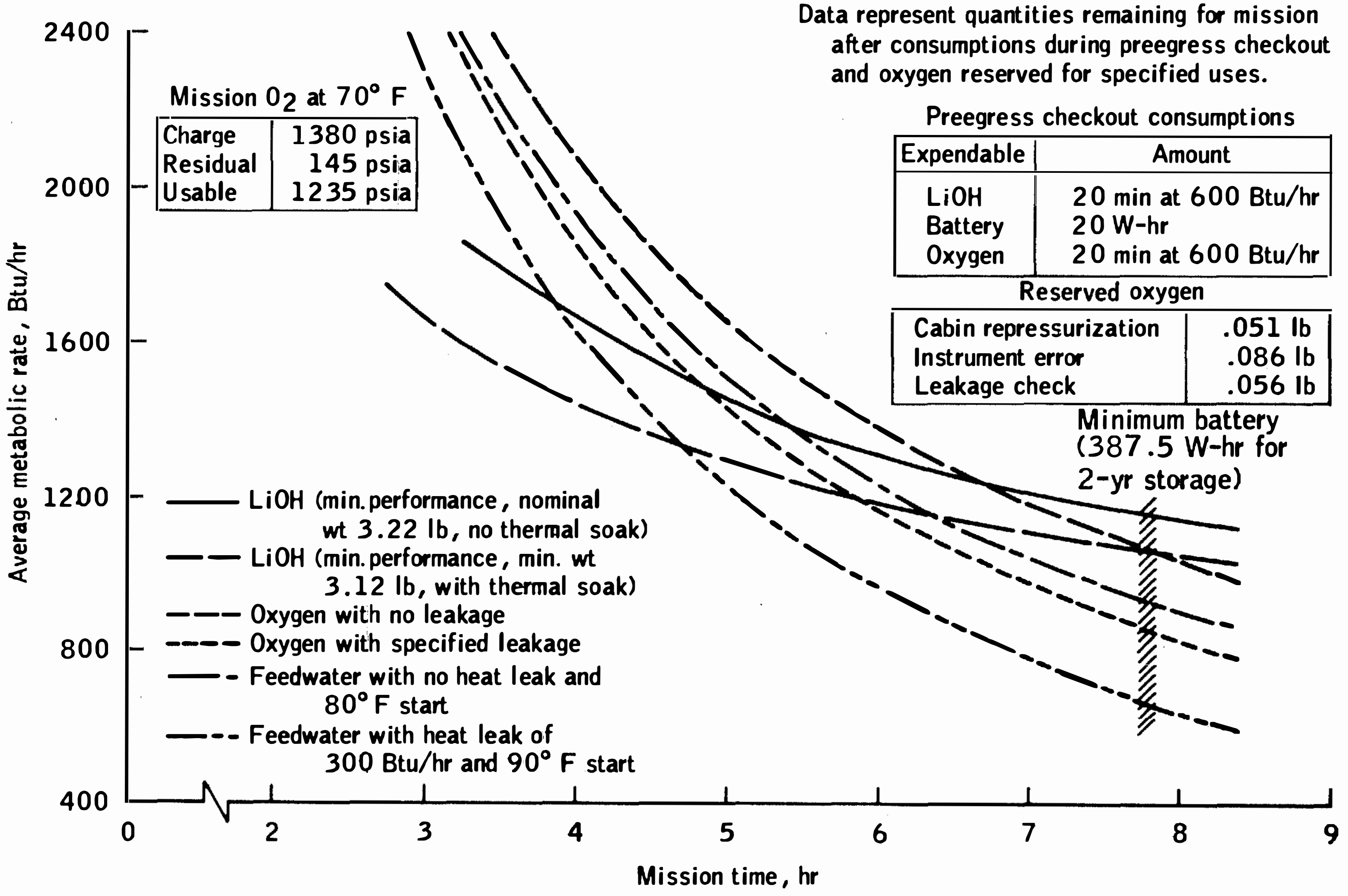


Figure 2-34.- Portable life support system.



Mission O_2 at 70° F

Charge	1380 psia
Residual	145 psia
Usable	1235 psia

Data represent quantities remaining for mission after consumptions during preegress checkout and oxygen reserved for specified uses.

Preegress checkout consumptions

Expendable	Amount
LiOH	20 min at 600 Btu/hr
Battery	20 W-hr
Oxygen	20 min at 600 Btu/hr

Reserved oxygen

Cabin repressurization	.051 lb
Instrument error	.086 lb
Leakage check	.056 lb

Figure 2-35.- Duration of -7 PLSS expendables.

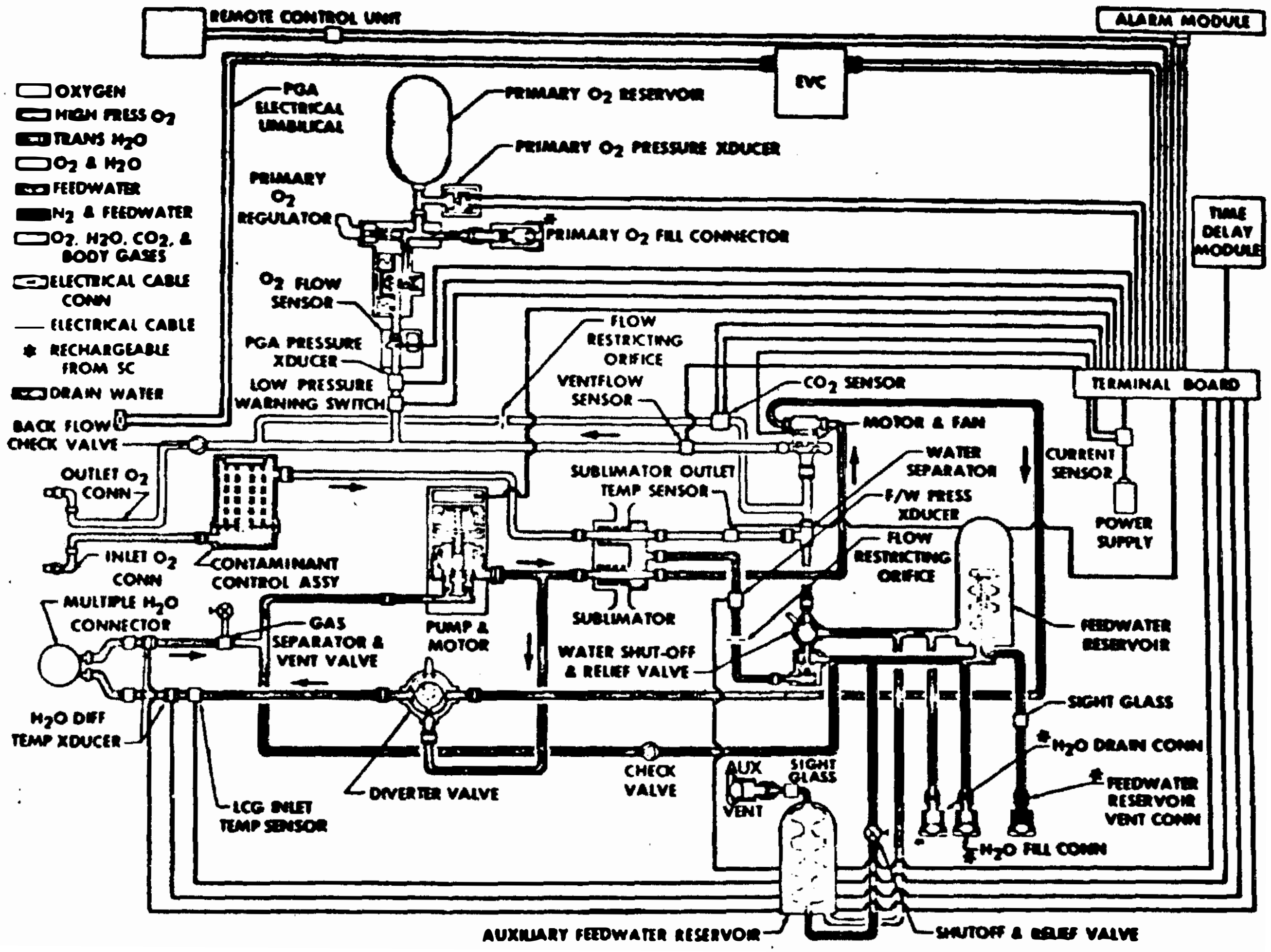


Figure 2-36.- System schematic of the -7 PLSS.

inlet dewpoint temperature is 50° F (or below), and suit inlet oxygen temperature is approximately 77° F (nominal). After passing through the suit vent system, the oxygen returns to the PLSS through the PLSS inlet connector.

In the PLSS, the oxygen passes through the contaminant control assembly where a bed of activated charcoal removes odors and a bed of lithium hydroxide granules removes carbon dioxide. A peripheral Orlon filter removes foreign particles.

From the contaminant control assembly, the oxygen passes through the sublimator. The sublimator cools the oxygen and condenses the water vapor. A sensor at the sublimator outlet measures sublimator outlet gas temperature for telemetry.

From the sublimator, the oxygen passes through a water separator which removes, at a maximum rate of 0.508 lb/hr, the condensate water entrapped in the oxygen flow. The condensate is ducted from the separator to the outer sections of the main and auxiliary feedwater tanks through the water shutoff and relief valve.

The oxygen from the separator returns to the inlet of the fan motor assembly. A carbon dioxide sensor shunted around the fan motor assembly samples the oxygen vent flow and monitors the carbon dioxide level for telemetry. Make-up oxygen from the primary oxygen subsystem enters the oxygen ventilating loop just downstream of the fan outlet. (The fan motor assembly operates at 18 600 ± 600 rpm with an input voltage of 16.8 ± 0.8 V dc.) Figure 2-37 is a schematic representation of the oxygen ventilating circuit.

2.5.2 Primary Oxygen Subsystem

The rechargeable, primary oxygen subsystem of the -7 PLSS is shown schematically in figure 2-38. The subsystem consists of a primary oxygen bottle, a fill connector, a pressure regulator, a shutoff valve, and connecting tubing. The primary oxygen bottle is a welded stainless-steel cylinder with cryogenically formed hemispherical ends. High-pressure, corrosion-resistant, stainless-steel tubes and fittings connect the primary oxygen bottle to the oxygen regulator assembly. The crewman actuates a shutoff valve to the primary oxygen regulator assembly by an operating lever located at the lower-right-front corner of the PLSS. When the PLSS is not in use or when the primary oxygen subsystem is being charged, the oxygen shutoff valve is closed.

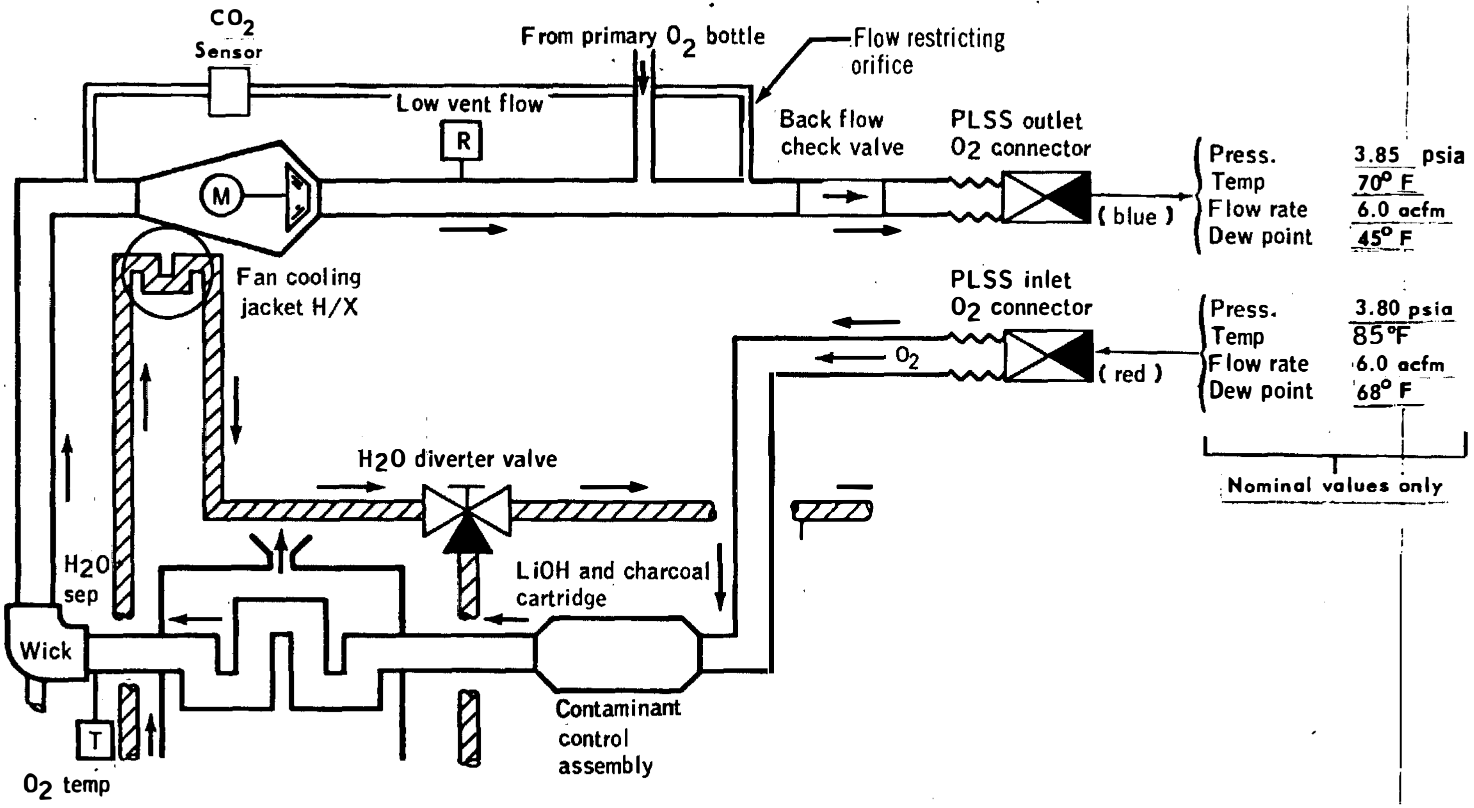


Figure 2-37.- Oxygen ventilating circuit.

