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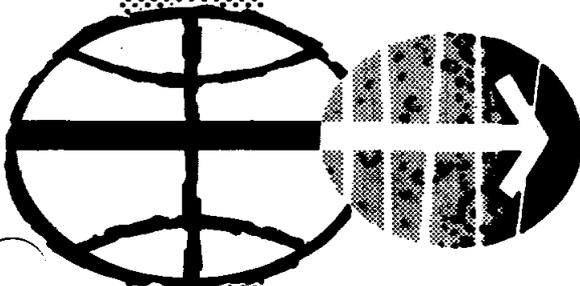
APOLLO OPERATIONS HANDBOOK EXTRAVEHICULAR MOBILITY UNIT,

VOLUME I:
SYSTEM DESCRIPTION
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CREW SYSTEMS DIVISION
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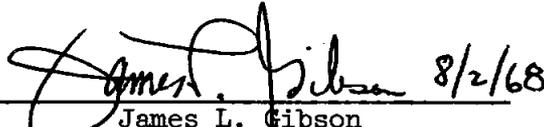
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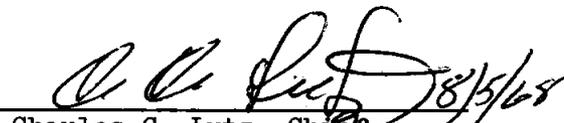
VOLUME I — SYSTEM DESCRIPTION

CSD-A-789-(1)

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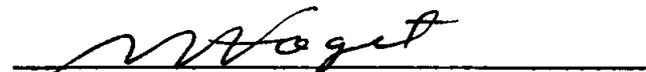

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PREFACE

This document is the fourth revision issue of volume I of the Apollo Operations Handbook. This revision incorporates applicable portions of revisions I, II, and III.

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ACRONYMS

AM	Amplitude modulation
BSLSS	Buddy secondary life support system
CCA	Communications carrier assembly
CDR	Commander
CM	Command module
CMP	Command module pilot
CSM	Command and service module
CWG	Constant wear garment
EKG	Electrocardiogram
EMU	Extravehicular mobility unit
EV	Extravehicular
EVC	Extravehicular communicator
EVCS	Extravehicular communications system
FCS	Fecal containment subsystem
FM	Frequency modulation
HSB	Helmet stowage bag
ICG	Inflight coverall garment
IHSB	Inflight helmet stowage bag
IRIG	Interrange instrument group
ITMG	Integrated thermal micrometeoroid garment
IV	Intravehicular
IVCL	Intravehicular coverlayer
LCG	Liquid cooling garment

LEVA Lunar extravehicular visor assembly

LHSB LEVA helmet storage bag

LITMG Lunar integrated thermal micrometeoroid garment

LM Lunar module

LMP Lunar module pilot

MIC Microphone

MK Maintenance kit

OPS Oxygen purge system

PAM Pulse amplitude modulation

PGA Pressure garment assembly (A7L PGA is a particular configuration of the pressure garment assembly)

PLSS Portable life support system

PTT Push-to-talk

PVC Polyvinylchloride

RCU Remote control unit

TLSA Torso limb suit assembly

TMG Thermal micrometeoroid garment

UCT Urine collection and transfer

UCTA Urine collection and transfer assembly

VCO Voltage controlled oscillator

VOX Voice operated switch

XMTR Transmitter

1.0 INTRODUCTION

1.1 PURPOSE

This volume provides familiarization information about the extravehicular mobility unit (EMU). This handbook describes the lunar configuration of the EMU except where noted. Deviation may be made for each mission. Operational and malfunction detection procedures are found in volume II of this handbook.

1.2 SCOPE

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

2.0 THE EMU SYSTEM DESCRIPTION (Including Support Accessories)

2.1 GENERAL DESCRIPTION

The extravehicular mobility unit (fig. I-1) is designed to protect the crewman in a low pressure environment and provide comfort, mobility, dexterity, and a specified unobstructed range of vision during pressurized and unpressurized modes of operation. There are two basic configurations which support an Apollo mission; an intravehicular configuration which affords pressure and fire protection, and an extravehicular configuration which provides pressure, fire, thermal, and micrometeoroid protection. Connectors permit both configurations to interface with spacecraft systems for pressurization, ventilation, communications, cooling, and waste management purposes. The EV configuration incorporates the portable life support system (PLSS) for pressurization, ventilation, communications, and temperature control when used for EV phases of the mission. Waste management systems are self-contained in both configurations.

The EMU is designed to be worn for 115 hours when used in conjunction with the spacecraft environmental control system. Maximum time in the pressurized EMU to assure the proper functioning and comfort of the crewman should be limited to 8 hours.

2.1.1 Extravehicular Configuration

The extravehicular configuration of the EMU (fig. I-2) provides the EV crewman with a habitable environment for a 4-hour, 4800-Btu design mission without replenishment of expendables. The EV configuration consists of the following systems and assemblies.

- a. EV pressure garment assembly (EV-PGA)
- b. Liquid cooling garment (LCG)
- c. Lunar extravehicular visor assembly (LEVA)
- d. Communications carrier assembly (CCA)
- e. Bioinstrumentation system

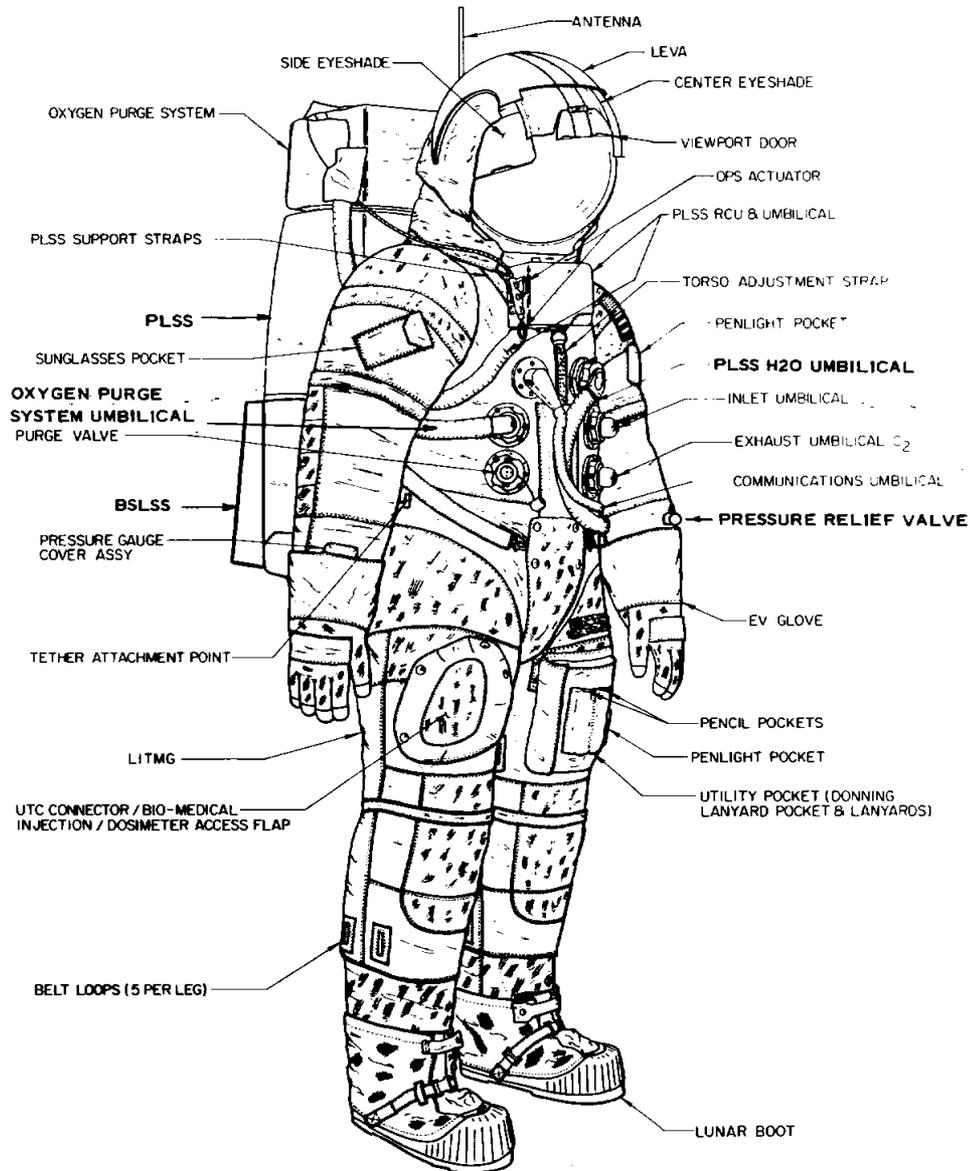


Figure I-1. - Extravehicular mobility unit with LITMG.

- f. Urine collection and transfer assembly (UCTA)
- g. Fecal containment subsystem (FCS)
- h. Dual position purge valve
- i. Portable life support system (PLSS)
- j. Oxygen purge system (OPS)

2.1.2 Intravehicular Configuration

The IV configuration (fig. I-3) consists of the following systems and assemblies.

- a. IV pressure garment assembly (IV-PGA)
- b. Constant wear garment (CWG)
- c. Communications carrier assembly (CCA)
- d. Bioinstrumentation system
- e. Urine collection transfer assembly (UCTA)
- f. Fecal containment subsystem (FCS)

2.1.3 Supporting Accessories

Several items, although not considered as part of the EMU, are required to support the EMU to enable it to adequately perform its desired functions. The following auxiliary items provide this support.

- a. LEVA helmet stowage bag (LHSB)
- b. Inflight helmet stowage bag (IHSB)
- c. Helmet shield
- d. EMU maintenance kit (MK)
- e. Feedwater collection bag
- f. Gas connector plugs

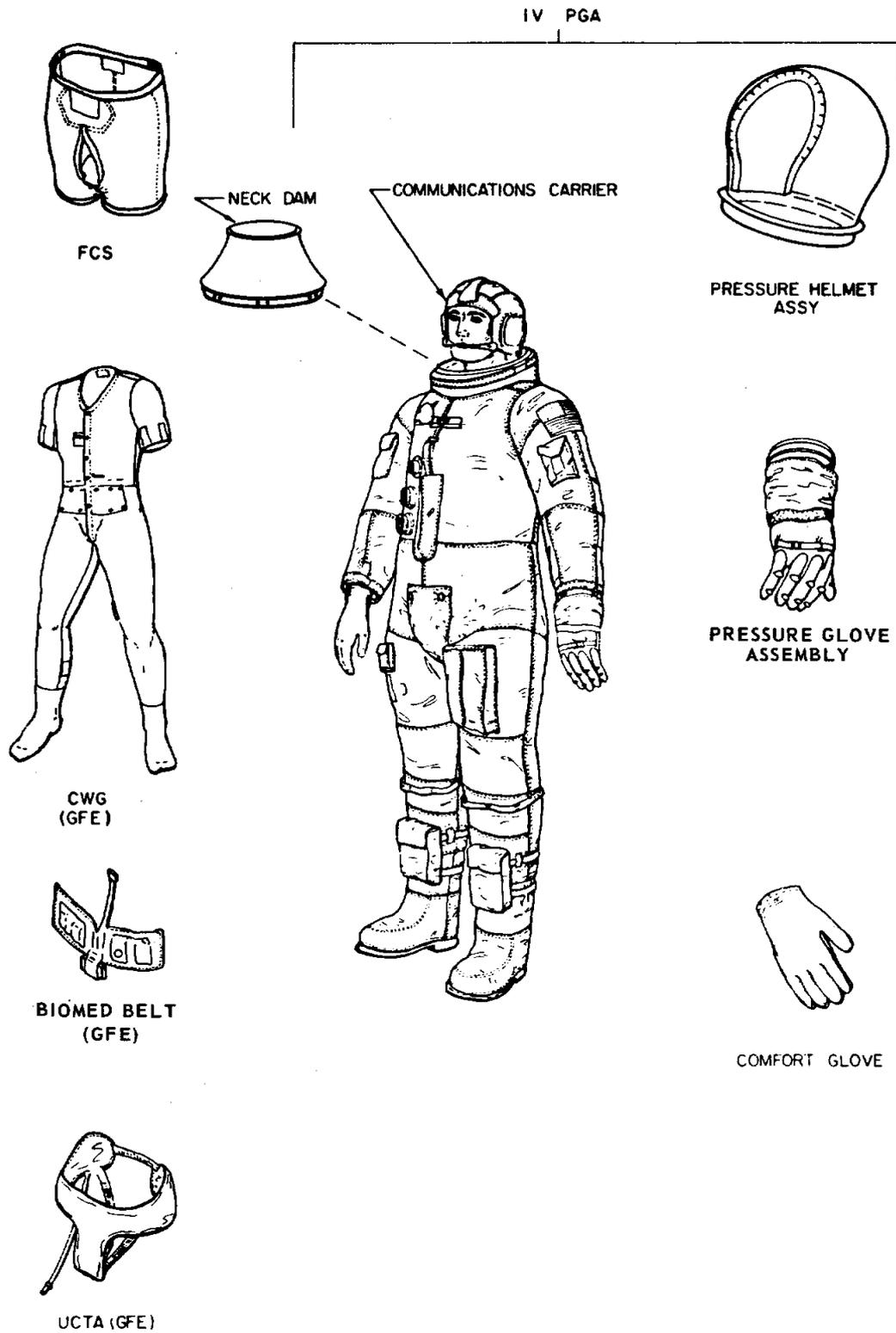


Figure I-3. - Intravehicular configuration.

- g. CWG electrical harness
- h. Lightweight headset (NAR responsible equipment)

2.1.4 Field Optional Items

The items designated as field optional items are shown in table I-I. These items may be altered at the option of the individual crewman. Certain items may also be repositioned as necessary to satisfy crewman comfort requirements. Field optional item changes should be determined as much as possible during initial fit check; however, field modifications may be accomplished when they are within the capability of the applicable support activity.

2.2 PRESSURE GARMENT ASSEMBLY

Two configurations of the pressure garment assembly (PGA) are to be flown on all Apollo missions. The intravehicular configuration (IV-PGA) shown in figure I-4 will be worn by the command module pilot (CMP) and the extravehicular configuration (EV-PGA) shown in figure I-5 will be worn by the commander (CDR) and the lunar module pilot (LMP). The two configurations are similar with the exception that the IV-PGA is equipped with an IV coverlayer (IVCL) and does not include hardware and controls necessary for extravehicular use. This deleted hardware includes the second inlet gas connector and its associated diverter valve, the second outlet gas connector, the pressure relief valve, the multiple water connector, and the tether mounting brackets.

Both the IV and the EV-PGA consists basically of a torso limb suit assembly, a pressure helmet assembly, pressure gloves, an external protective coverlayer, and various connectors, controls, and instrumentation. The PGA's are designed to be worn for a contingency CM transearth return of 115 hours at a regulated pressure of 3.75 ± 0.25 psid in conjunction with either the constant wear garment (CWG) or the liquid cooling garment (LCG). A comparison of suit weights and other characteristics is given in table I-II.