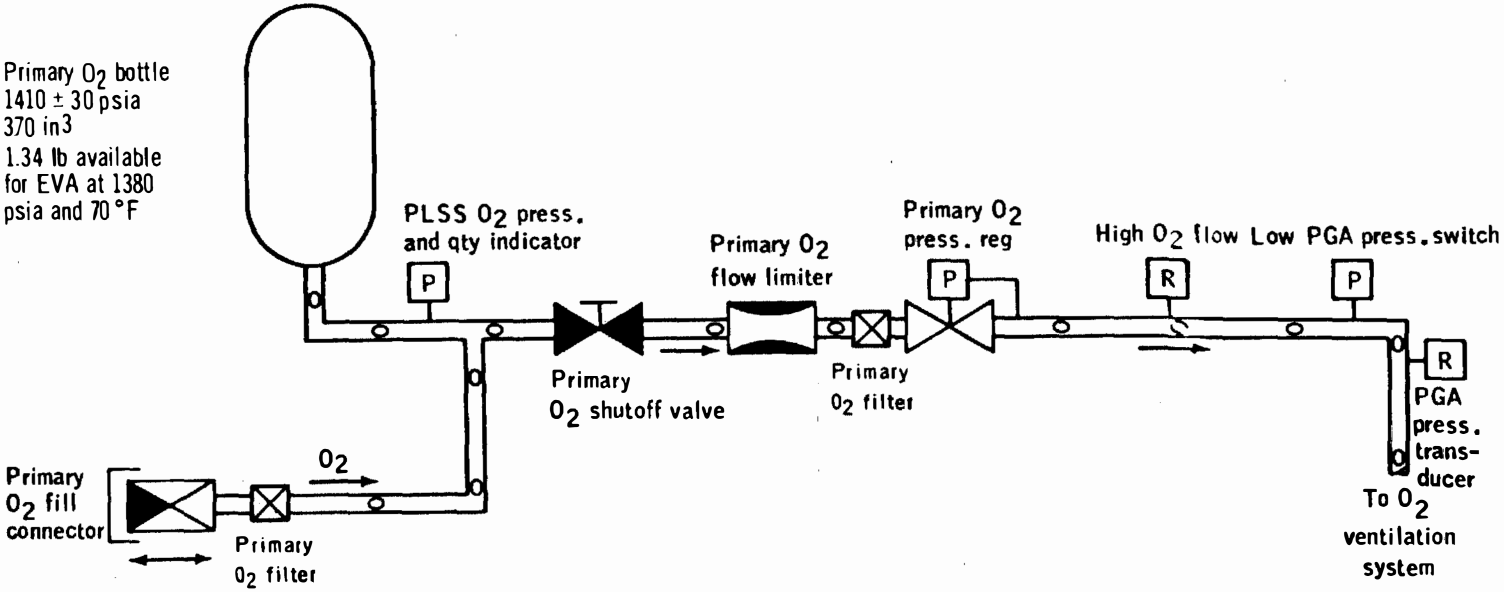


Figure 2-38.- Primary oxygen subsystem.

The initial ground charge and the LM recharge pressure for the first four recharges is 1410 ± 30 psia. Recharge pressure for the fifth recharge is 1310 psia minimum. The charging process (except for the fifth recharge) gives a minimum of 1.340 pounds of usable oxygen for EVA at 1380 psia and 70° F. This oxygen supply is ample for a 5-hour EVA at 1200-Btu/hr metabolic load plus 300 Btu/hr of EMU leakage.

Make-up oxygen flows from the primary oxygen bottle through the shutoff valve and regulator to the oxygen ventilating circuit. The regulator provides a pressure of 3.85 ± 0.15 psia to the vent circuit. An orifice limits the flow to a maximum of 4.0 pounds per hour at 70° F with a supply pressure of 1500 psia, thereby protecting the PGA from overpressurization if the regulator fails open. A primary oxygen pressure transducer at the oxygen bottle outlet provides electrical signals to the RCU oxygen quantity indicator and to the PLSS telemetry system. If oxygen flow exceeds 0.50 to 0.65 pound per hour, an oxygen flow sensor downstream of the regulator gives an audible tone until the flow decreases to 0.50 to 0.65 pound per hour (a continuous high flow of 0.50 to 0.65 pound per hour for 5 seconds is needed to cause actuation). Two additional pressure transducers in the primary oxygen subsystem are used to monitor PGA pressure. One is used for telemetry monitoring, and the other activates an audible warning tone when pressure drops below 3.10 to 3.40 psid. The primary oxygen subsystem is recharged through a leak-proof, self-sealing, quick-disconnect fill connector.

2.5.3 Liquid Transport Loop

The recirculating liquid transport loop provides thermal control for the crewman by dissipating heat through the sublimator. Warm transport water from the LCG enters the PLSS through the MWC. The water then passes through a gas separator which can entrain a minimum of 30 acc of gas. Should cooling performance degrade because of additional gas, the crewmen can vent the trap manually to ambient and ready it for further entrapment. From the separator, the transport water enters the pump which forces the water through the sublimator for cooling. The pump provides a minimum flow of 4.0 pounds per minute with a pressure rise of 1.9 psi across the inlet and outlet portions of the PLSS MWC. The cooled water from the sublimator passes through the fan motor cooling jacket and then through the diverter valve and out of the MWC.

The crewman regulates coolant flow with the diverter valve. In the minimum position, most of the flow is diverted past the sublimator. In the maximum position, all of the flow from the LCG passes through the sublimator. The intermediate position provides midrange cooling. The liquid transport loop is interconnected to the feedwater loop by a check valve which permits make-up water to enter the transport loop upstream of the pump.

A differential temperature transducer senses the differential temperature of LCG water entering and leaving the PLSS, and a temperature transducer senses LCG inlet temperature. Both transducers provide electrical signals for telemetry.

A schematic of the liquid transport loop is shown in figure 2-39.

2.5.4 Feedwater Loop

The feedwater loop is shown schematically in figure 2-40. This loop contains a primary feedwater reservoir and an auxiliary feedwater reservoir. The reservoirs supply water to the porous plate of the sublimator and collect condensation supplied by the water separator.

Each reservoir is a bladder-type rechargeable tank. Minimum capacities are 8.40 pounds of water for the primary reservoir and 3.06 pounds of water for the auxiliary reservoir. Feedwater from both reservoirs flows through a manually operated shutoff and relief valve. This valve, when in the off position, acts as a relief valve to prevent overpressurization of the feedwater reservoir. Feedwater then enters the porous plate of the sublimator. The feedwater forms an ice layer on the surface of the porous plate which is exposed to vacuum. Heat from the liquid transport loop and oxygen ventilating circuit is conducted to the porous plate and is dissipated by sublimation of the ice layer. A flow-limiting orifice between the shutoff and relief valve and the sublimator prevents excess water spillage from the sublimator porous plate during startup or during a possible sublimator breakthrough (a condition in which ice fails to form on the surface of the porous plate). A separate shutoff and relief valve isolates the auxiliary feedwater reservoir from the primary feedwater reservoir during normal operation. If the primary feedwater supply is depleted during EVA, the crewman can open the auxiliary reservoir shutoff and relief valve to provide additional

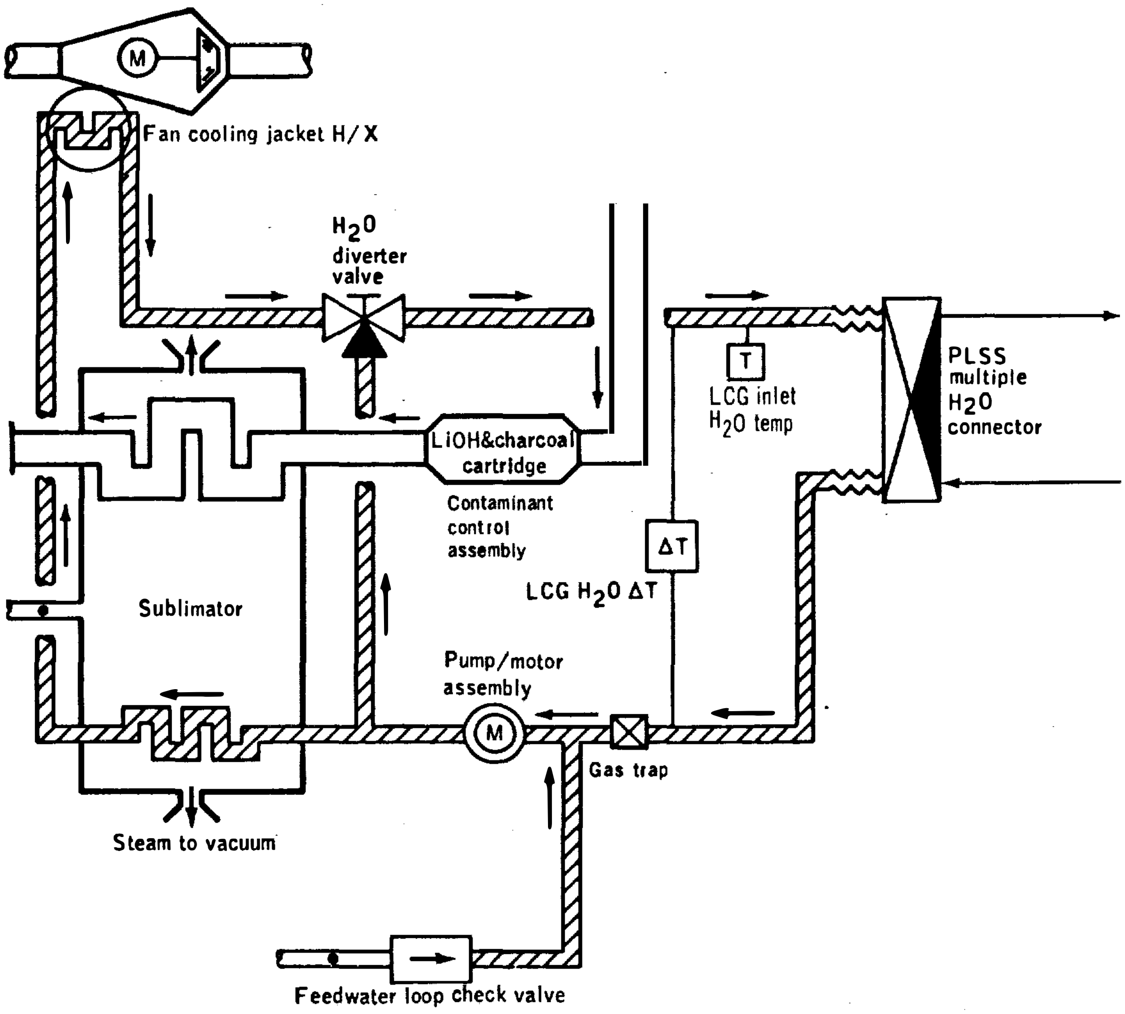


Figure 2-39.- Liquid transport loop.