2.2.1 Torso Limb Suit Assembly (TLSA)

The torso limb suit assembly (TLSA) is that portion of the PGA encompassing the entire body with the exception of the

TABLE I-I.- 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.
LITMG pocket loops	Pocket loops may be positioned as necessary to ensure correct pocket location.
Arm bias	Arm bias may be varied as necessary to ensure the preferred elbow angle when the suit is pressurized.
Liner comfort pads	Comfort pads may be positioned as necessary to decrease pressure points.
Removal of Velcro from vent system	Velcro hooks may be eliminated in wrist area to reduce irritation.
Custom length of palm restraint straps	Palm restraint strap length may be varied to correspond with hand size.
Custom length of neck dam lanyard	Lanyard length may be varied as necessary.
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 30° intervals per astronaut preference.
Custom length UCTA hose	UCTA hose length can be varied as necessary.
Custom length torso tie-down webbing	Torso tiedown webbing length can be altered to satisfy individual crewman requirements.
Orientation or length of PGA liner electrical harness keeper tabs	Electrical harness keeper tabs may be lengthened or reorientated as necessary.

TABLE I-I.- FIELD OPTIONAL ITEMS - Concluded

Item	Action
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 use of the comfort gloves may be deleted.

TABLE I-II.- PRESSURE GARMENT ASSEMBLY CHARACTERISTICS

Item	Value	
	PGA with LITMG	PGA with IV coverlayer
Weight	43.42 lb	34.13 lb
Operational temperature limitations	$\pm 250^{\circ}$ F	S/C wall -20° to $+150^{\circ}$ F
Leak rate at 3.7 psid (max.)	180.00 scc/min (0.0315 lb/hr)	180.00 scc/min (0.0315 lb/hr)
Operating pressure	3.75 ± 0.25 psid	3.75 ± 0.25 psid
Structural pressure	6.00 psid	6.00 psid
Proof pressure	8.00 psid	8.00 psid
Burst pressure	10.00 psid	10.00 psid
Pressure drop		
12 acfm, 3.5 psia, 50° F, and inlet diverter valve open (IV position)	4.70 in. H ₂ O	4.70 in. H ₂ O
6 acfm, 3.9 psia, 77° F, and inlet diverter valve closed (EV position)	1.80 in. H ₂ O	

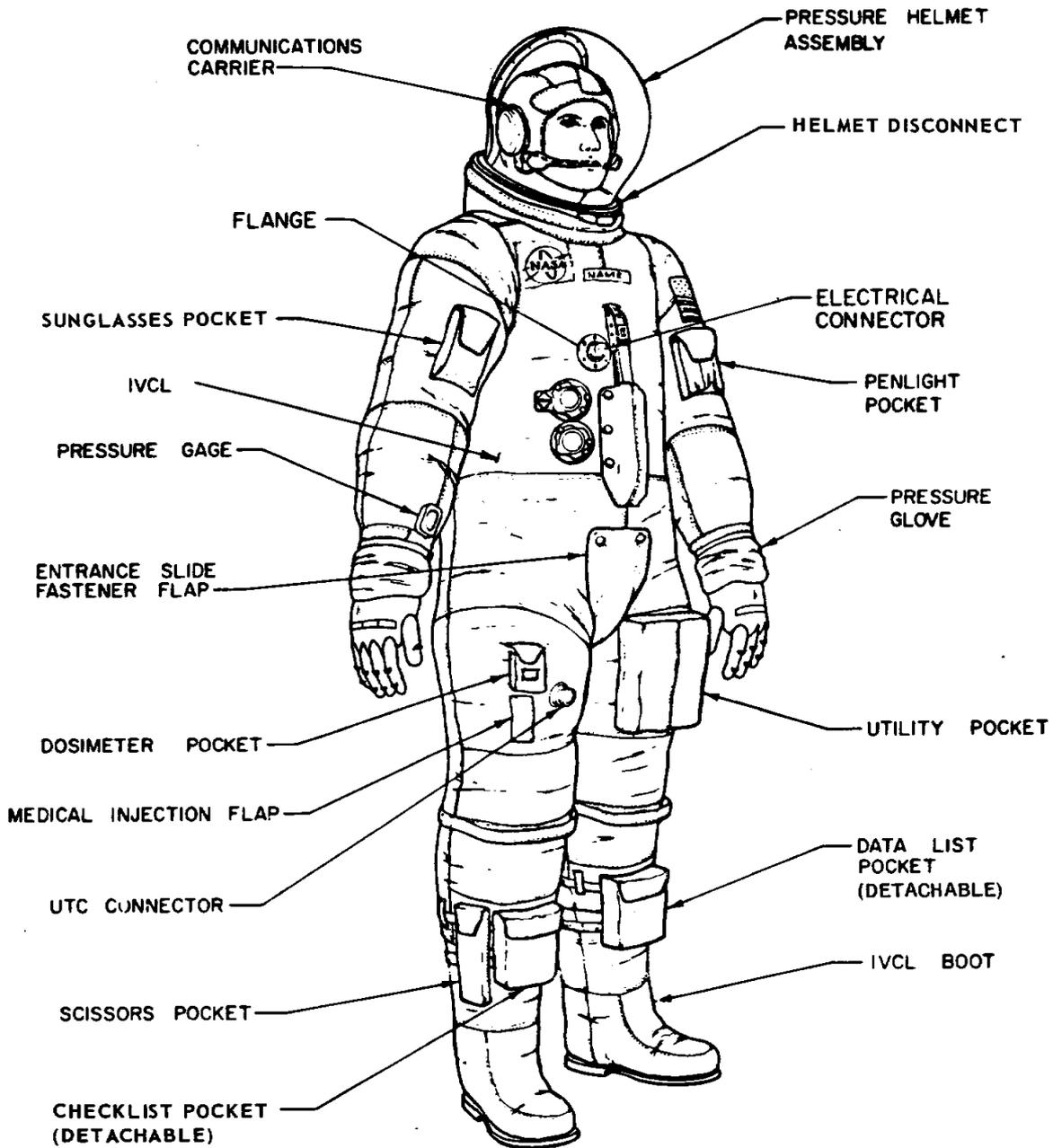


Figure I-4. - Intravehicular pressure garment assembly.

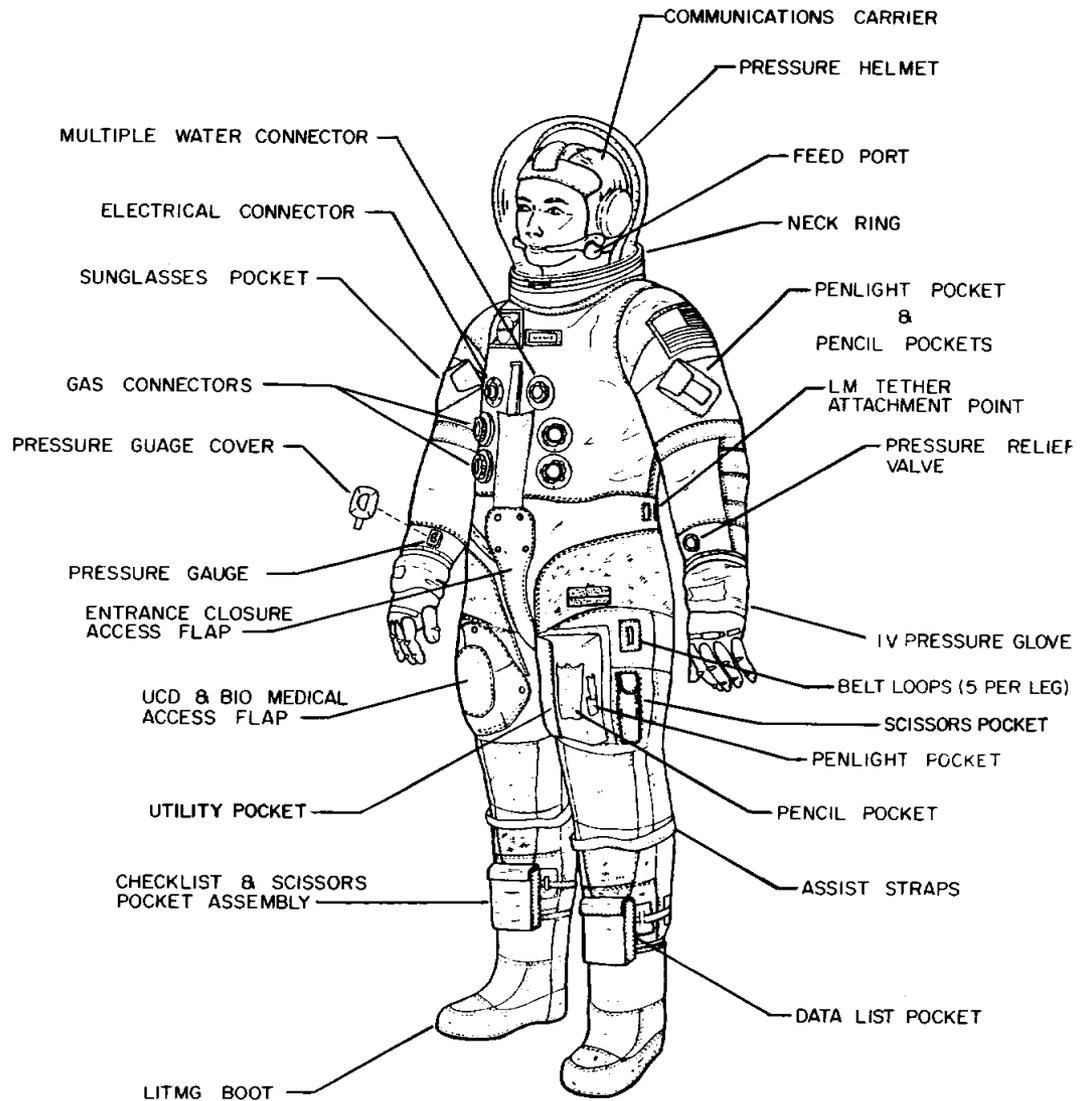


Figure I-5. - Extravehicular pressure garment assembly with arm bearing.

head and hands. The TLSA for the EV-PGA (fig. I-6) and that installed in the IV-PGA (fig. I-12) are basically the same, but some differences do exist primarily because of different mission requirements. The EV-PGA TLSA will be explained first, and only the differences will be discussed for the IV configuration.

2.2.1.1 The TLSA-EV Configuration

The EV configuration TLSA is shown in figure I-6. The torso portion of the TLSA is custom-sized and the limb portions are graduated in size and adjustable to accommodate individual limb lengths.

A pressure sealing and restraint slide fastener closure permits entry into the torso limb suit. A lock assembly, shown in figure I-7, is secured to the restraint assembly and is employed on the suit to captivate the pressure sealing slider to prevent inadvertent opening.

Convolute joints of near constant volume are located at the shoulders, elbows, wrists, hips, knees, and ankles to permit joint movements that require a minimum expenditure of energy. Restraint cables or cords with reinforced attachment points are provided to sustain axial limb loads during pressurized modes of operation and to prevent ballooning of the convolute joints. A typical convolute/cable restraint system is shown in figure I-8. The diagram also shows the biomedical injection patch which is built into the right thigh portion of the torso limb suit to permit a crewman to self-administer a hypodermic injection without jeopardizing the gas retention quality of the PGA. The patch location is identified by a red zigzag stitch line around the perimeter.

The torso limb suit incorporates arm assemblies (fig. I-9). The arm bearing enhances arm rotational movements above the elbow. The PGA boot, which is connected to the torso limb suit, is sized to the individual crewman's foot and has an ankle convolute designed to permit ankle extension and flexion movements. A metal heel clip is provided to interface the boot to the CM couch foot pan for restraint.

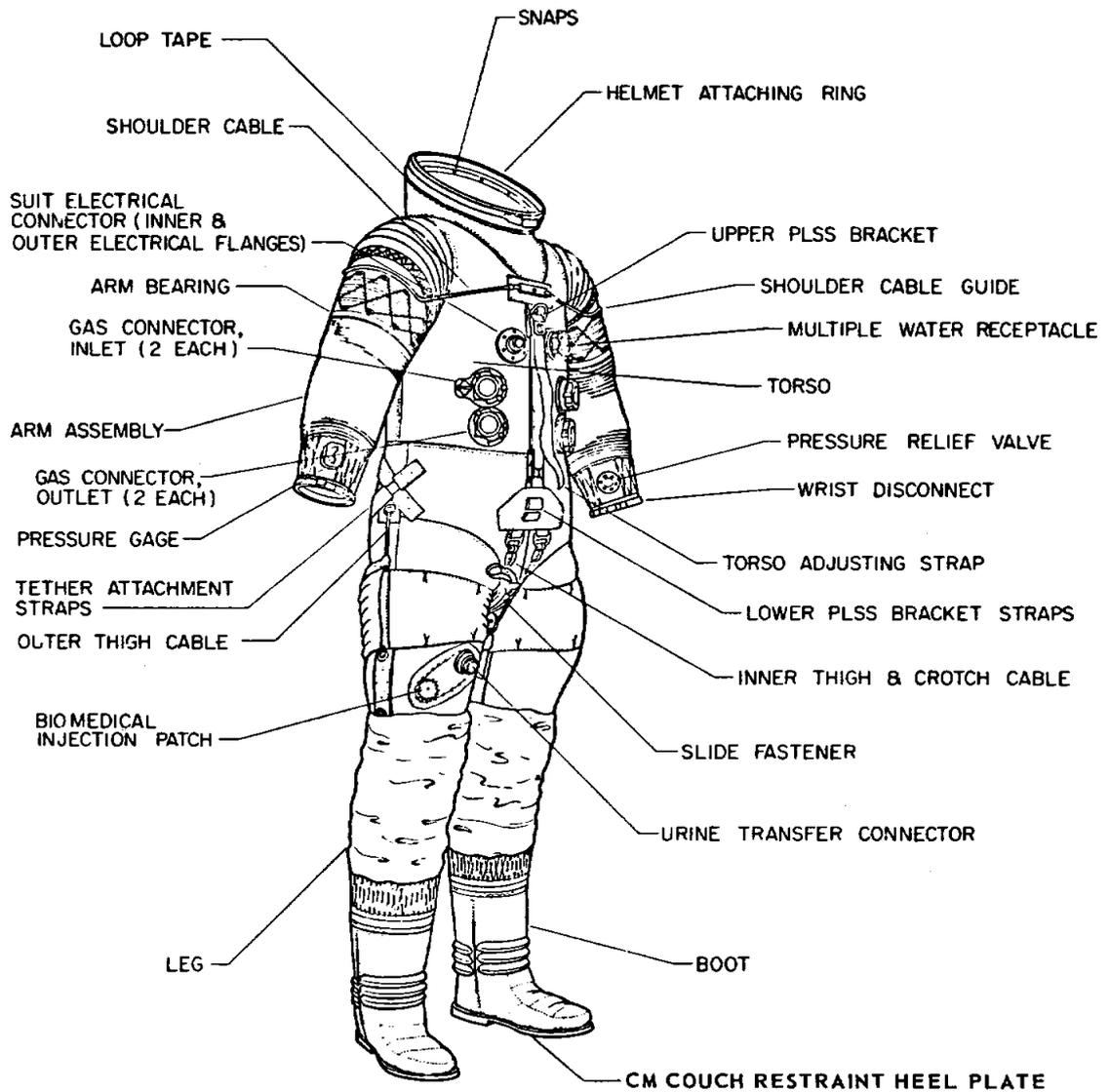
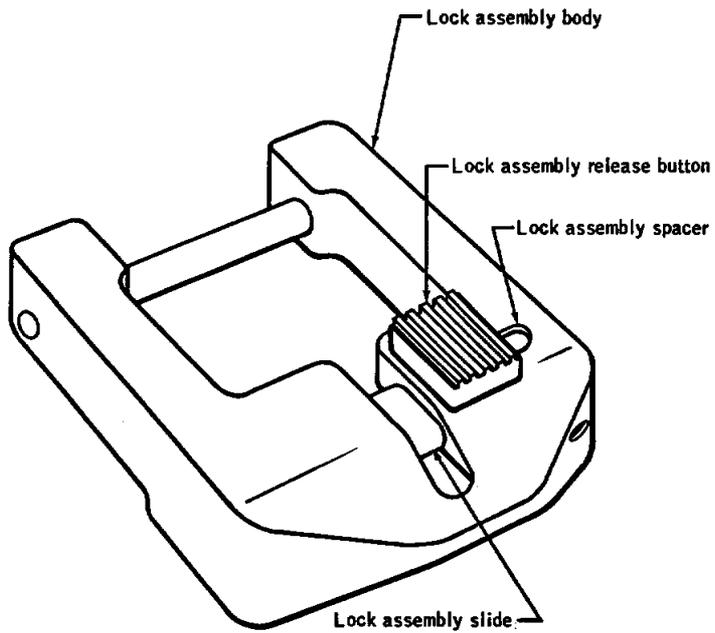


Figure I-6. - The EV TLSA with arm bearing.