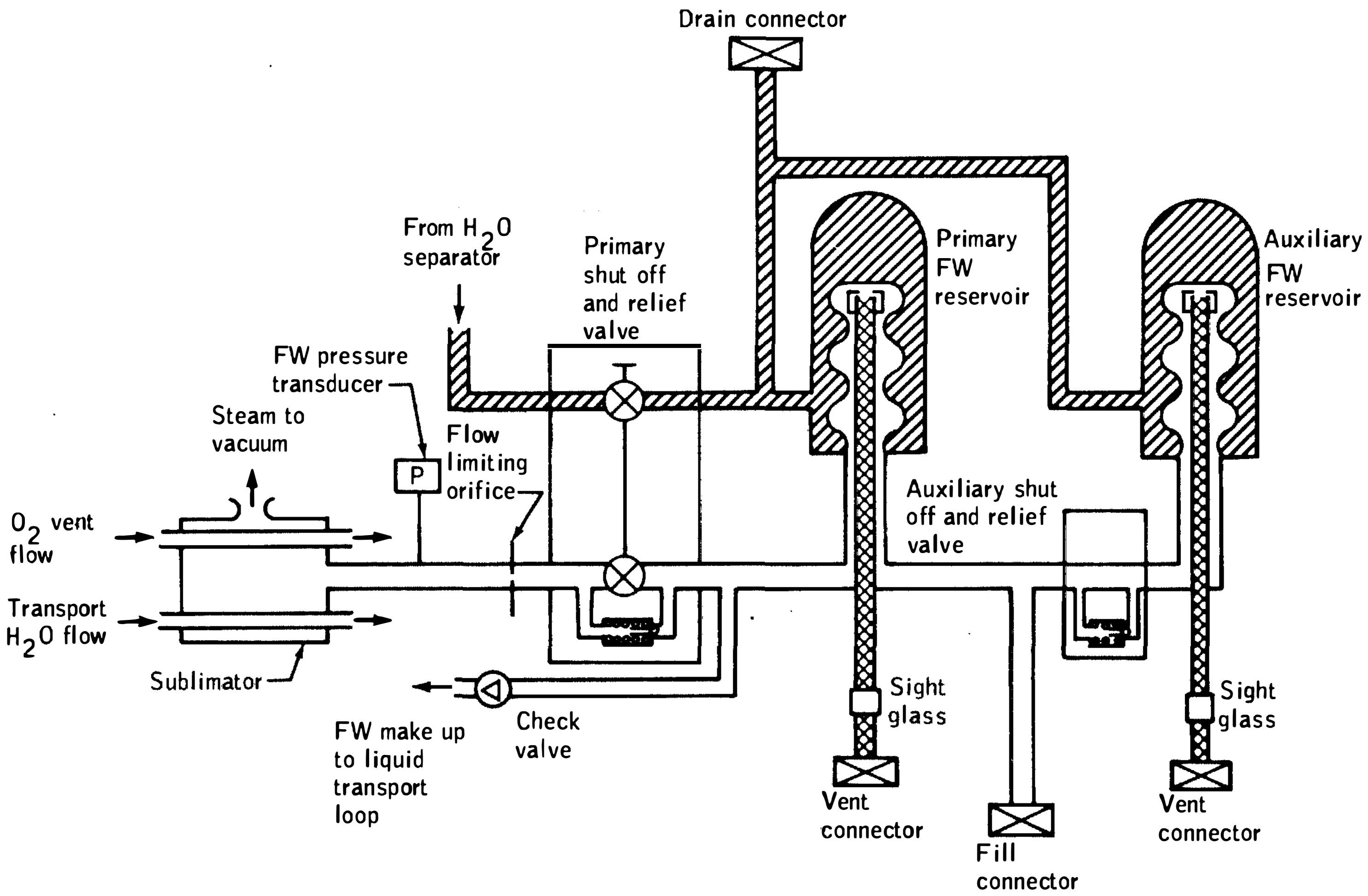


Figure 2-40.- PLSS feedwater loop.

cooling. Both the primary and auxiliary feedwater shutoff and relief valves are actuated by handles at the lower-right-front corner of the PLSS. The feedwater reservoirs also provide make-up water to the liquid transport loop via a check valve.

Oxygen ventilating loop pressure forces the condensate from the water separator into the space between the reservoir housings and the bladders of both feedwater reservoirs. This action causes a pressure of 3.3 psid on the feedwater bladder.

The feedwater reservoirs are recharged and drained through fill and drain connectors attached to both sides of the bladders. Recharge and drainage are performed simultaneously. Each bladder contains a vent line with a vent connector. During recharge, the vent connector is connected to a vacuum line to remove entrapped gas and assure a full charge.

A feedwater pressure transducer just upstream of the sublimator provides telemetry monitoring to identify sublimator breakthrough or feedwater depletion. The transducer also contains a switch which actuates an audible warning and the low feedwater pressure warning flag on the RCU if feedwater pressure drops to 1.2 to 1.7 psia.

2.5.5 Electrical Power Subsystem

The electrical power subsystem provides dc electrical power through appropriate connectors to the fan motor assembly, the pump motor assembly, and for communications and instrumentation. A 16.8 ± 0.8-V dc, 11-cell, silver-zinc alkaline battery supplies the power.

The minimum capacity of the -7 PLSS power supply is 387.5 watt-hours which is for a battery shelf life of 2 years.

The sliding pin locking device, shown in figure 2-41, holds the battery in place. Between extravehicular activities, a crewman can release this device to replace the battery.

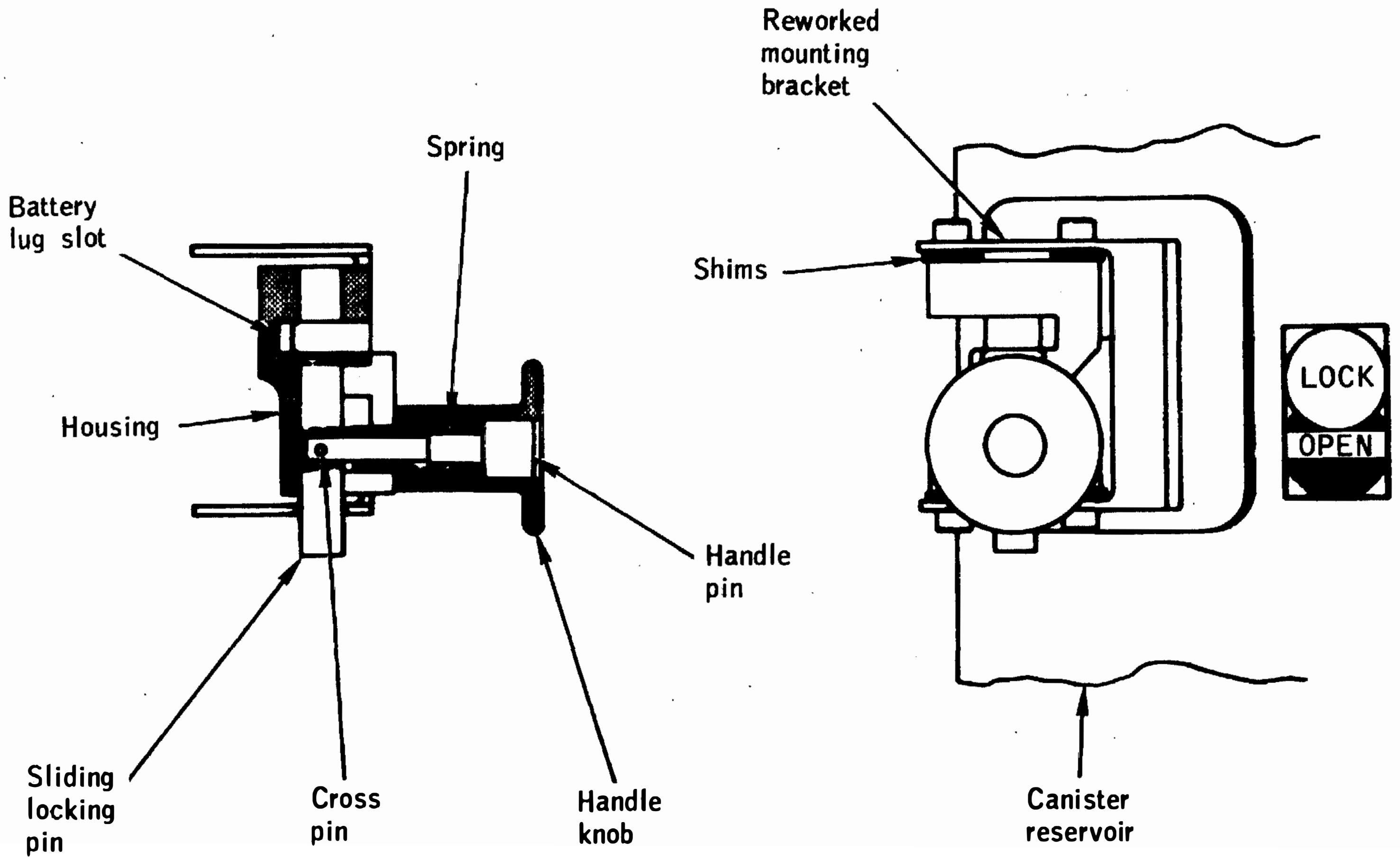


Figure 2-41.- Battery locking device.

Electrical power requirements are as follows.

	Maximum, watt	Nominal, watt
Pump	10.0	8.4
Fan	32.5	21.8
EVCS	12.8	10.9

Current limiters protect selected electric circuits against overcurrents which could cause fires. These limiters pass transient current in excess of a normal load but open at sustained overload. Table 2-X lists current limiter ratings. Transducers provide signals for telemetry of battery current and voltage.

2.5.6 Extravehicular Communications System

The EVCS (fig. 2-42) provides the following basic capabilities:

a. Simultaneous and continuous telemetry from two extravehicular crewmen

b. Duplex voice communications between earth and one or both of the two extravehicular crewmen

c. Uninterruptable voice communications between the crewmen

d. Thirty telemetry channels, 30 by 1-1/2 pam, per each extravehicular communicator (EVC) with 26 channels available for status information

e. Separate subcarrier frequencies for continuously monitoring each crewman's ECG during EVA

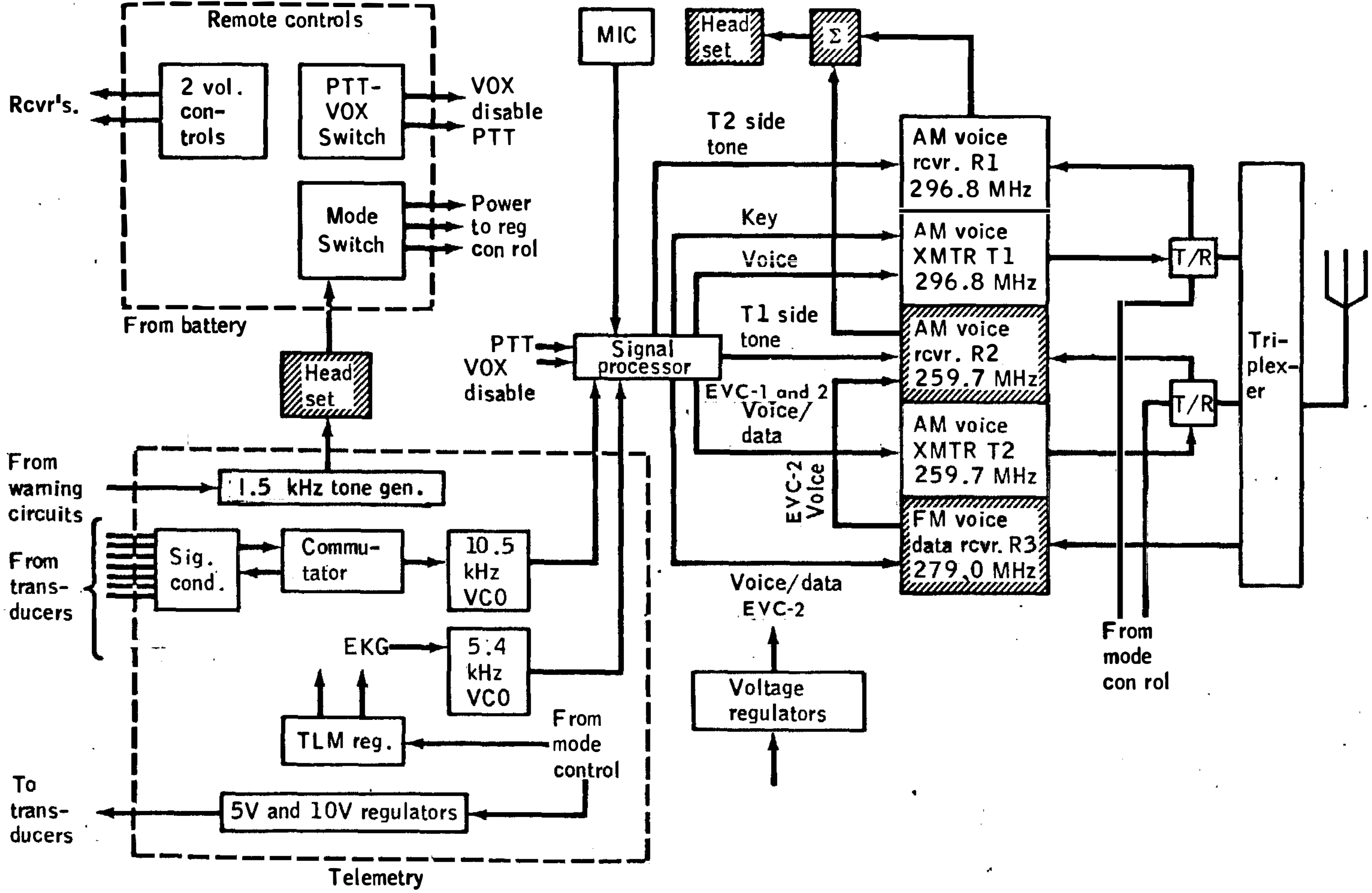
f. An audible alarm for 10 ± 2 seconds in the event of an unsafe condition (if the EVC mode-selector switch position is changed and the unsafe condition still exists, the warning tone will come on again for 10 ± 2 seconds.)