LOCKED POSITION

Figure I-7. - Restraint closure lock assembly.

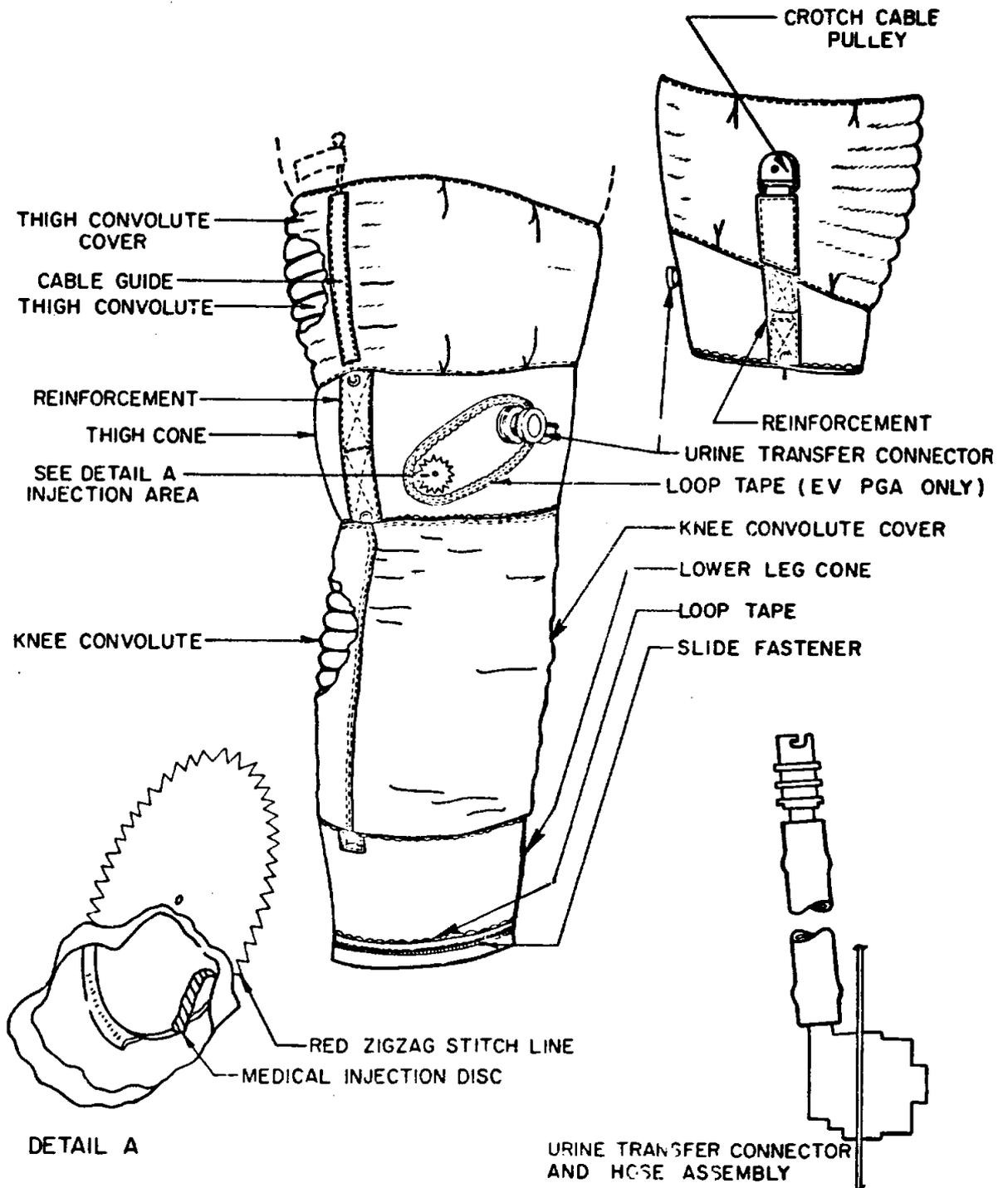


Figure I-8. - Leg assembly.

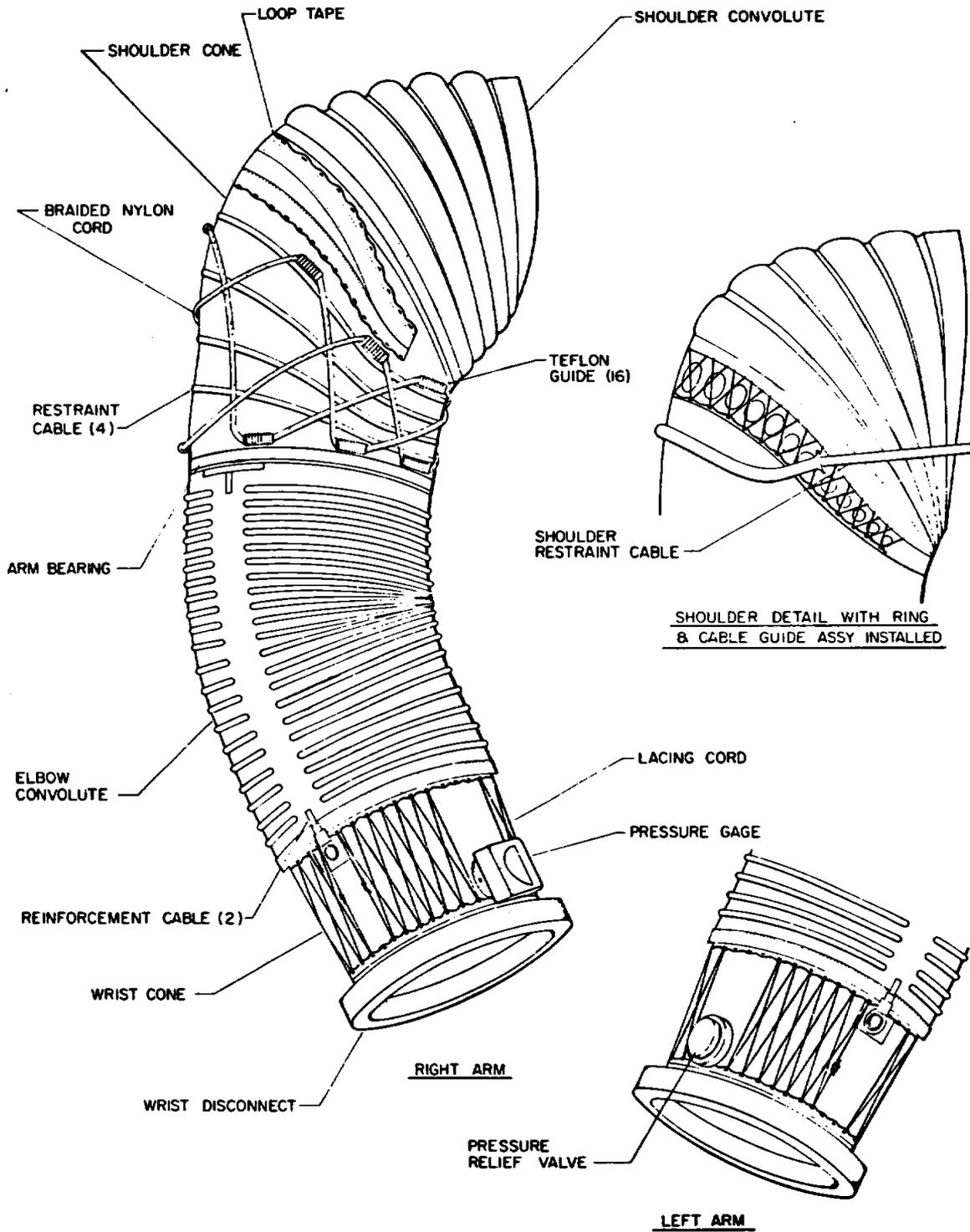


Figure I-9. - Arm assembly with arm bearing.

The innermost layer of the torso limb suit is a liner for comfort and improved donning. A series of noncollapsible ducts are attached on the inner surface of the neoprene-coated nylon bladder and serve as part of the ventilation system. Figure I-10 shows the duct system installed in the EV configuration. The two inlet gas connectors and the two outlet gas connectors are each interconnected by plenum chambers. The ventilation ducts to the torso area and the head are connected to the inlet connectors. The gas outlet flow is from the extremities. A nylon restraint layer maintains the conformal shape of the suit.

2.2.1.2 The TLSA-IV Configuration

The IV configuration of the TLSA (fig. I-11) is basically the same as that for EV.

The IV-TLSA incorporates the arm using the net restraint (fig. I-12). The added mobility provided by the arm bearing is not necessary for intravehicular operations.

The IV ventilation system requires only one set of inlet and outlet gas connectors. The IV ventilation system is shown in figure I-13. It can be seen from this diagram that there is also only one torso vent duct, instead of two as used in the EV configuration.

The left arm of the IV configuration does not incorporate provision for a pressure relief valve. This is not required as a pressure relief capability is provided in the CM suit loop.

2.2.2 Pressure Helmet Assembly

The pressure helmet is a detachable, transparent closure with provisions for feeding, drinking, and attachment of the lunar extravehicular visor assembly (LEVA). The helmet, shown in figure I-14, contains a feedport which allows insertion of a probe for administering water and contingency food to a crewman while wearing the complete PGA in either the pressurized or unpressurized condition. A synthetic elastomer foam vent pad is bonded to the back of the helmet shell to provide a headrest, and to act as a ventilator flow manifold which directs the flow of gas to the oral-nasal area. This flow

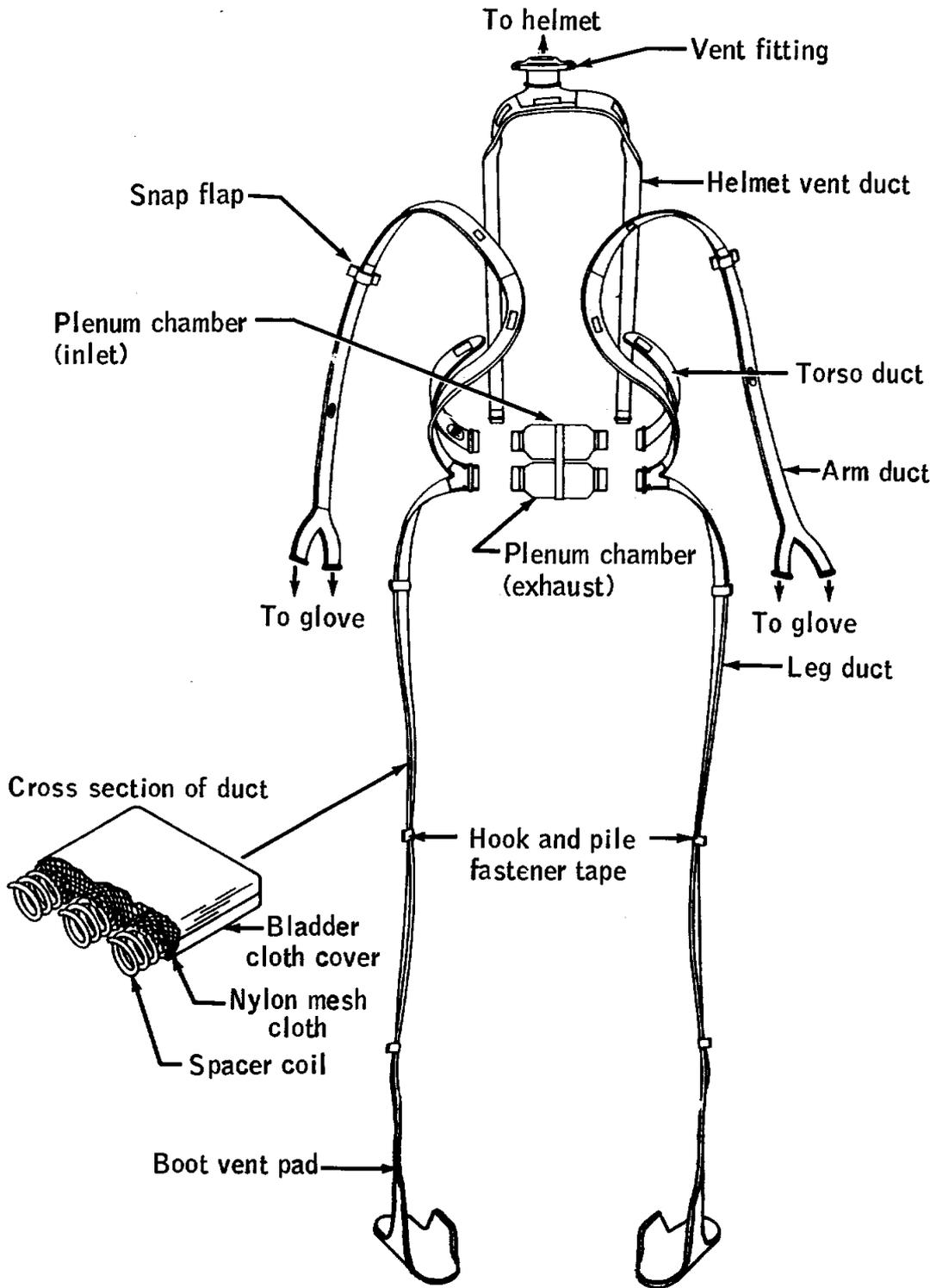


Figure I-10. - The EV ventilation installation.

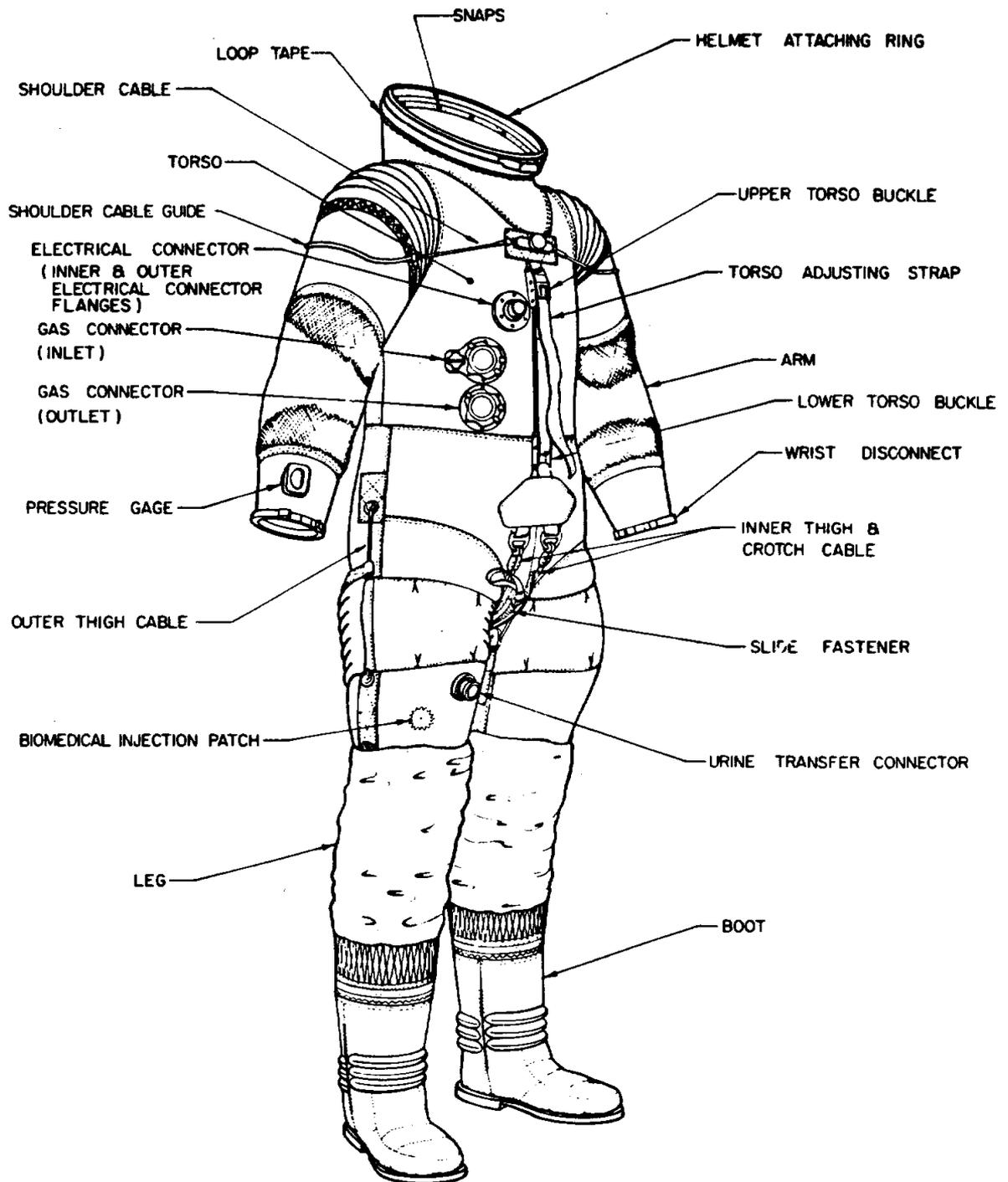


Figure I-11. - Intravehicular torso limb suit assembly.

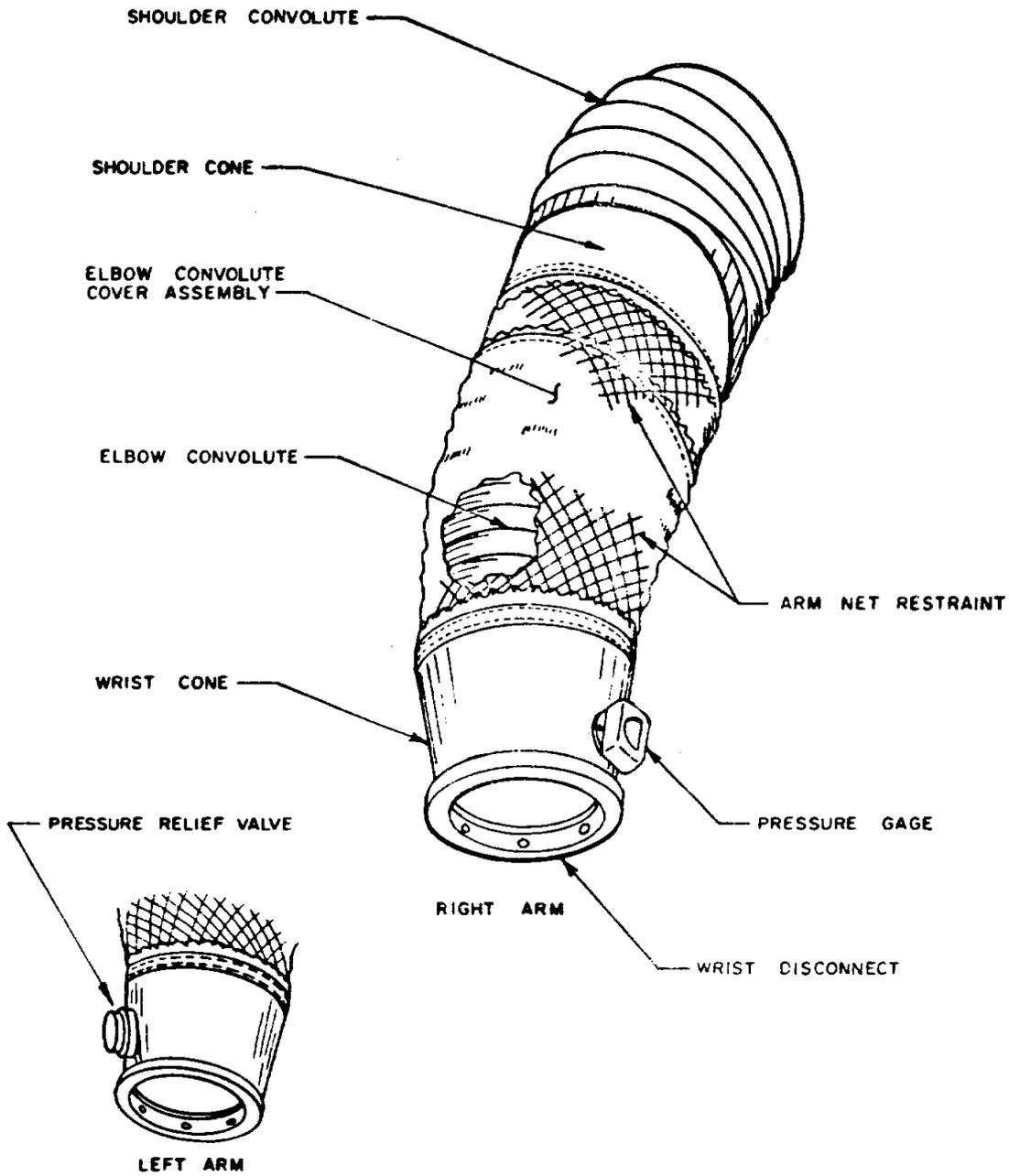


Figure I-12. - Arm assembly with net restraint (IV-PGA only).

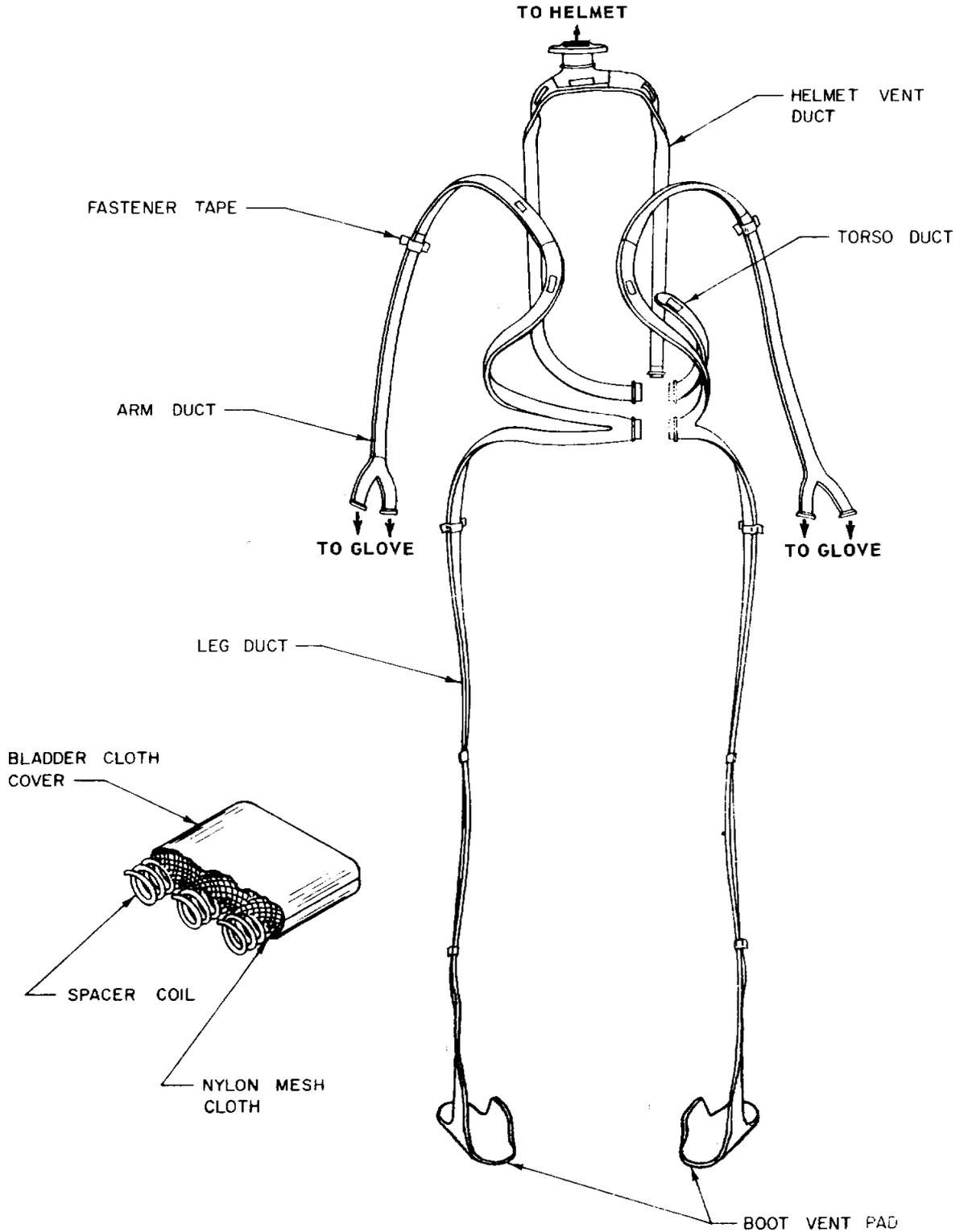


Figure I-13. - The IV ventilation installation.

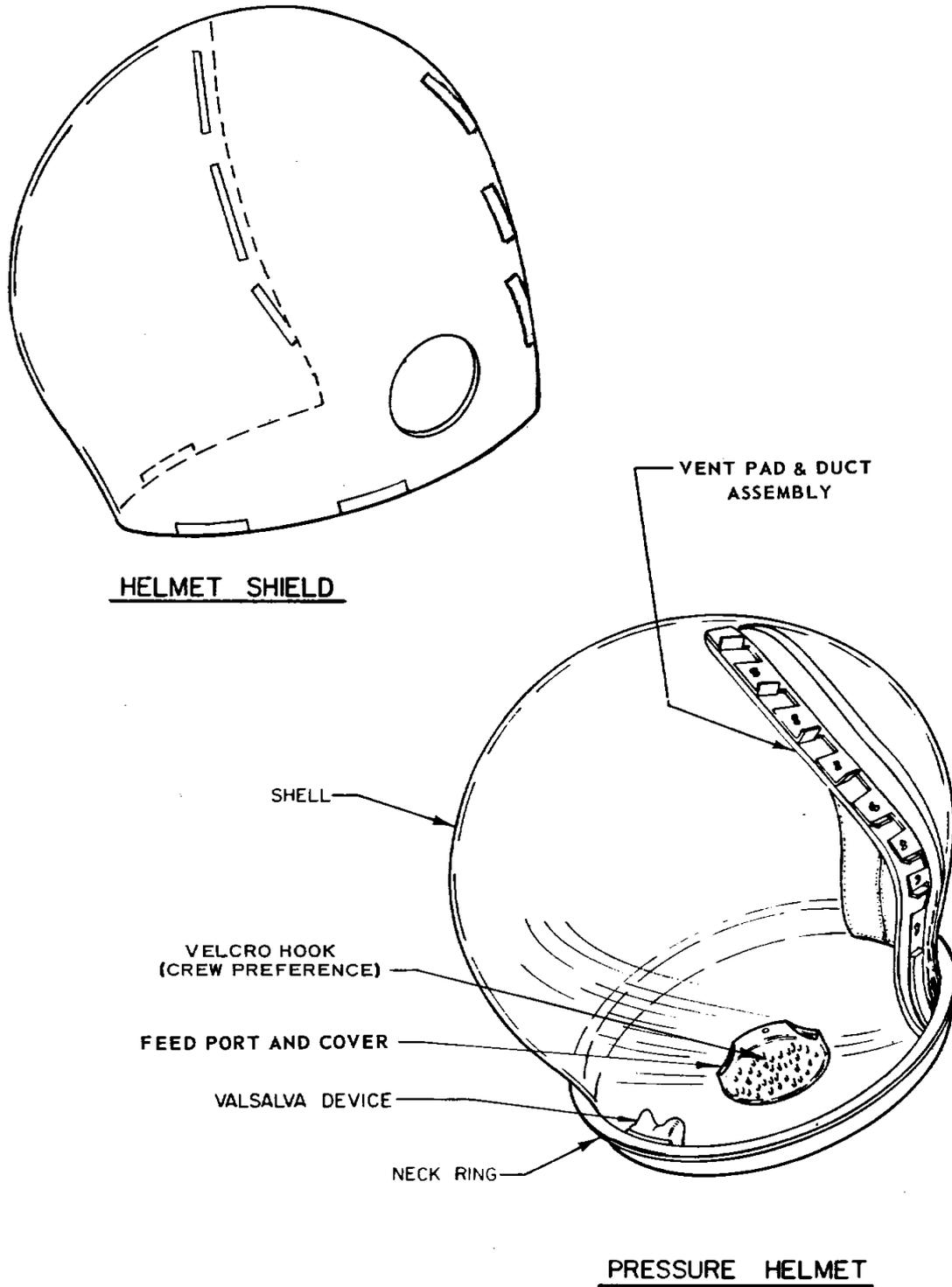


Figure I-14. - Pressure helmet assembly.

causes an efficient exhaust of CO₂ from the nasal area through the torso neck opening. Index marks are provided on the helmet half and the suit half of the neck ring (helmet connector) to assist in the alinement of the helmet when donning.

For donning the helmet, the helmet neck locking ring (fig. I-15) is placed in the ENGAGE position. Index marks are used to aline the helmet neck ring to the suit neck ring. The helmet is then pressed into place and the lock subassembly (fig. I-16) rotated to the LOCK position. The helmet may be removed by pressing the lock button, pulling out the lock subassembly, and rotating the locking ring to the OPEN position. When the lock subassembly is released, the locking ring will automatically go back to the ENGAGE position.

2.2.2.1 Helmet Shield

A slip-on helmet shield (fig. I-14) provides scuff protection for the pressure helmet during tunnel transfer or other intravehicular operation when the probability of scratching or otherwise damaging the helmet is increased.

The helmet shield is a transparent, UV-stabilized, polycarbonate "half-bubble" molded to fit over the front area of the pressure helmet. The shield extends over a rear portion of the helmet to hold it in place. Foam padding on the underside of the shield prevents the shield from scratching the pressure helmet when it is donned.