The EVCS consists of two extravehicular communicators (EVC-1 and EVC-2) which are an integral part of the PLSS. The EVC-1 consists of two amplitude modulation (AM) transmitters, two

TABLE 2-X.- PLSS/EVCS CURRENT LIMITER RATINGS

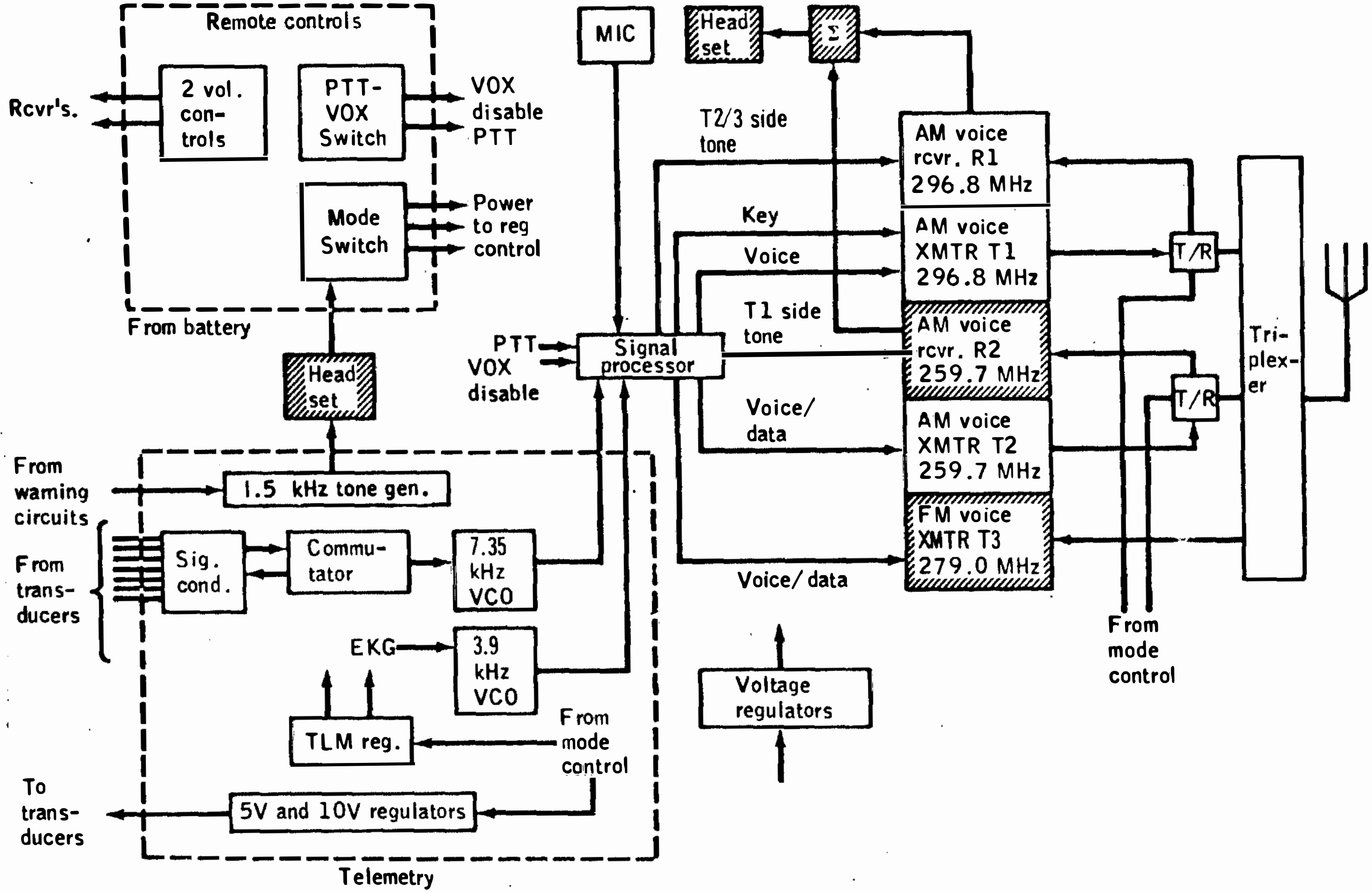
Component	Current ratings of -7 configuration, A
Fan	22-gage wire — current protection is not provided[a]
Pump	22-gage wire — current protection is not provided[a]
ECG	1/4 (with series 32.4- to 39.2-ohm, 1/2-watt resistor)
Left microphone	1/8 (with series 32.4- to 39.2-ohm, 1/2-watt resistor)
Right microphone	1/8 (with series 32.4- to 39.2-ohm, 1/2-watt resistor)
Vent flow sensor	1/16
Time delay module	1/16
High O_2 flow sensor	None (unit has built-in current limiter)
EVC (dual-primary mode voltage regulator)	2
EVC (secondary mode voltage regulator)	2
EVC telemetry	1
Alarm module	1/2
Voltage regulators	3/4
Time delay module (for high O_2 flow sensor)	1/16
EVC warning tone generator	1/16

[a] The maximum overload current of 22-gage copper wire is 40 amps.



(a) The EVC-1.

Figure 2-42.- Extravehicular communications system.



(b) The EVC-2.

Figure 2-42.- Concluded.

AM receivers, one frequency modulation (FM) receiver, signal-conditioning circuits, a telemetry system, a warning system, and other components required for system operation. The EVC-2 is similar to the EVC-1 except that the EVC-2 has an FM transmitter instead of an FM receiver.

Each EVC can be controlled manually by a four-position switch for each of the following modes of operation.

a. Off (O)
b. Dual (AR)
c. Primary (A)
d. Secondary (B)

The dual mode is the normal operating position of the switch. In this mode, the EVC-2 transmits a 0.3- to 2.3-kHz voice signal and two interrange instrument group (IRIG) subcarriers (3.9 and 7.35 kHz) via a 279-MHz FM transmitter. The transmitter has an unmodulated output in excess or 500 mW. The composite signal from the EVC-2 is received at EVC-1, mixed with an additional 0.3- to 2.3-kHz voice signal and two additional IRIG subcarriers (5.4 and 10.5 kHz), and transmitted to the LM on a 259.7-MHz AM link. The composite signal of two voice and four subcarriers is then relayed from the LM to the earth via S-band. The EVC-2 also receives EVC-1 output (which includes the original EVC-2 transmission) on a 259.7-MHz receiver; thus, a duplex link between the two EV crewmembers is established. Communications signals are transmitted from the earth to the LM via S-band and are then relayed to both astronauts on the 296.8-MHz AM link.

The outputs of the FM and AM receivers are summed with an attenuated input voice signal and applied to the earphones. The audio output levels of both receivers are individually controlled by separate volume controls located in the RCU affixed to the chest of the PGA. The input voice signal is attenuated 10 dB to provide a sidetone for voice level regulation.

The dual mode provides uninterruptable duplex voice communications between the crewmembers and the LM/earth linkup plus simultaneous telemetry from each crewmember via relay through EVC-1.

In the event of a malfunction in the dual mode, the system is backed up by the primary- and secondary-mode positions. (Note that both crewmen should never be in the primary or secondary modes simultaneously. Severe distortion and interference will occur, and communications will be temporarily lost.)

In the primary and secondary modes, duplex voice communication is maintained between the two crewmen and the LM. The secondary mode, however, has no telemetry capability. Also, the secondary-mode transmitter is inoperative unless activated by the voice-operated switch or the manual switch. The transmitter is continually operative in the dual and primary modes.

The telemetry unit contains a warbling 1.5-kHz warning tone. Any one of four problems (high oxygen flow, low vent flow, low PGA pressure, or low feedwater pressure) will key the tone and alert the astronaut to check the remote control unit for a visual indication of the problem area to be investigated. The operation of the warning system is independent of mode selection.

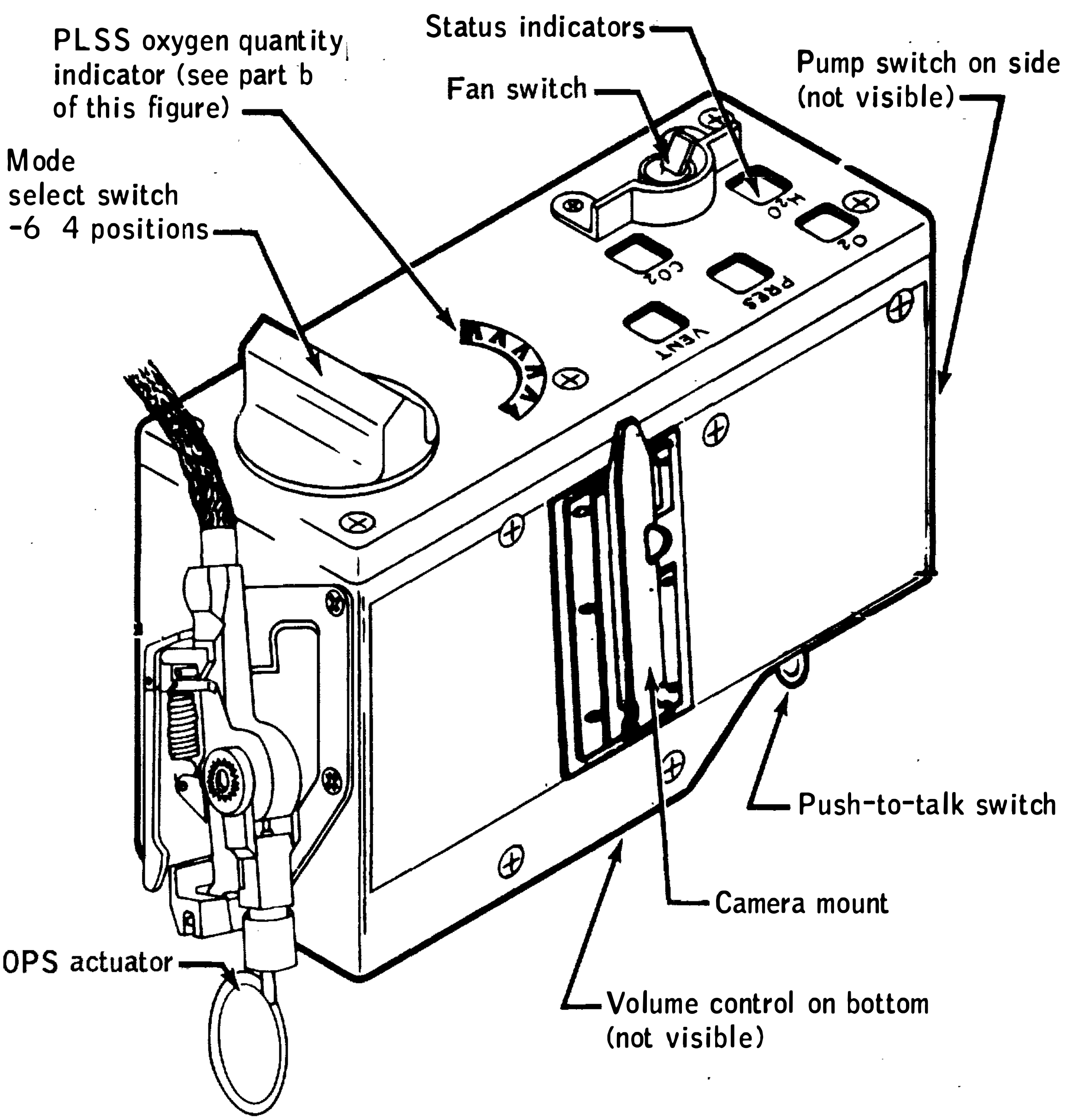
Each telemetry system can accommodate up to 26 commutator channels (table 2-XI) at 1-1/2 samples per second and one ECG channel and provides a data accuracy of 2 percent root mean square.