2.2.3 Pressure Gloves

The pressure glove is a flexible, gas-retaining device which attaches and locks to the torso limb suit by means of a quick-disconnect coupling. There are two basic types of pressure gloves; the PGA pressure glove used for intravehicular operations with the PGA, and the EV glove used during extravehicular activities.

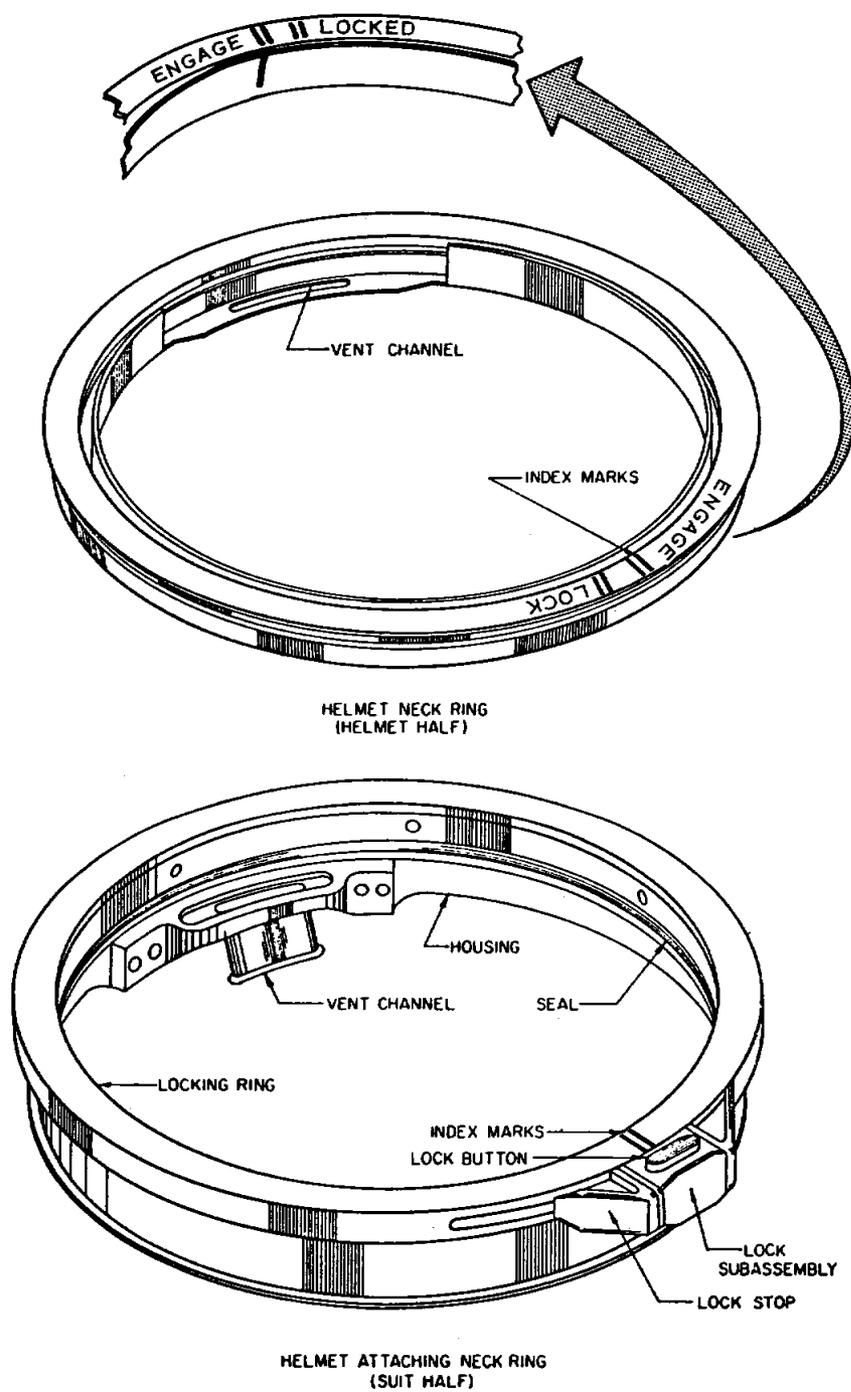
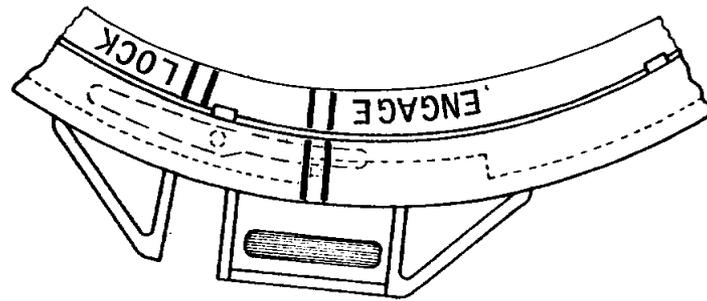
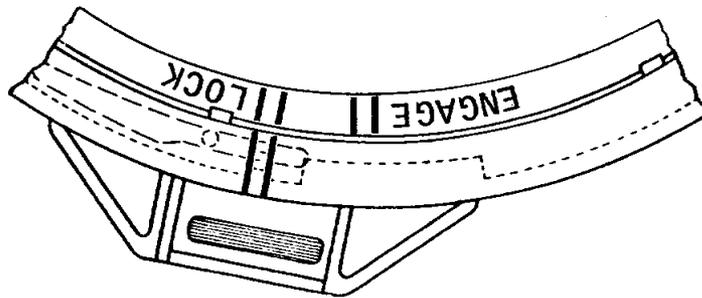


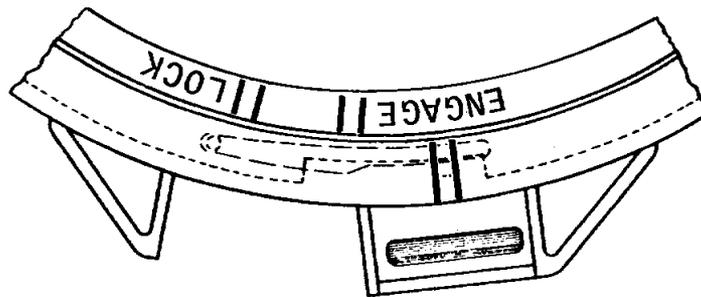
Figure I-15. - Helmet neck ring.



ENGAGE



LOCK



UNLOCK

NOTE: DONNING HELMET

Helmet neck ring and suit ring alignment marks in line only in 'ENGAGE' and 'LOCK' positions

Figure I-16. - Helmet neck ring lock subassembly and helmet ring.

2.2.3.1 The PGA Glove Assembly

The PGA glove (fig. I-17) is used for intravehicular use only. Under normal conditions, the gloves will be donned only when the suit is to be pressurized.

The PGA glove consists primarily of a bladder molded from a hand-cast of the individual crewman's hand. Dexterity of the bladder is increased by built-in relief projections located over the knuckle areas. A standard convoluted section is incorporated in the wrist area to provide omnidirectional mobility of the wrist. The convoluted section is restrained by a system of sliding cables which are secured to the wrist disconnect. The glove side wrist disconnect is the male portion of the wrist disconnect assembly and features a sealed bearing which permits 360° of glove rotation. The fingerless glove is a restraint assembly which is cemented onto the bladder at the wrist area, and encloses the entire hand exclusive of the fingers and thumb. A palm restraint strap is used to minimize the ballooning effect created under pressurized conditions thereby enhancing grip control. The convolute covers serve to protect the bladder and convolute restraint system. The sliding cable-type convolute restraint system accepts the axial load across the convolute.

2.2.3.2 The EV Glove Assembly

The EV glove (fig. I-18) is a protective hand covering which interfaces with the torso limb suit prior to egress for extravehicular operations. The glove consists of a modified PGA pressure glove covered by the EV glove shell. The shell covers the entire hand and has an integral cuff or gauntlet which extends above the wrist disconnect as far as the PGA pressure gage or the pressure relief valve. The EV glove shell is a multilayered assembly which provides scuff, abrasion, and thermal protection to the pressure glove. The layup of the EV glove is described in figure I-19. A woven metal fabric (Chromel-R) is incorporated over the palm and fingers to provide abrasion protection, and additional layers of insulating material are incorporated in the palm area for added thermal protection. The thumb and fingertip shells are made of high-strength silicone rubber-coated nylon tricot for improved tactility and strength. A silicone dispersion coating is applied to the palm, around the thumb and to the inner side of each finger to provide increased gripping characteristics. The outer cover is conformal and does not appreciably restrict the dexterity of the inner glove. A

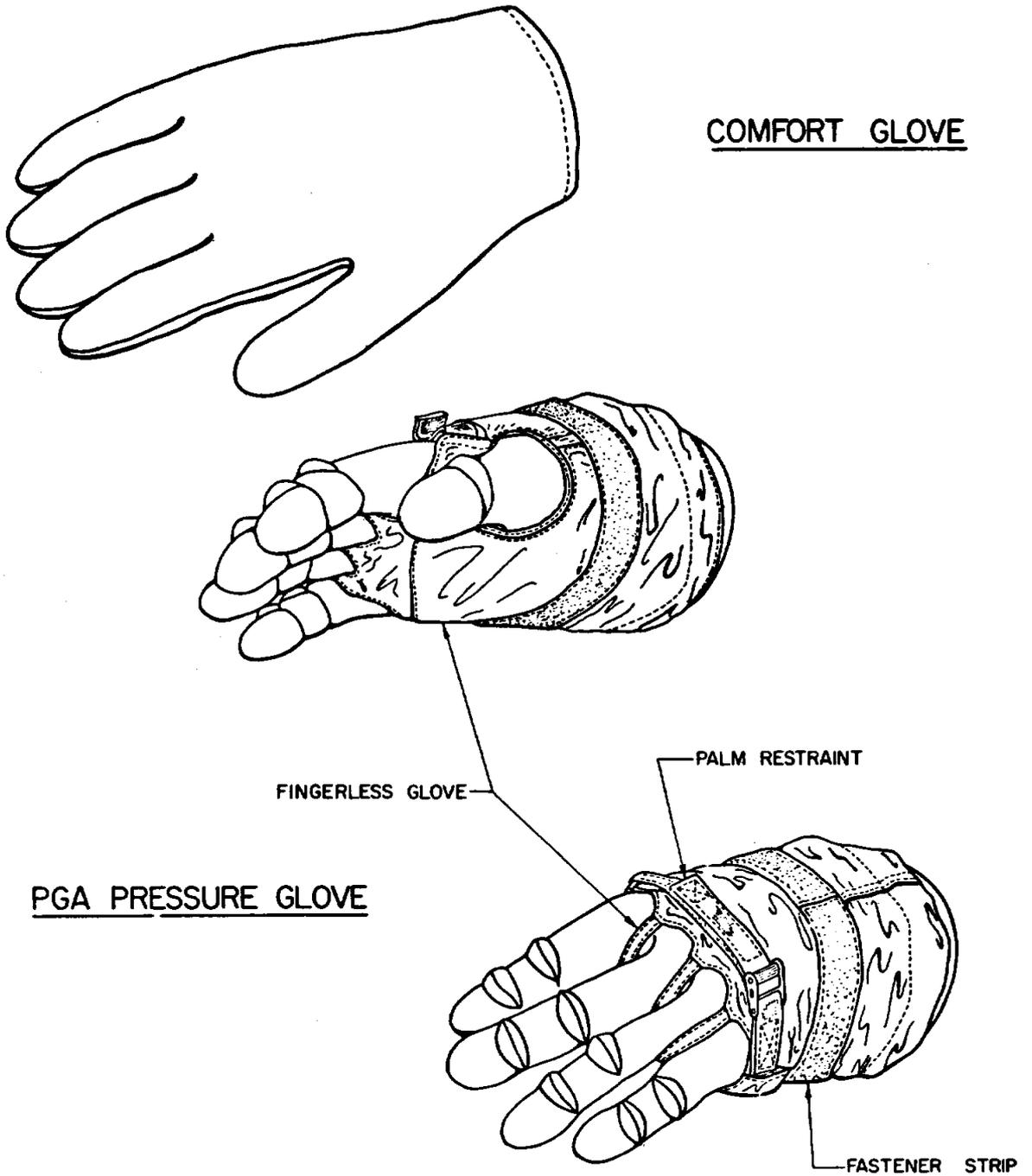


Figure I-17. - The PGA/TMG pressure glove assembly.

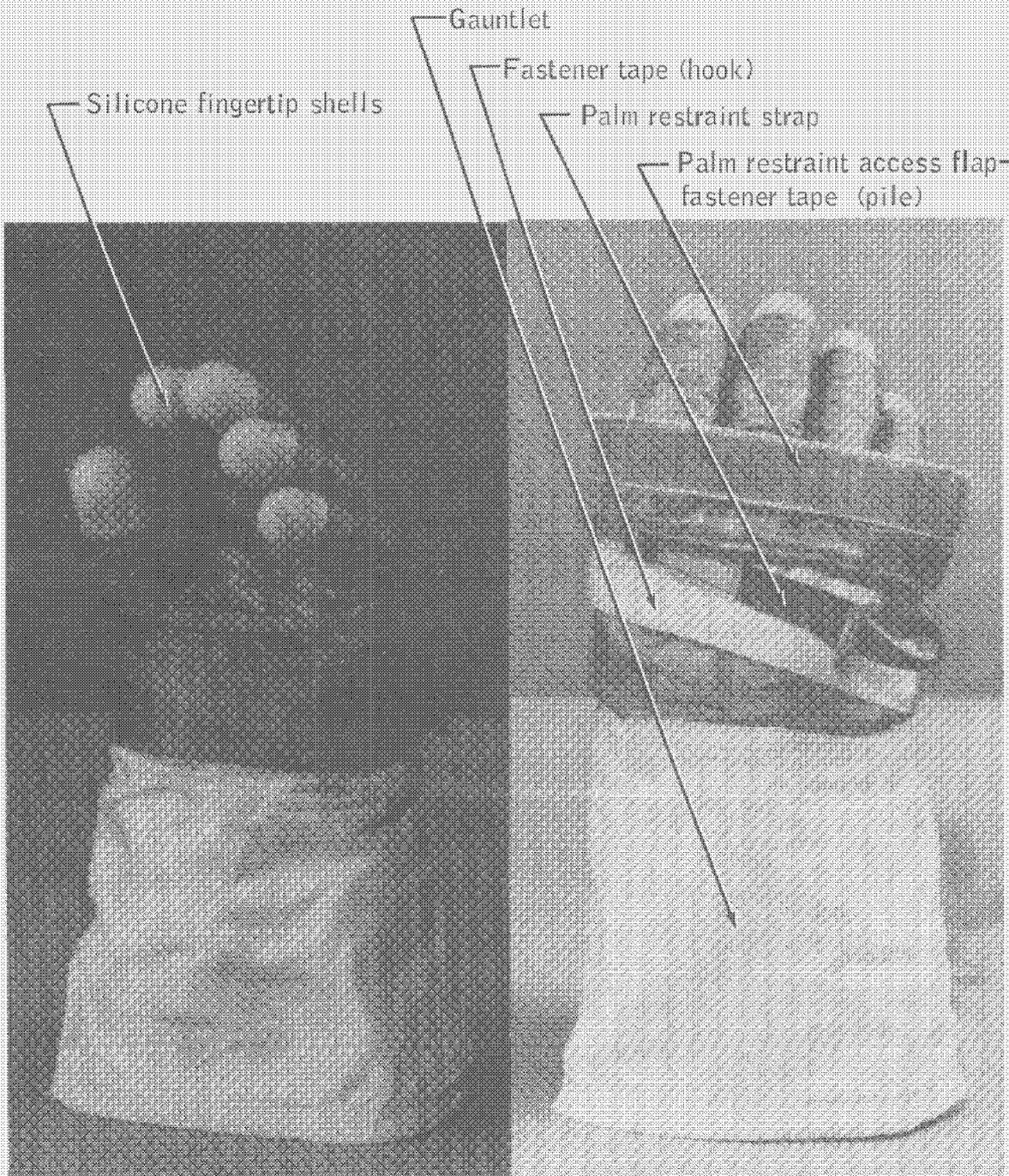
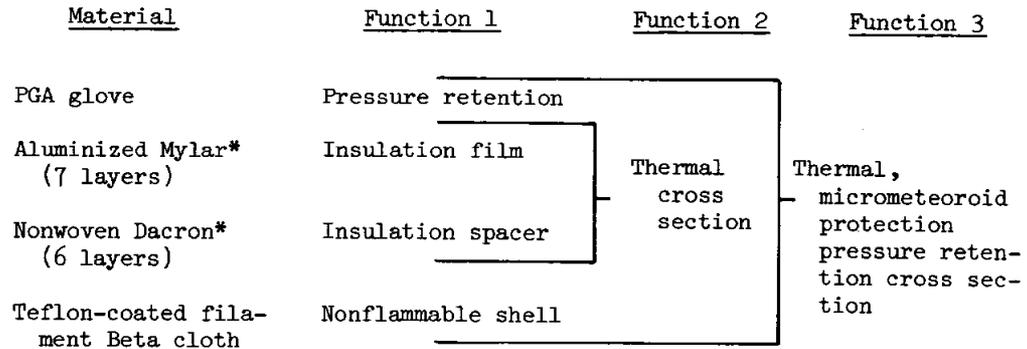
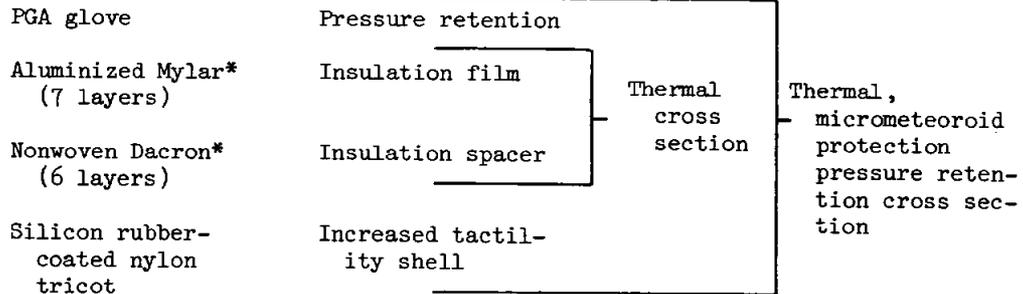


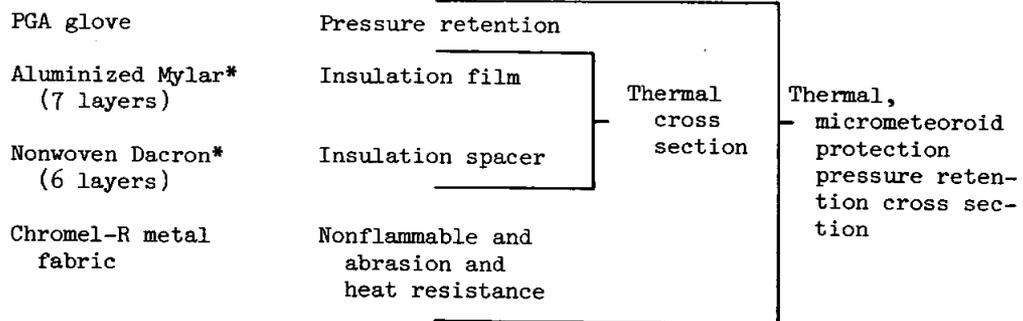
Figure I-18. - Extravehicular glove.



GAUNTLET



THUMB- AND FINGER-TIPS



PALM, THUMB, AND FINGERS

*Alternating layers of insulation and spacer.

Figure I-19. - Material cross section for EV glove (listed from the inside out).

flap is sewn onto the back of the glove shell and provides access to the palm restraint strap. The flap is opened or closed by engaging or disengaging the hook-and-pile fastener tape strips. The palm restraint strap can be tightened as necessary to minimize the ballooning effect of pressurization. The shell assembly is secured to the pressure glove at the back and palm areas of the hand by hook-and-pile fastener tape and near the tip of each finger by two anchor straps and neoprene adhesive. When the palm restraint flap is disengaged and the glove shell assembly is pulled back to disengage the hook-and-pile tape strips, the glove shell can be removed for contingency spacecraft control by disengaging the cemented interfacing areas near the fingertips.

A cover glove constructed of a single layer of silicone-coated Nomex is provided with each EV glove for increased abrasion protection during EV operation of the core driller. Each cover glove is without fingertips to maintain the original tactility of the EV glove. The EV glove palm restraint has been modified to allow ready access to the restraint strap and to secure the cover glove by using the restraint access flap. The cover glove is required only for the core drilling operation and is expendable after that time.

2.2.3.3 Wristlets

Cotton wristlets are available as a field optional item to prevent chafing caused by the PGA wrist disconnects when gloves are removed.

2.2.3.4 Comfort Glove

Comfort gloves constructed of nylon tricot (fig. I-17) are provided as field optional items to be worn under either the PGA glove or the EV glove. The comfort glove provides for easier donning of the pressure glove and acts as a sweat absorption layer between the hand and the pressure glove bladder.

2.2.4 External Protective Coverlayers

External coverlayers are integrated with the PGA's to provide added protection to the crewman and to the space suit. The extent of this protection depends upon the configuration of the PGA and the intended environment to which it will be exposed. The IV-PGA is provided with an intravehicular coverlayer (IVCL) and the EV-PGA is provided with an integrated thermal micrometeoroid garment (ITMG).

2.2.4.1 Intravehicular Coverlayer

The IV coverlayer (fig. I-20) is a three-layered overgarment designed to protect the crewman and the torso limb suit from abrasion. The IVCL is conformal in shape to the torso limb suit with mobility relief incorporated into the knee, elbow, shoulder, and hip areas. The coverlayer is composed of three layers: an inner layer of Nomex cloth, and two outer layers of nonflammable Teflon-coated filament Beta cloth. Additional abrasion layers (constructed of one thickness of Teflon-coated filament Beta cloth) are incorporated on the exterior of the suit at the knee, elbow, and shoulder areas. An abrasion pad, constructed of Nomex felt, is attached to the suit at each shoulder area. Additional scuff protection is provided by Teflon cloth patches in high abrasion areas.

Accesses through the IVCL are provided for the entrance closure, and the medical injection disk and urine transfer connector by means of flap assemblies. These flap assemblies have identical cross sections to the main body of the IVCL. The IVCL also includes a flashlight pocket on the upper left arm section for stowage of two pens and a pen flashlight, a sunglasses pocket on the upper right arm section, and a utility pocket on the upper left thigh section. All pocket assemblies are constructed of an outer layer of Beta cloth over an inner layer of Nomex fabric, and all are held closed by means of flameproof Velcro located on the flaps.

There is also an IVCL boot cover assembly which fits over the torso limb suit boot which is secured by mating and lacing the loop tape located around the top and the bottom of the boots. The IVCL boot cover assembly is constructed of the same materials as the main body of the IVCL and does not incorporate a heel and sole.

2.2.4.2 Lunar Integrated Thermal Micrometeoroid Garment

The lunar integrated thermal micrometeoroid garment (LITMG) (fig. I-21) is a lightweight multilaminate assembly designed to cover and conform to the contours of the torso limb suit assembly. The cross section of materials (reference fig. I-22) for the LITMG affords protection against the thermal and micrometeoroid hazards encountered during the free space and lunar excursions of an Apollo mission. For protection against abrasion, an additional external layer of Teflon fabric is attached to the knee, waist, elbow, and shoulder areas, and a layer of Chromel R is added on the back under the PLSS.

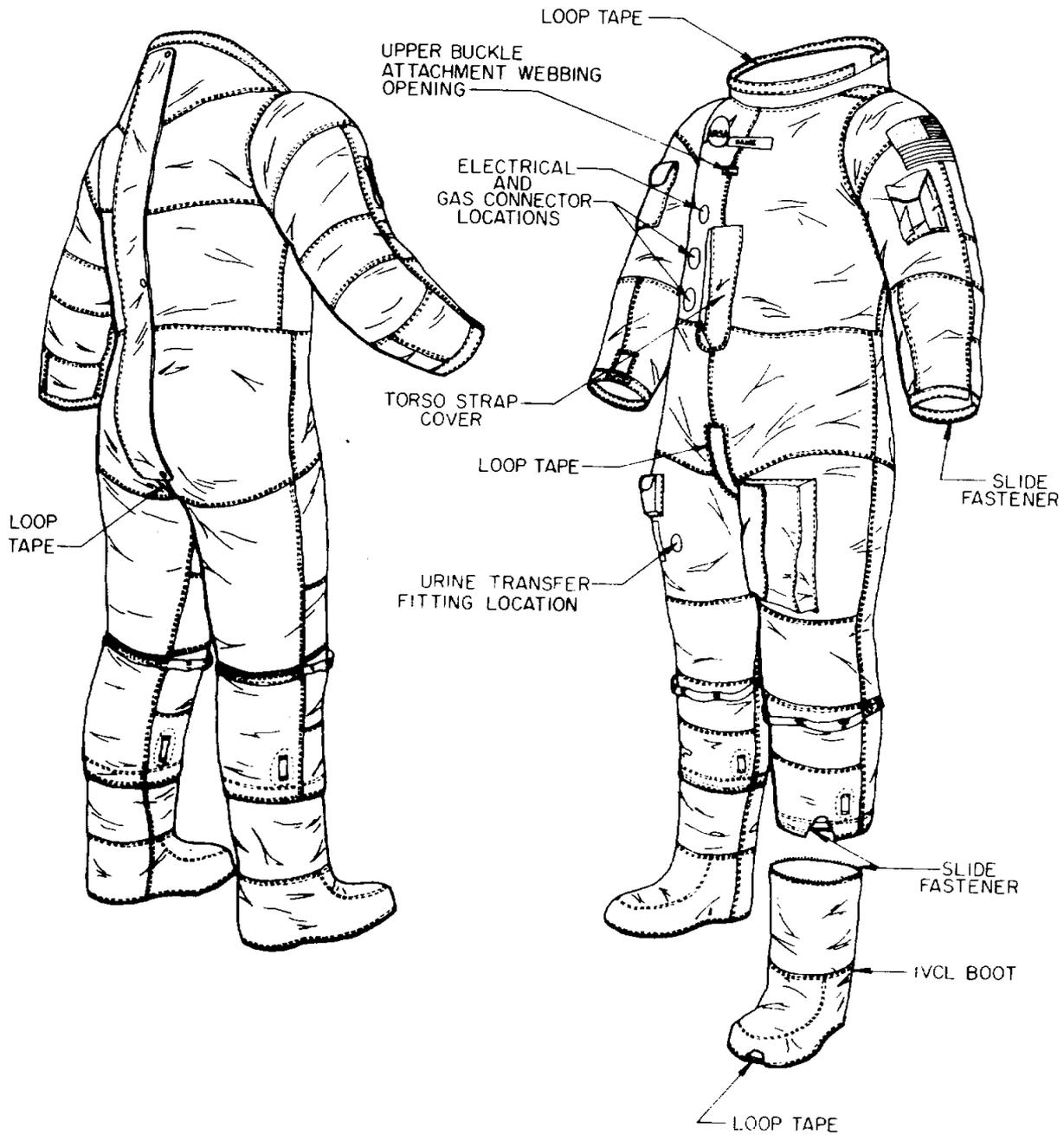


Figure I-20. - Intravehicular coverlayer.

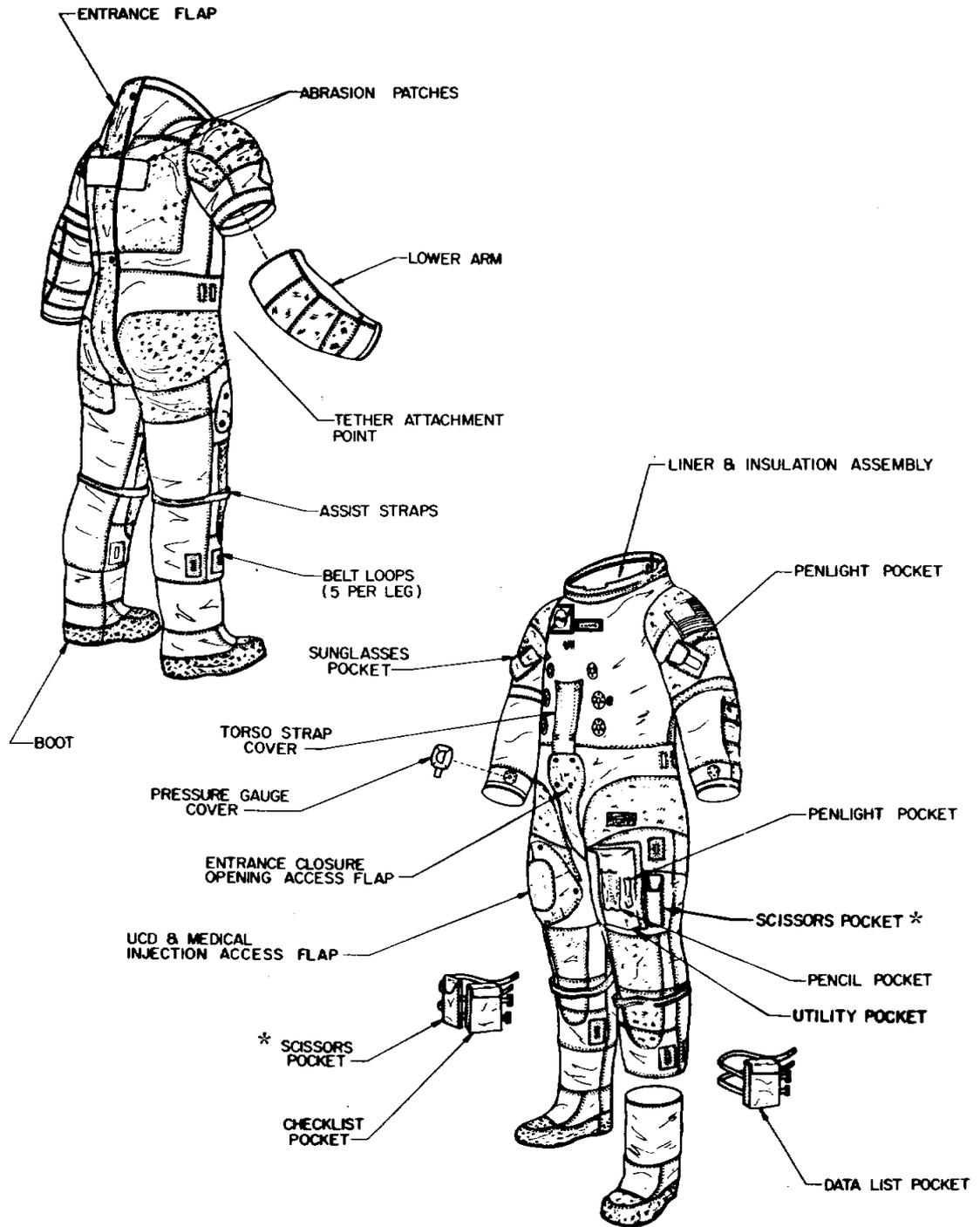


Figure I-21. - Lunar integrated thermal micrometeoroid garment.