2.5.7 Remote Control Unit

The RCU (fig. 2-43) is a chest-mounted instrumentation and control unit which provides the crewman with easy access to certain PLSS/EVCS controls and displays. Controls include a fan switch, a pump switch, a communications mode-selector switch, a push-to-talk switch, and two communications volume control knobs. Displays include an oxygen quantity indicator and four active status indicators (warning flags). A fifth status indicator is provided, but is not presently used. The status indicators are illuminated by beta particle capsules requiring no electricity. Any one of four problems (high oxygen flow, low vent flow, low PGA pressure, or low feedwater pressure) will cause a cylinder to rotate and reveal the illuminated warning symbol underneath. Simultaneously, the warble tone in the EVCS is activated to alert the crewman

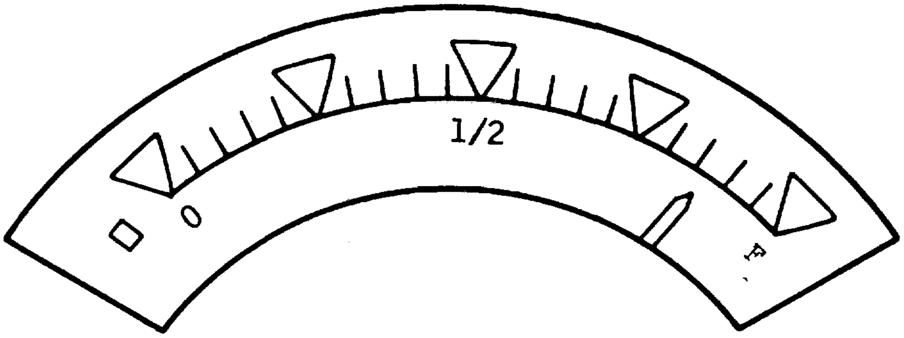
TABLE 2-XI.- PLSS/EVCS COMMUNICATIONS TELEMETRY CHARACTERISTICS

Measurement title	Instrumentation range	Discriminator output range, V dc	Commutator channels
Zero calibration	0 V dc	0	1
Full-scale calibration	5 V dc	5	2
PGA pressure	2.5 to 5.0 psid	0 to 5	3, 21, 24, 27
Feedwater pressure	0 to 5.0 psia	0 to 5	4, 15, 22, 26
Battery current	0 to 10 amps	0 to 5	5, 11
Battery voltage	15.5 to 20.5 V dc	0 to 5	6, 20
Water difference temperature	0° to 15° F	0 to 5	8, 19
LCG inlet temperature	40° to 90° F	3.13 to 1.86	9, 17
Sublimator gas outlet temperature	40° to 90° F	3.13 to 1.86	10, 16
Primary oxygen pressure	0 to 1110 psia	0 to 5	12, 13, 23, 28
Carbon dioxide partial pressure	0.1 to 30 mm Hg	0 to 5	7, 14, 18, 25
Synchronization	- -	(Double width pulse)	29, 30



(a) Pictorial view of main elements.

Figure 2-43.- Remote control unit.



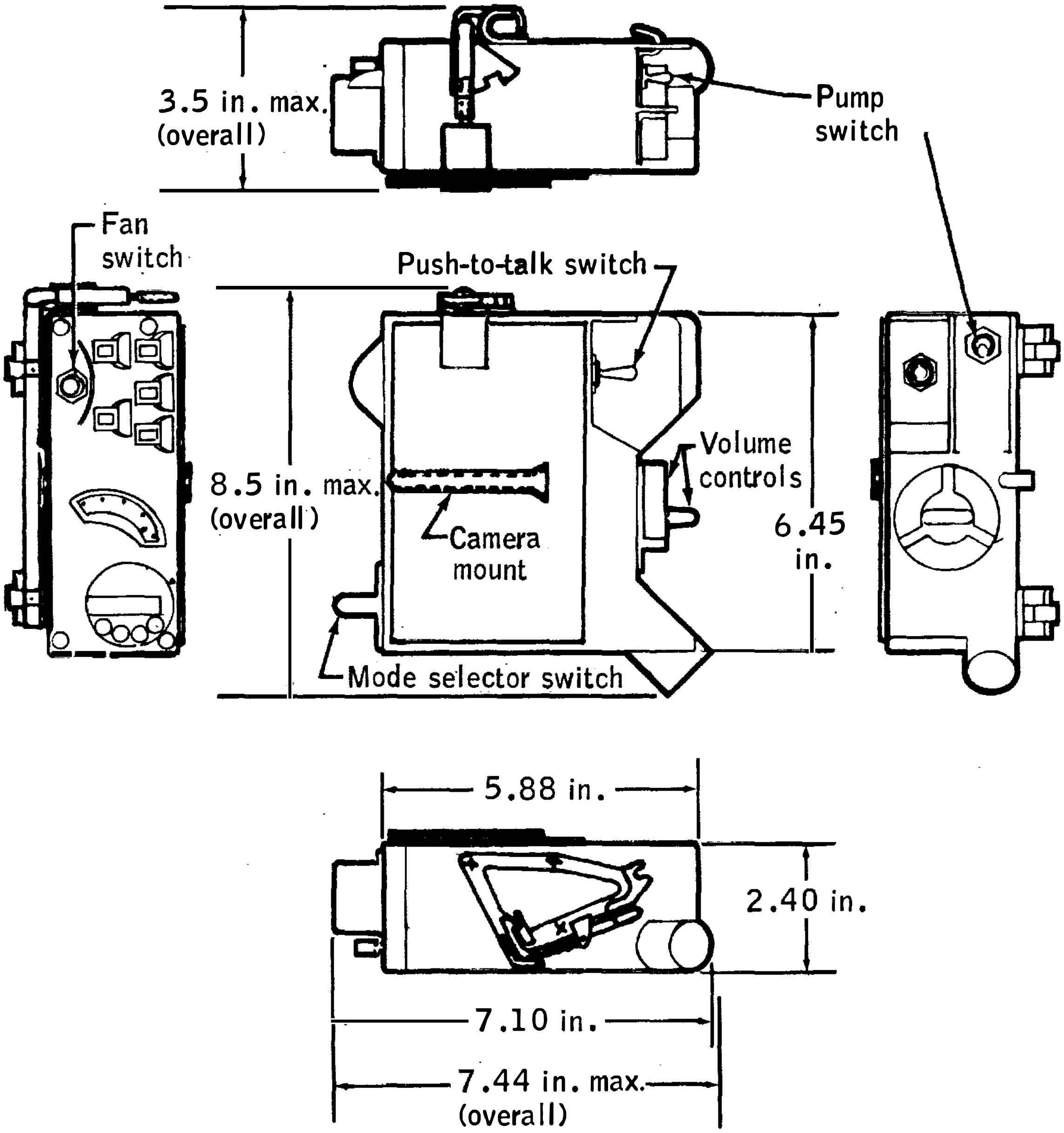
Each increment of indicator represents 68 psia.

Marking	Oxygen bottle pressure range, psia[a]
0	150 ± 68
1/4	490 ± 68
1/2	825 ± 68
3/4	1163 ± 68
F	1500 ± 68

[a] With RCU in a horizontal position and zero g.

(b) Oxygen quantity indicator markings and accuracies.

Figure 2-43.- Continued.



(c) Dimensions.

Figure 2-43.- Concluded.

to check his RCU and determine the problem area. Each warning symbol is a key to corrective action as follows.

Function	Indicator label	Symbol	Indicated action
High oxygen flow	O_2	O	Actuate OPS
Low PGA pressure	Pressure	O	Actuate OPS
Low vent flow	Vent	P	Purge
Low feedwater pressure	H_2O	A	Open auxiliary feedwater shut-off valve or use BSLSS as required

In addition to the above functions, the RCU provides a mounting point for the OPS actuator cable and the camera bracket.

2.6 OXYGEN PURGE SYSTEM

The OPS (fig. 2-44) supplies the EMU with oxygen purge flow and pressure control for certain failure modes of the PLSS or PGA during EVA. In the event of a PLSS failure, the OPS flow is regulated to 3.7 ± 0.3 psid for 30 minutes to provide breathing oxygen to the crewman, to prevent excessive carbon dioxide buildup, and to provide limited cooling. In this mode, the crewman sets his purge valve in the high-flow position (8.1 pounds per hour). In a second mode, the OPS may be used to provide make-up flow to the PLSS oxygen ventilating circuit via the PGA at flow rates of 0.07 to 2.0 pounds per hour. Finally, the OPS can be used in conjunction with the BSLSS (as described in section 2.7) to provide a 1.25-hour supply of purge flow for a crewman with a failed PLSS. For this mode, the crewman sets his purge valve in the low-flow position (4.0 lb of O_2 per hour).

In the lunar EVA configuration, the OPS is mounted on top of the PLSS (fig. 2-1). For normal EV activity from the command module, the OPS is worn in the helmet-mounted mode as shown in figure 2-45. During contingency EV transfer from the lunar module, however, the OPS is attached by straps to the lower front torso of the PGA (fig. 2-46).

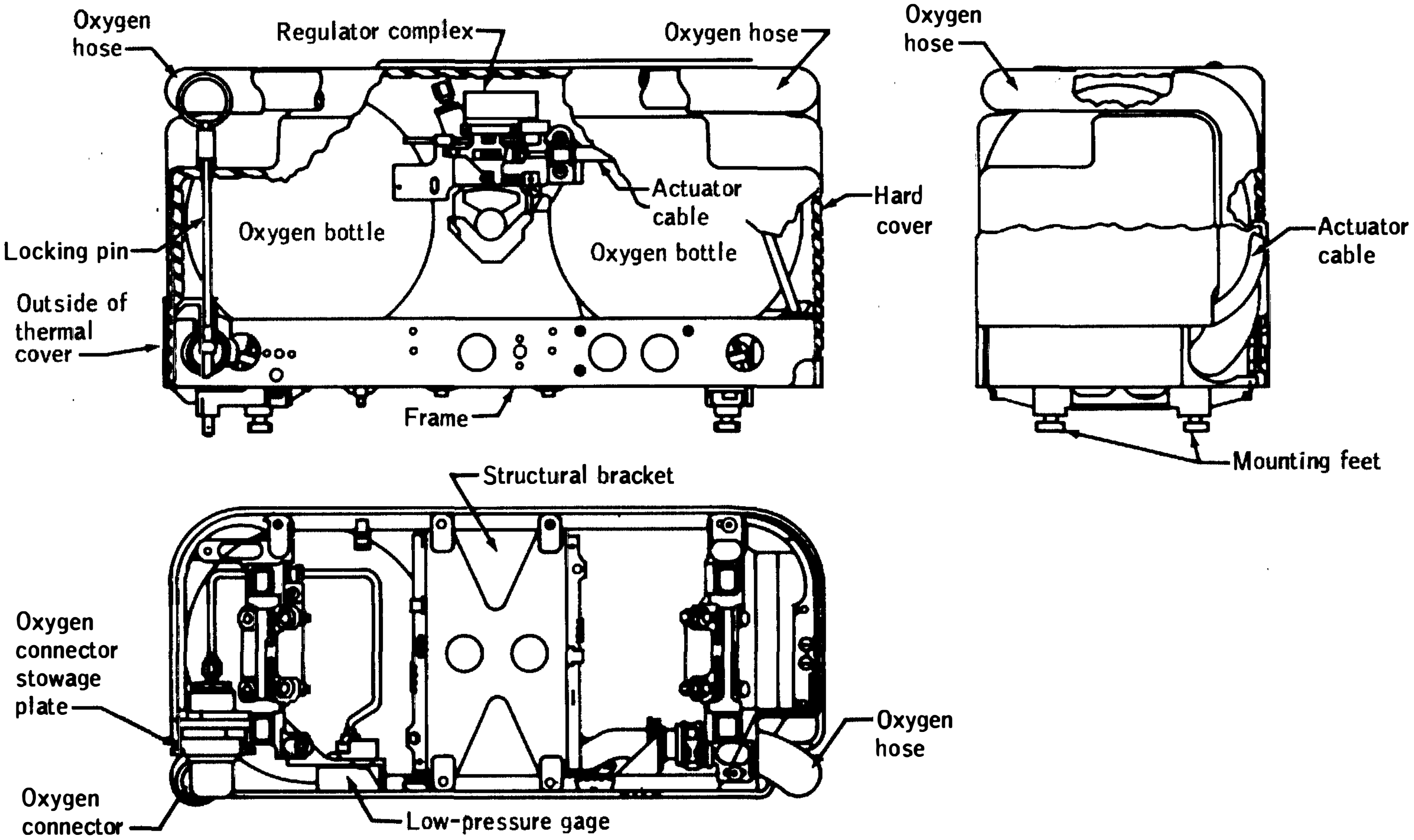


Figure 2-44.- Oxygen purge system, -3 configuration.