<u>Material</u>	<u>Function 1</u>	<u>Function 2</u>	<u>Function 3</u>
Rubber-coated nylon (ripstop)	Inner liner		
Aluminized Mylar* (5 layers)	Thermal radiation protection	Thermal cross section	Thermal, micrometeoroid protection cross section
Nonwoven Dacron* (4 layers)	Thermal spacer layer		
Aluminized Kapton film/Beta marquisette lami- nate (2 layers)	Thermal radiation protection		
Teflon-coated fil- ament Beta cloth	Nonflammable and abrasion pro- tection layer		

*Alternating layers of insulation and spacer.

Note: In addition to the above coverage, there is a 40- to 60-percent coverage by Teflon abrasion patches.

**Figure I-22. - Material cross section for lunar ITMG
(listed from the inside out).**

Pockets are provided on the shoulder of each arm and on the thigh of the left leg. Three belt loops are secured at the bottom of each leg for holding the detachable data-list pocket and the checklist and scissors pockets. An active dosimeter pocket is located under the urine transfer connector (UTC) and medical injection access flap.

Access flaps constructed of a thermal resistant cross section are held closed by a system of snap fasteners and fire resistant hook-and-pile fastener tape. These access flaps cover the entrance closure and the UTC and medical injection area. Thermal protective covers provide protection to the pressure relief valve and the PGA pressure gage while permitting continuous monitoring of the suit pressure.

The commander's ITMG has 1-1/2-inch identification bands of red Beta fabric completely circling each knee and elbow. These bands provide visual identification of the crew commander.

The LIITMG boots cover the PGA boots exclusive of the sole and heel. Each boot assembly employs the same cross section as the LIITMG. A system of loop tape and lacing cord secures the LIITMG boots to the PGA boots at the boot top and around the sole and heel area. A zipper is provided at the top of each boot for attachment to the leg of the LIITMG. A Teflon patch encircling the ankle has been added to each ITMG boot assembly to prevent skin abrasion caused by the lunar boot.

2.2.5 Connectors, Controls, and Instrumentation

The PGA contains various connectors, controls, and instrumentation necessary to: (1) interface with the spacecraft environmental control system, (2) allow the crewman to make adjustments for comfort and safety, (3) allow the crewman to monitor system status, and (4) interface with the portable life support system and oxygen purge system (EV-PGA only).

2.2.5.1 Gas Connectors

Both configurations are provided with an inlet and an outlet gas connector (fig. I-23) for interfacing with the ventilation loops of the ECS, PLSS, or other life supporting systems. The EV-PGA, however, is provided with two sets; the two inlet connectors interconnected by a plenum chamber, and the two outlet connectors interconnected the same way. This is required to provide an uninterrupted transfer between life support systems.

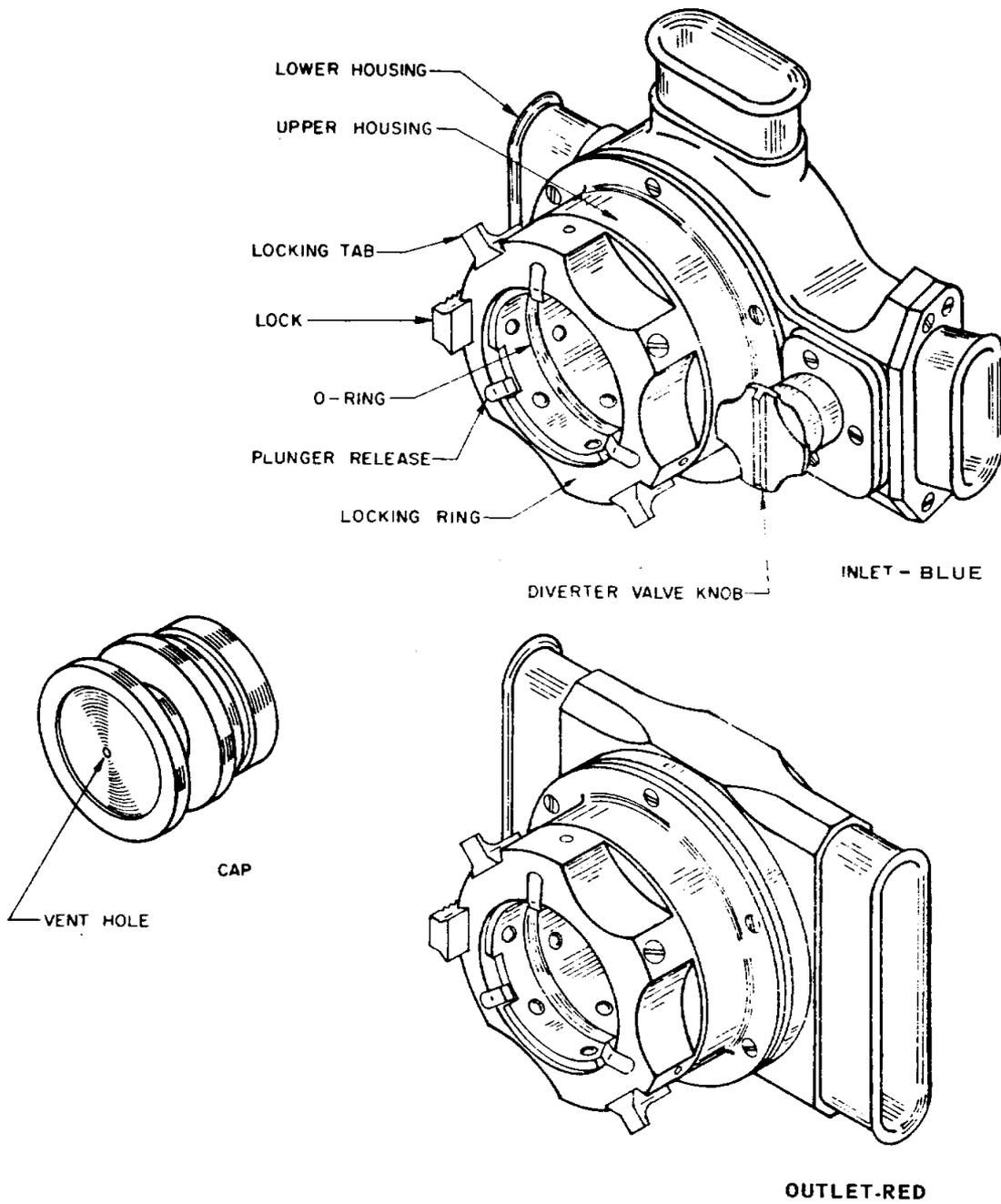


Figure I-23. - Gas connectors.

An umbilical connector is automatically locked by placing it firmly into the gas connector. (Force required should not exceed 20 pounds.) Once the umbilical connector is firmly engaged with the PGA gas connector, the crewman then engages (locks) the redundant lock. The redundant lock is engaged by sliding it in the direction of the connector base using the thumb and forefinger. The PGA gas connectors must be manually unlocked to release and disengage the umbilical. The locking tabs may be released by pulling outward with the thumb and forefinger, thus disengaging them and enabling the locking ring to be rotated to the gas connector OPEN position. This permits the umbilical to be separated from the gas connector. The gas connector locking ring will automatically be in its OPEN position, for immediate or subsequent reengagement of the umbilical.

- 2.2.5.1.1 Inlet gas connector.- The inlet gas connector (fig. I-23) is a flange-mounted ball/lock assembly with an automatic locking and manual unlocking mechanism. A spring-loaded water block, when gas connectors are not used, seals the connector port preventing a flow of gas out of the PGA when pressurized, or a flow of water into the PGA when submerged in water. The hose nozzle cannot be disengaged unless the water block seats and providing a gas seal. A gas connector cap (fig. I-23) is provided for installation in an unused inlet connector port to prevent inadvertently depressing the water block. The cap has a vent hole through it to equalize pressure on both sides of the cap when installed.

The inlet connector permits the distribution of inlet ventilating gas flow to the helmet, torso ducts, and to the adjacent inlet connect (EV configuration only). The inlet connector has a butterfly diverter valve with two positional modes; OPEN, used for intravehicular operations, and CLOSE, used for extravehicular operations. The position of the valve is identified by a raised projection on the diverter valve knob, horizontal for OPEN, and vertical for CLOSE. In the CLOSE (EV) position, the inlet gas flow is directed to the helmet vent duct and in the OPEN (IV) position, the flow is divided between the helmet vent duct and the torso duct(s). To change the valve positions, the control knob is pulled out and rotated 90° in either direction to the desired position. The direction is not important since the knob may be rotated 360° in either direction.

2.2.5.1.2 Outlet gas connector.- The outlet gas connector (fig. I-23) is a flange-mounted ball/lock assembly with an automatic locking and manual unlocking mechanism. The outlet connector also incorporates a spring-loaded water block which prevents the flow of gas out of or water (when submerged) into the suit when the connector is not in use. The hose nozzle cannot be disengaged unless the water block seats providing a gas seal.

A gas connector cap is provided for installation in the unused connector port to prevent inadvertently depressing the water block. The cap has a vent hole through it to equalize pressure on both sides of the cap when installed.

2.2.5.2 Multiple Water Connector

The multiple water connector (fig. I-24) is a dual passage ball/lock assembly consisting of a receptacle, LCG water connector, PLSS water connector and plug. The receptacle is mounted on the extravehicular PGA torso and acts as the interface between the LCG connector and the PLSS water connector. A protective internal plug provides PGA pressure integrity when the LCG water connector has been removed from the PGA multiple water receptacle.

To engage and disengage the LCG water connector during donning and doffing, the following procedure is employed. With the locking ring in its OPEN position, the LCG water connector is aligned with the receptacle port by positioning with a thumb and forefinger and rotating the locking ring to its LOCK position. To disengage the LCG water connector, the two locking tabs are pulled out with the thumb and forefinger and the locking ring is rotated to its OPEN position. The LCG water connector is then extracted from the receptacle. To engage the PLSS water connector, the connector is aligned 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 PLSS water connector may be disengaged by pulling the two locking tabs out and rotating the locking ring to its OPEN position. The locking mechanism will remain in that position ready for immediate or subsequent engagement.

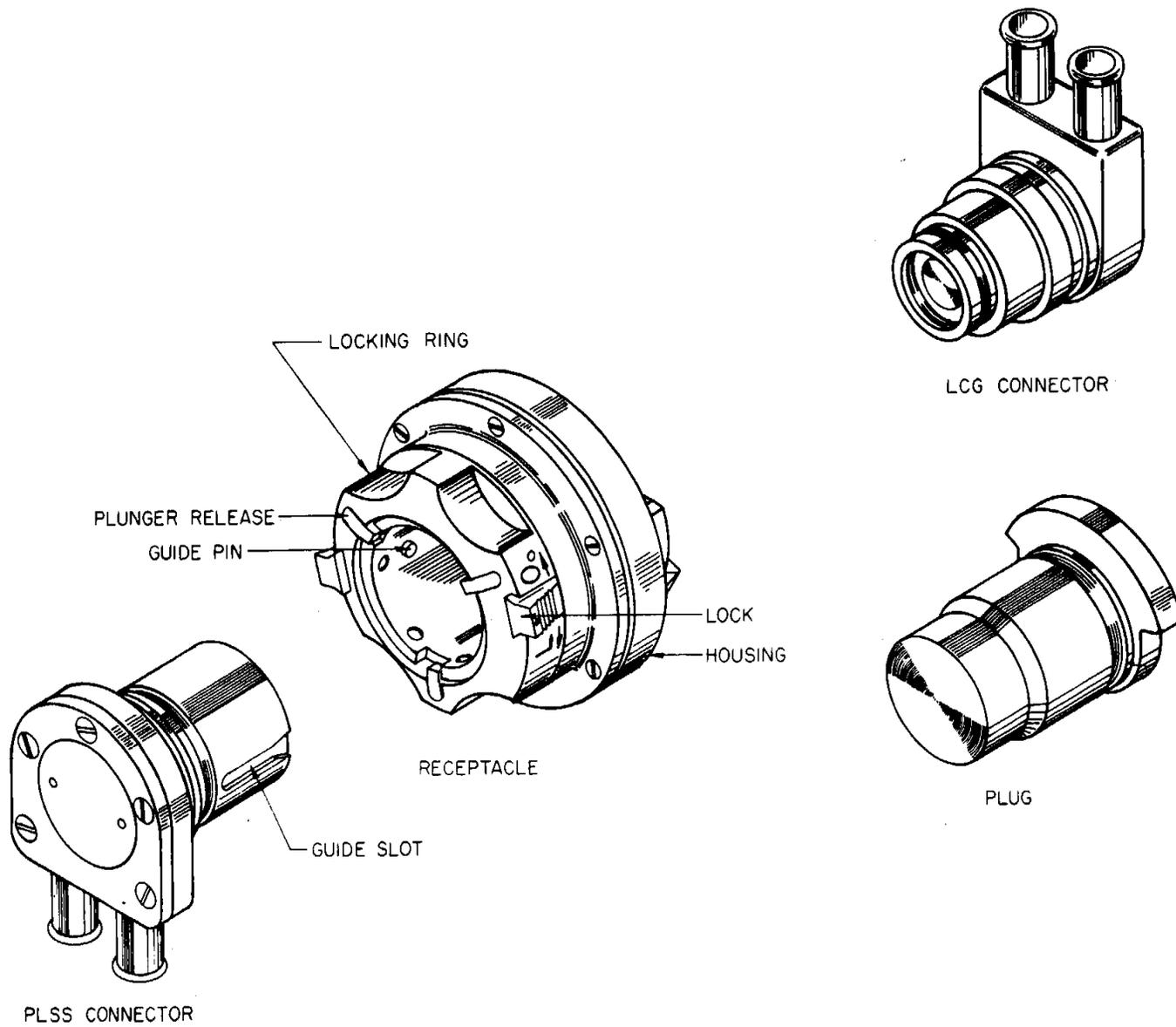


Figure I-24. - Multiple water connector.

2.2.5.3 Wrist Disconnect

The PGA wrist disconnect coupling (fig. I-25) has a suit half and a glove half. The suit coupling has a manually activated lock mechanism which has three positions: ENGAGE, LOCK, and OPEN. To connect the glove to the suit, the suit locking ring is put in the ENGAGE position and the glove coupling is placed into the suit coupling. The locking ring is then rotated to the LOCK position. To remove the glove, the two locking tabs are pulled outward with the thumb and second finger, the locking ring torqued slightly toward its OPEN position, and the lock button depressed, permitting rotation to OPEN position.

2.2.5.4 Suit Electrical Harness and Bioharness

The suit electrical harness (fig. I-26) has a central 61-pin connector from which two branches extend. One branch is used to connect to the communications cap or carrier, while the second, shorter branch is connected to the bioharness. The communications branch includes a 21-pin connector, and the bioinstrumentation 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 torso limb suit assembly. A strip of loop tape extends from the central connector to each branch connector and is anchored in place to offer restraint support for the branch electrical wires. Each branch is covered with a Teflon fabric sheath and a Teflon fabric cover. The restraint loop tape and the Teflon fabric covers are attached to each connector with a metal clamp. The central 61-pin connector is designed to receive the ball/lock engagement mechanism of the communications and bioinstrumentation umbilical of the spacecraft or the portable life support system. The 9- and 21-pin connectors employ a pawl or latch engaging mechanism.