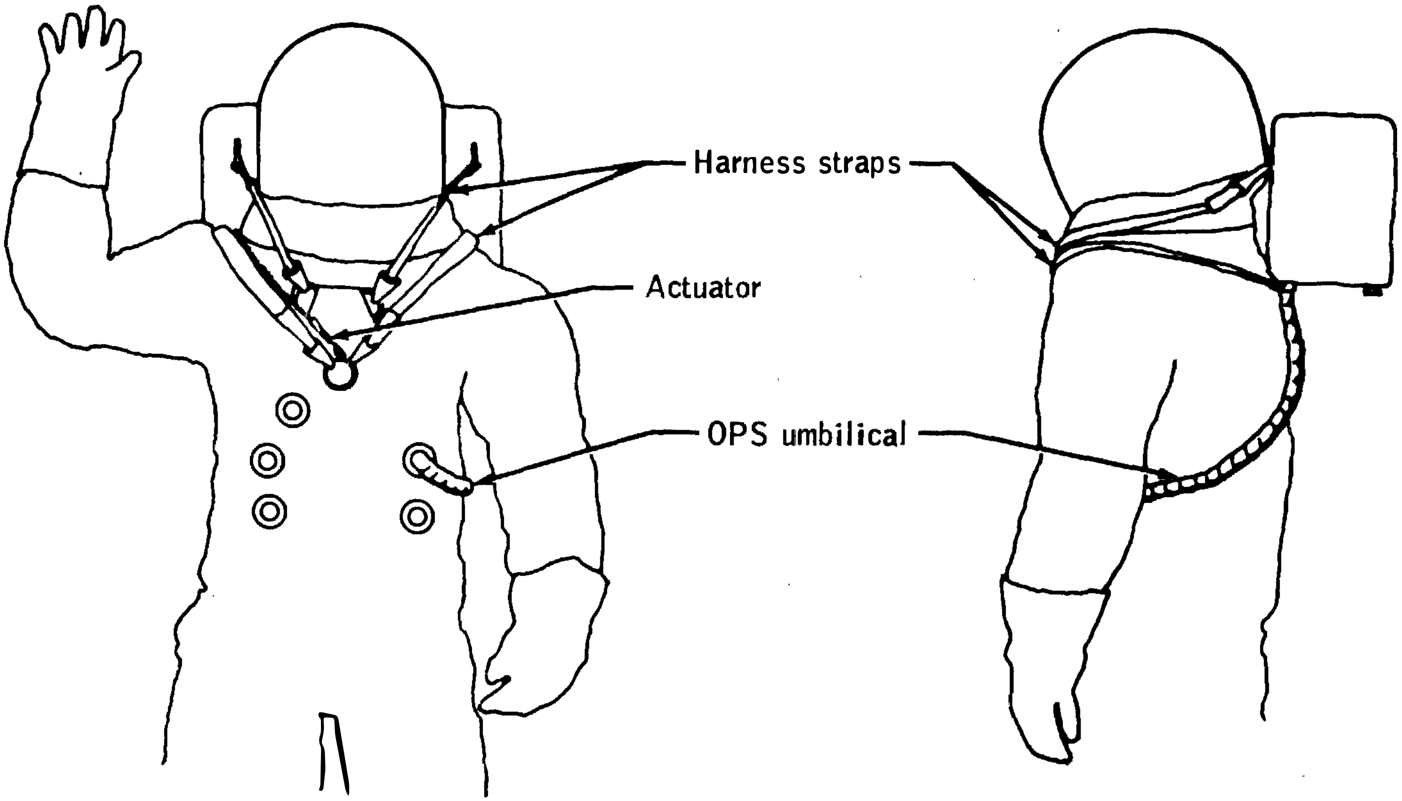


Figure 2-45.- The OPS worn in the helmet-mounted mode.

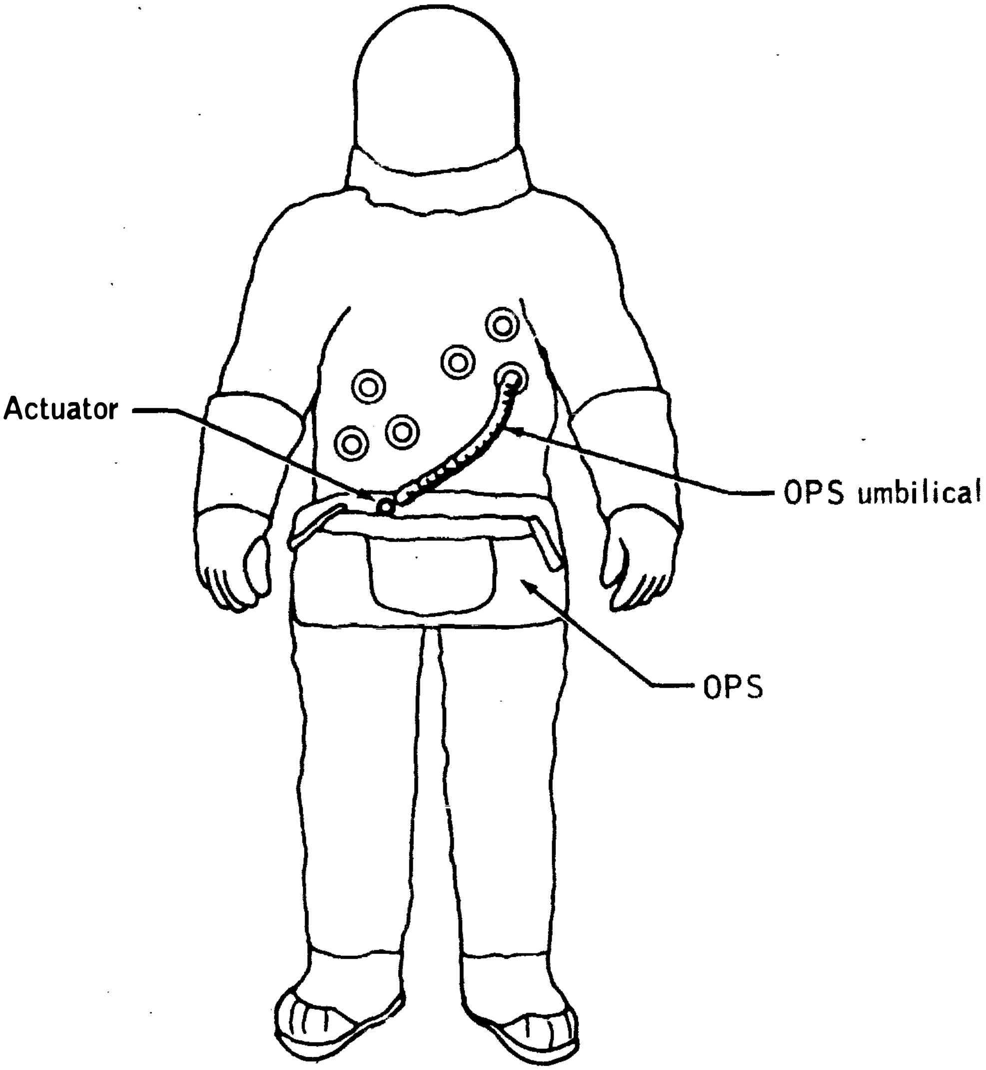


Figure 2-46.- The OPS worn in the torso-mounted contingency mode.

A schematic representation of the OPS is shown in figure 2-47. The OPS consists of two interconnected, spherical, high-pressure oxygen bottles (total of 5.1 pounds of usable oxygen at 5880 ± 80 psia and 70° F), a pressure regulator assembly, a fill fitting, a high-pressure gage, a delta-pressure gage, a suit connector and hose, a suit connector stowage plate, a shutoff valve, and an actuator cable and handle. The OPS has no communications capability, but provides the hard mount for the PLSS antenna. The OPS used for Apollo 15 and subsequent missions differs from the OPS used on Apollo 14 in that attachment points for the PLSS harnesses have been moved to permit helmet mounting. Also the oxygen outlet temperature control capability incorporated in the OPS for all missions through Apollo 13 has been deleted. Thus the heater, control circuitry, terminal board, temperature sensor, power switch, and battery have been removed.

The OPS is not rechargeable during a mission. The high-pressure gage is used to monitor bottle pressure during ground charge and during preoperational checkout. The delta-pressure gage is used during preoperational checkout to verify regulated flow through a 0.44- to 0.70-pound-per-hour orifice mounted on the connector stowage plate.

2.7 BUDDY SECONDARY LIFE SUPPORT SYSTEM

The BSLSS enables two EVA crewmen to share the water cooling provided by one PLSS following loss of cooling capability in the other PLSS. The system is shown schematically in figure 2-48 and in use by two crewmen in figure 2-49. The BSLSS is made up of six principal components.

a. Two water hoses 8-1/2 feet long and 3/8 inch inside diameter to carry the coolant flow between the good PLSS and the other crewman

b. A normal PLSS water connector on one end of the double hose

c. A flow-dividing connector on the other end of the double hose consisting of an ordinary PLSS water connector coupled with a receptacle to accept a PLSS water connector

d. A 4-1/2-foot restraint tether with hooks for attachment to the PGA LM restraint loops

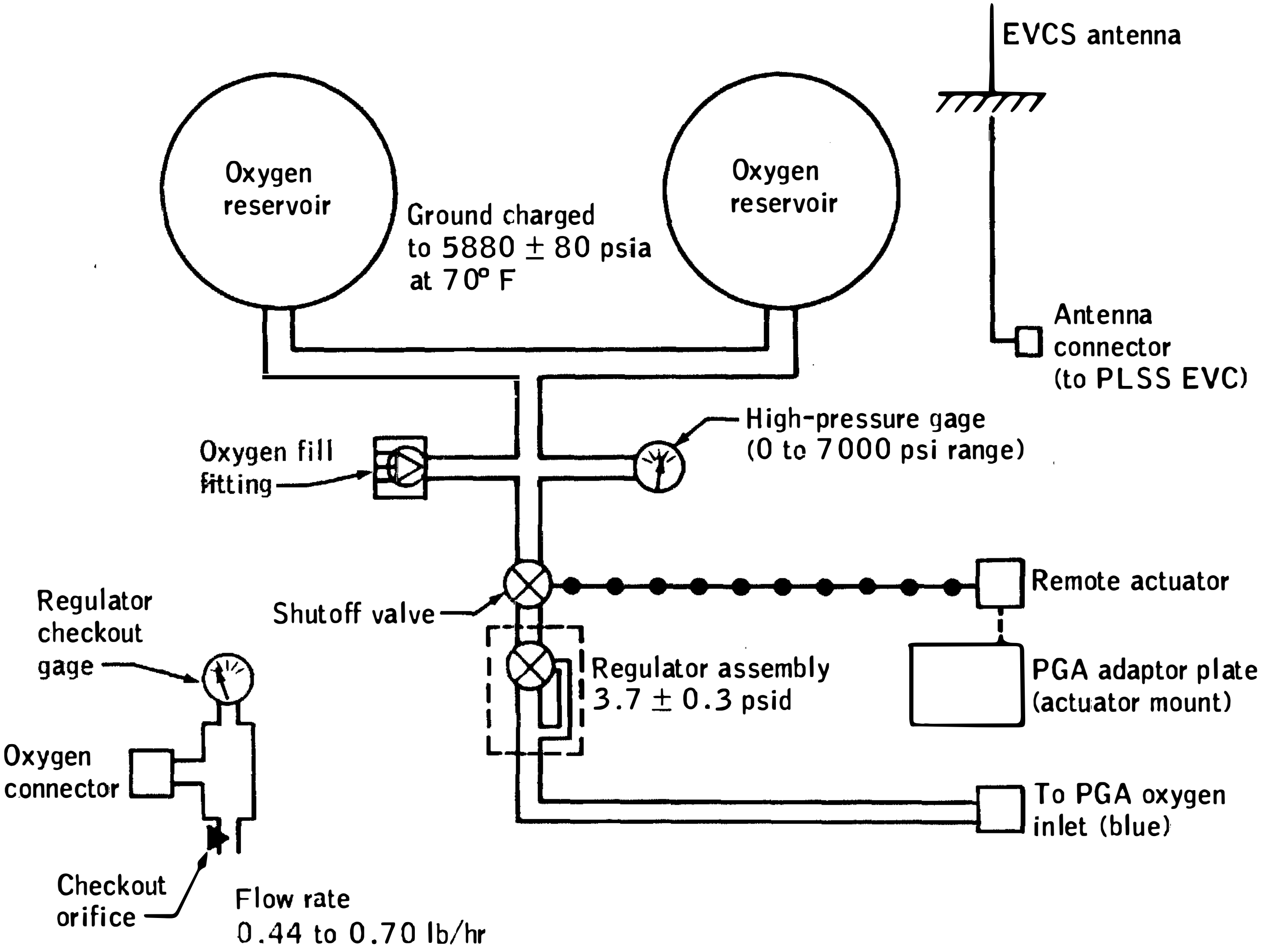


Figure 2-47.- Oxygen purge system schematic.

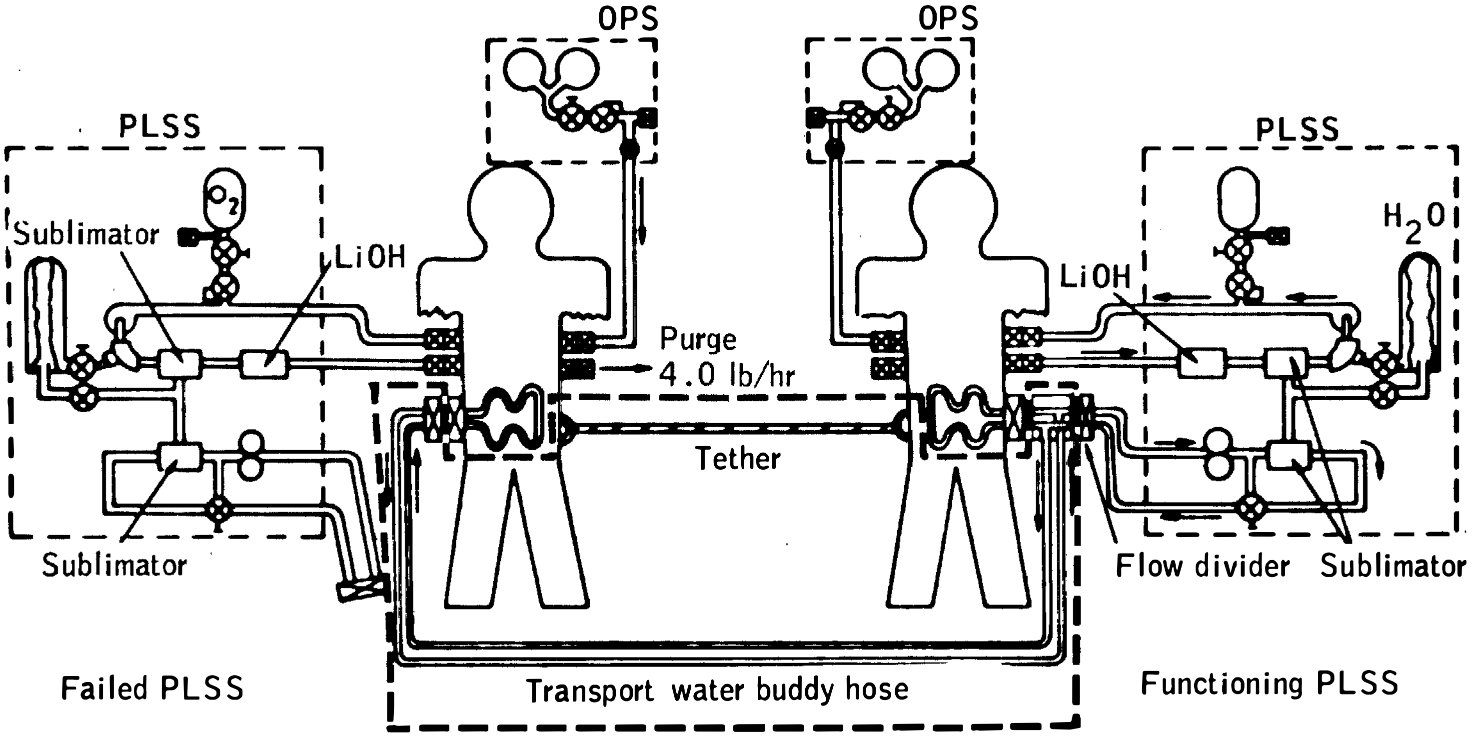


Figure 2-48.- Buddy secondary life support system schematic.

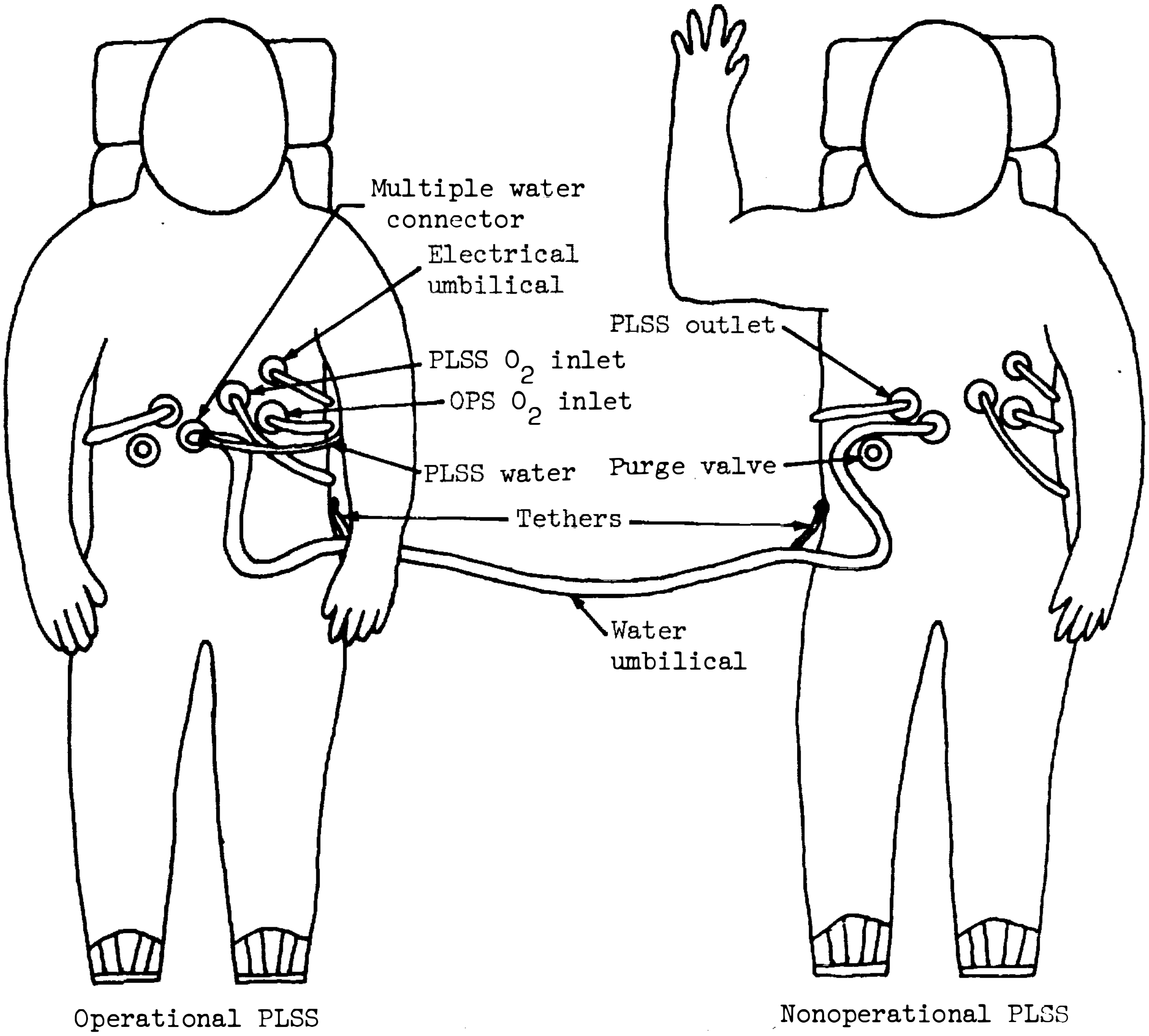


Figure 2-49 .- Buddy secondary life support system connected.

e. A thermal sheath the length of the hoses with tether breakouts 2 feet from each end

f. A thermal pouch for stowage of the assembly on the PLSS during EVA and in the LM cabin during non-EVA periods (fig. 2-50)

The BSLSS hose stowage is illustrated in figure 2-50.

2.8 PRESSURE CONTROL VALVE

A pressure control valve (PCV) controls PGA pressure during normal EV transfer from the command module. This is a relief valve installed in one of the PGA outlet gas connectors prior to EVA. A purge valve is installed in the other outlet gas connector. Oxygen is supplied from the command module environmental control system at a flow rate of 10 to 12 pounds per hour via an umbilical to one of the PGA gas inlet connectors. The OPS, worn in the helmet-mounted configuration, provides a backup oxygen supply. The PCV contains a spring-loaded poppet which senses suit pressure and unseats, dumping a sufficient amount of suit oxygen to space to maintain suit pressure in the 3.5- to 4.0-psid range. The PCV is also sized to prevent suit pressure from falling below 3.2 psid in the event the poppet fails open. The PCV is shown in a schematic representation in figure 2-51.

2.9 PLSS FEEDWATER COLLECTION BAG

Deleted

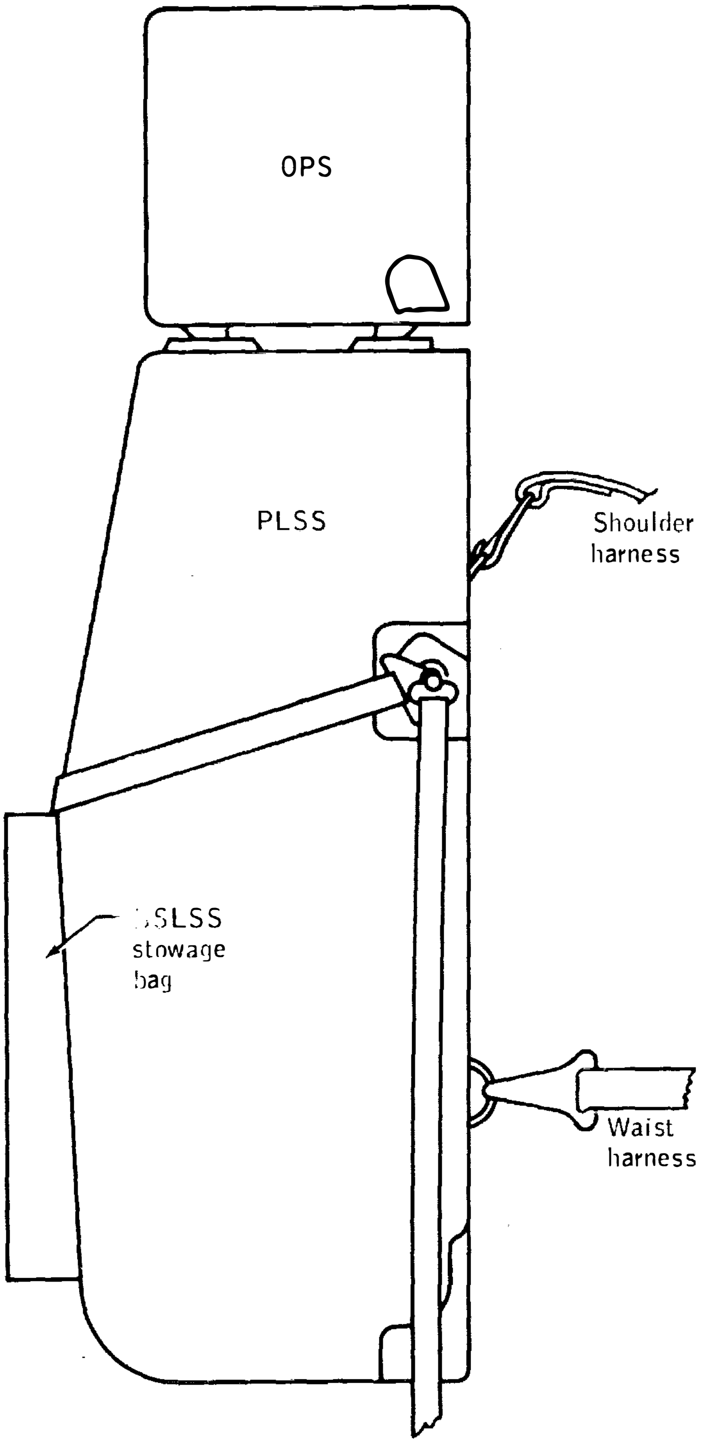
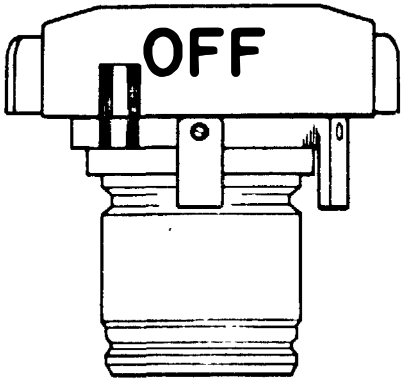
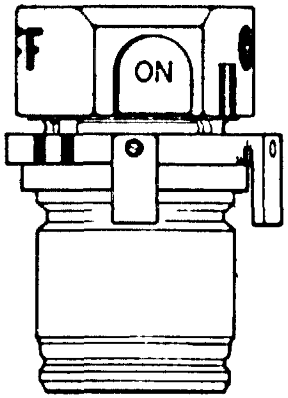


Figure 2-50.- BSLSS hose stowage.



PCV in off position



PCV in on position

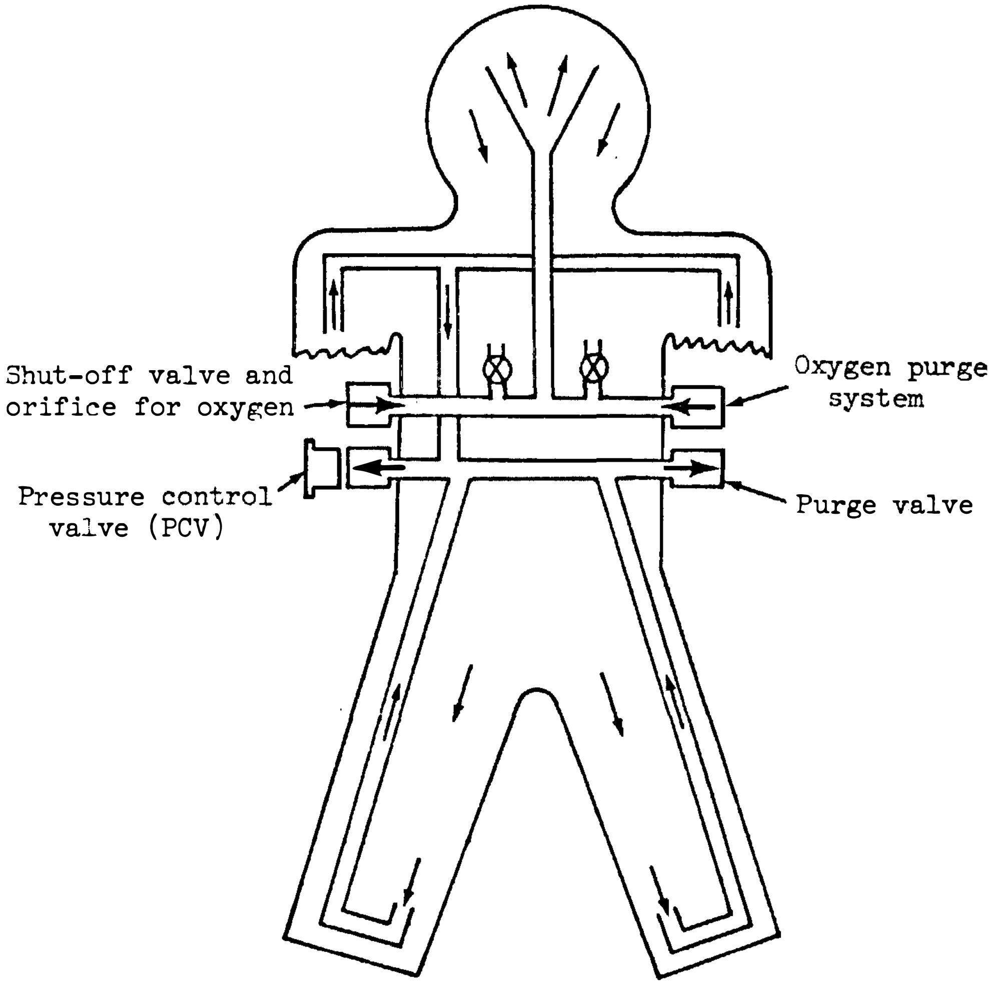


Figure 2-51.- Pressure control system.

2.10 BIOMEDICAL INSTRUMENTATION SYSTEM

The biomedical instrumentation system (fig. 2-52) is attached to either the CWG or the LCG and contains the necessary instrumentation for crew status check. The instrumentation connected to the PGA electrical harness consists of an ECG signal conditioner, ZPN signal conditioner, dc-dc converter, and axillary and sternal electrodes.

2.10.1 Electrocardiogram Signal Conditioner

The ECG signal conditioner has a signal wave ranging between 0 and 5 volts peak to peak which is representative of inflight heart activity.

2.10.2 Impedance Pneumogram Signal Conditioner

The ZPN signal conditioner and associated electrodes provide flight measurement of transthoracic impedance change. A pair of electrodes is used to measure respiration rate over a wide dynamic range of activity.

2.10.3 The dc-dc Power Converter

The dc-dc power converter delivers +10- and -10-volt power to each signal conditioner from the single-ended 16.8-volt power source.

2.10.4 Electrodes

The electrodes are attached directly to the skin with an adhesive disk filled with conductive paste. The ECG sternal electrodes are attached to the ECG signal conditioner and the ECG axillary electrodes are attached to the ZPN signal conditioner.

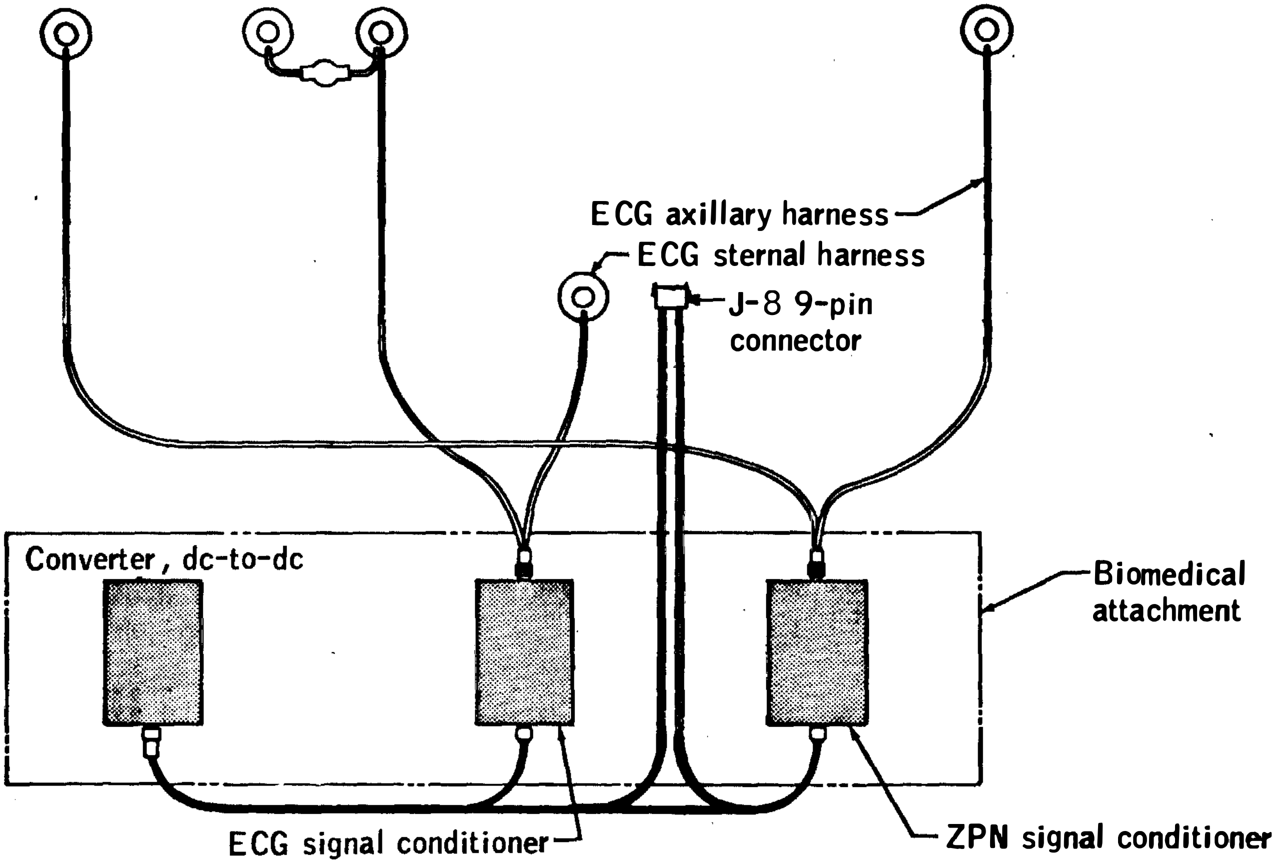


Figure 2-52.- Biomedical instrumentation system.

3.0 EXTRAVEHICULAR MOBILITY UNIT SYSTEMS

3.1 PRIMARY PRESSURIZATION AND VENTILATION

The EMU primary pressurization and ventilation system (fig. 3-1) is a closed-loop gas system which provides a habitable environment for the astronaut during Apollo EVA missions. A precharged oxygen bottle (1410 ± 30 psia) and pressure regulator pressurizes the system to 3.85 ± 0.15 psig and supplies the system with make-up oxygen to satisfy a 1200-Btu/hr metabolic load plus an EMU leakage factor for a 5-hour EVA design mission. The pressurized, breathable gas is forced through the loop at a rate of 6.00 cfm by a circulation pump. The circulated gas flows through the pressurizable portion of the PGA consisting of a TLSA, helmet, and a pair of gloves.

Within the pressurizable envelope, a ventilation distribution system directs the gas flow from the inlet connector to the helmet and the torso, if desired, down over the body to the limb extremities, then through noncrushable ducts to the outlet gas connector. The exhaust gas flows from the PGA to the PLSS through an umbilical.

Within the PLSS, the gas passes through a contamination-control assembly where odors are removed by activated charcoal. Carbon dioxide is removed by chemical reaction with LiOH, and foreign particles are filtered out by a peripheral Orlon filter. The oxygen passes from the contamination-control assembly to a sublimator which then cools the circulated oxygen. The cooled oxygen passes from the sublimator to the water separator where excess water entrained in the cooled oxygen is removed at a maximum rate of 0.508 lb/hr. The oxygen passes from the water separator to the fan/motor assembly for recirculation.

If a hypodermic injection is required, it is administered through the biomedical injection patch located on the left thigh. The patch is a self-sealing disk which prevents suit leakage as a result of the injection.

Suit pressure can be monitored continuously on a pressure gage installed on the left wrist of the PGA. The dial-indicating instrument is calibrated from 2.5 to 6.0 psid. In the event of suit overpressure, a pressure relief valve, located on the right thigh of the EV PGA and the left wrist

To be determined

Figure 3-1.- EMU primary pressurization and ventilation system.

cone of the CMP PGA, opens at pressures of 5.00 to 5.75 psid and reseats at not less than 4.6 psid.

The flow of oxygen through the PLSS regulator assembly is limited to a maximum of 4.0 lb/hr at 1500 psia to protect the PGA against overpressurization in the event of a failed-open regulator. This is accomplished by an orifice between the regulator and the prime oxygen bottle and fill connector. The fill connector is a leak-proof, self-sealing, quick-disconnect connector used for recharging the primary oxygen subsystem. Recharge time from a 1425-psia source at 0° to 60° F is a nominal 75 minutes. An oxygen flow sensor gives an audible tone when PLSS primary oxygen flow exceeds a 0.50 to 0.65 lb/hr band and will remain actuated until the flow decreases to 0.50 to 0.65 lb/hr (a continuous high flow of 0.50 to 0.65 for 5 seconds is needed for actuation). A primary oxygen pressure transducer provides electrical signals to the oxygen quantity indicator for crew visual read-out and to the telemetry system of the PLSS.

Two additional pressure transducers are incorporated in the primary oxygen subsystem to monitor the PGA pressure. One transducer is used for telemetry monitoring, and the other activates an audible warning tone when PGA pressure drops below 3.10 to 3.40 psid.

3.2 LIQUID COOLING SYSTEM

The EMU oxygen pressurization and ventilation system removes body heat by carrying evaporated body perspiration from the PGA. To reduce body fluid loss and increase body cooling efficiency, the liquid cooling system is employed for transporting metabolic heat from the PGA. The liquid (water) cooling system (fig. 3-2) is a closed-loop system fed by a pressurized water reservoir. The reservoir is pressurized by the EMU pressurization and ventilation system, and a pump circulates the water through the closed-loop system at a nominal rate of 4.0 lb/min.

The water supplied by the PLSS passes through the inlet passage of the multiple water connector and circulates through the manifold and a network of polyvinylchloride tubing contained in the LCG. During the circulation process, the heat within the PGA is transferred by conduction to the water which returns through the outlet passage of the multiple

To be determined

Figure 3-2.- EMU liquid cooling system.

water connector to the PLSS for cooling. The water within the PLSS is circulated through the sublimator to provide the cooling. The sublimator is supplied with expendable feedwater from the feedwater reservoir.

The feedwater is enclosed by a collapsible bladder within the reservoir with the exterior of the bladder exposed to the ventilation loop pressure through the water separator. This pressure provides the force required to supply feedwater to the sublimator. It also enables the portion of the feedwater reservoir external to the bladder to be used for the storage of waste water removed from the ventilation loop.

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