2.2.5.5 UCTA Connector and Hose Installation

The UCTA connector and hose installation (fig. I-8) consists of a ball/lock connection and a sized length of hose. The connector is flange-mounted to the right leg thigh cone and is designed to receive the spacecraft waste management umbilical. The hose assembly is attached to the inner connector and extends to a male adapter which mates with the UCTA connector. The installation is designed to convey waste from the UCTA to the spacecraft waste management system.

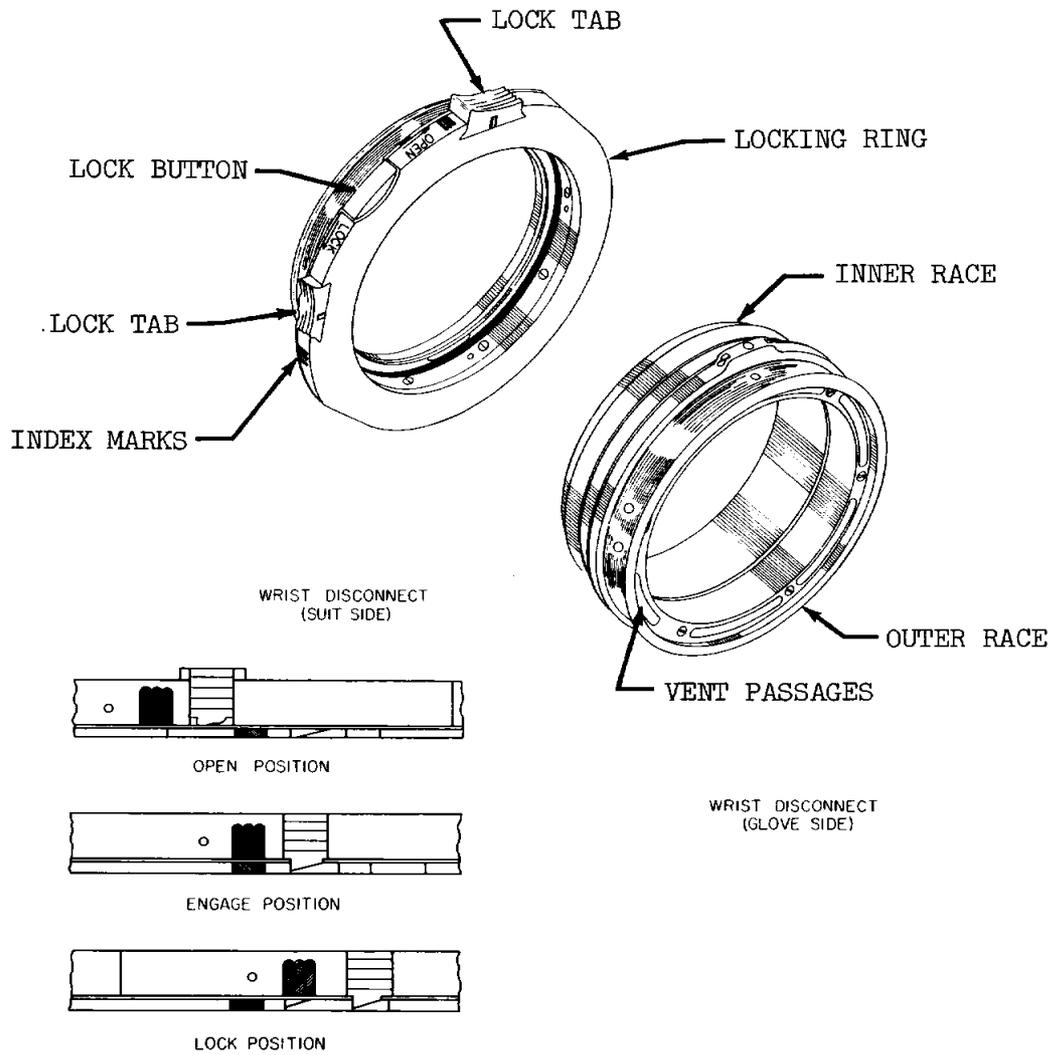


Figure I-25. - Wrist disconnect.

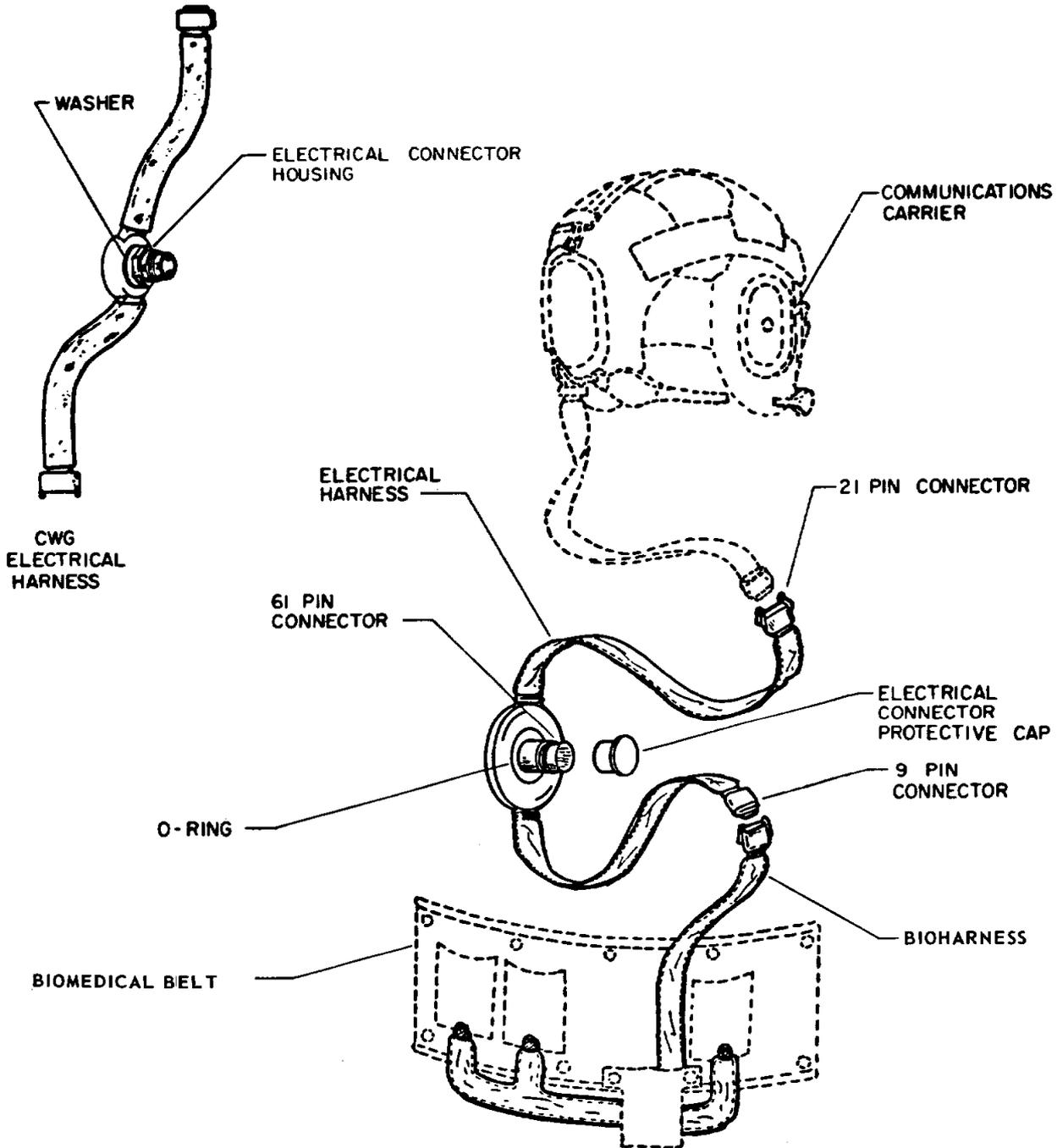


Figure I-26. - Suit electrical harness and CWG electrical harness.

2.2.5.6 Detachable Pockets

Detachable pockets are strapped around the left and right leg of the ITMG or IVCL. The data-list pocket may be installed "flap down" on the right thigh, "flap up" on the left thigh, or on the lower left leg, whichever the crewman prefers. The checklist and scissors pocket is strapped to the lower right leg. As a field optional item, Velcro hook-and-pile may be installed to allow the crewman to fasten the pocket flap in the open position.

2.2.5.7 Neck Dam

A neoprene neck dam (fig. I-27) engages into the helmet attaching ring to prevent water from entering the suit during water egress. A restraining lanyard that snaps onto the PGA is provided.

2.2.5.8 Pressure Relief Valve

The pressure relief valve (fig. I-28) is thermally insulated and is mounted on the left wrist of the PGA, and opens and closes between 4.8 and 5.5 psid to protect the PGA from over-pressurization. The valve fully reseats at 4.8 psid to maintain PGA pressure integrity. The valve accommodates a flow rate of 3.6 lb/hr at 5.5 psia in the event of a failed-open primary oxygen pressure regulator in the PLSS.

2.2.5.9 Pressure Gage

The dial indicating pressure gage (fig. I-55) enables the crewman to ascertain at a glance the amount of pressure (within ± 0.15 psi) in the PGA. The gage is thermally insulated and is mounted on the right wrist cone. The dial covers a pressure range of 2.5 to 6.0 psig.

2.2.5.10 Dual Position Purge Valve

The purge valve (fig. I-29) is inserted in the red unused outlet gas connector during EVA. The purge valve has two positions, low flow and high flow, which may be changed during a purge if conditions require it. The low flow position flows 4.0 ± 0.2 lb/hr of O_2 at 4.0 psia PGA pressure during the purge operation. This provides adequate CO_2 washout when

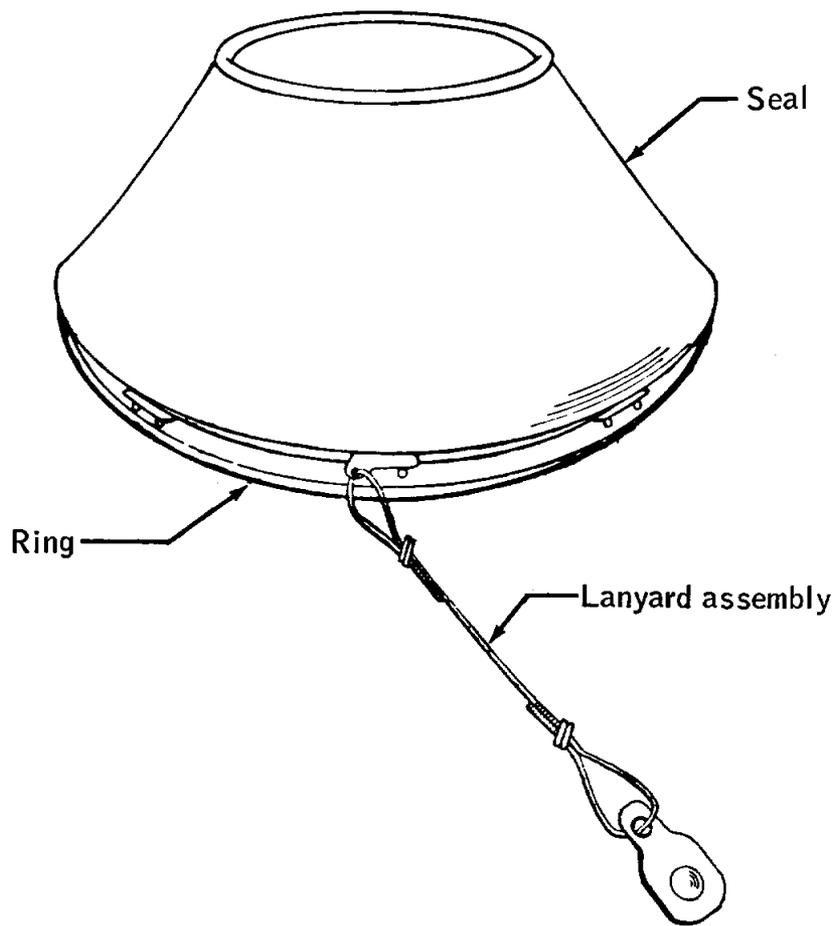


Figure I-27. - Neck dam with lanyard.

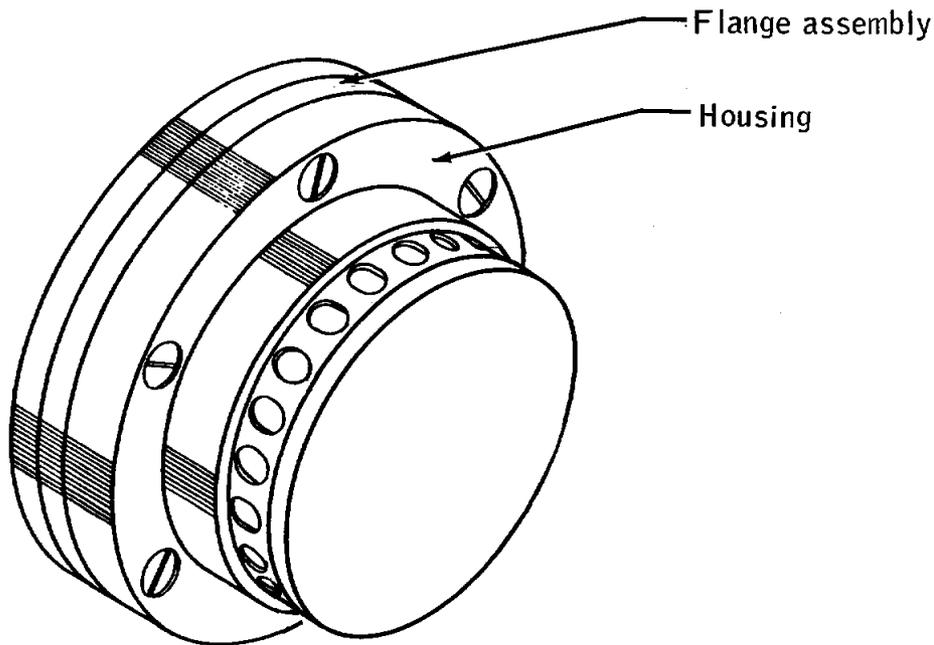


Figure I-28. - Pressure relief valve.

additional cooling is not required. The high flow position flows 8.1 ± 0.3 lb/hr of O_2 at 4.0 psia PGA pressure during the purge operation if CO_2 washout and additional metabolic cooling is required. To change positions the small button on the face of the valve is depressed and the knurled portion of the valve is rotated to the position desired. The valve is activated by removing the additional locking pin and depressing the two activation tabs. The order of the two steps is not critical. To shut off purge flow the valve can be removed from the gas connector or the center barrel can be depressed and the locking pin reinserted.

2.2.6

Lunar Boots

The lunar boots (fig. I-30) provide thermal and abrasive protection for the PGA/ITMG boots during lunar surface operations. The lunar boots are designed to permit free movement of the feet and do not restrict the PGA/ITMG boots. The lunar boots are donned prior to EVA by inserting and positioning the PGA boots with the donning straps (located at the top rear of each lunar boot) and engaging the snap strap. A strap which extends across the instep from each heel is also latched to provide a more secure fastening. The latching mechanism of the strap can be activated by a crewmember wearing extra-vehicular gloves.

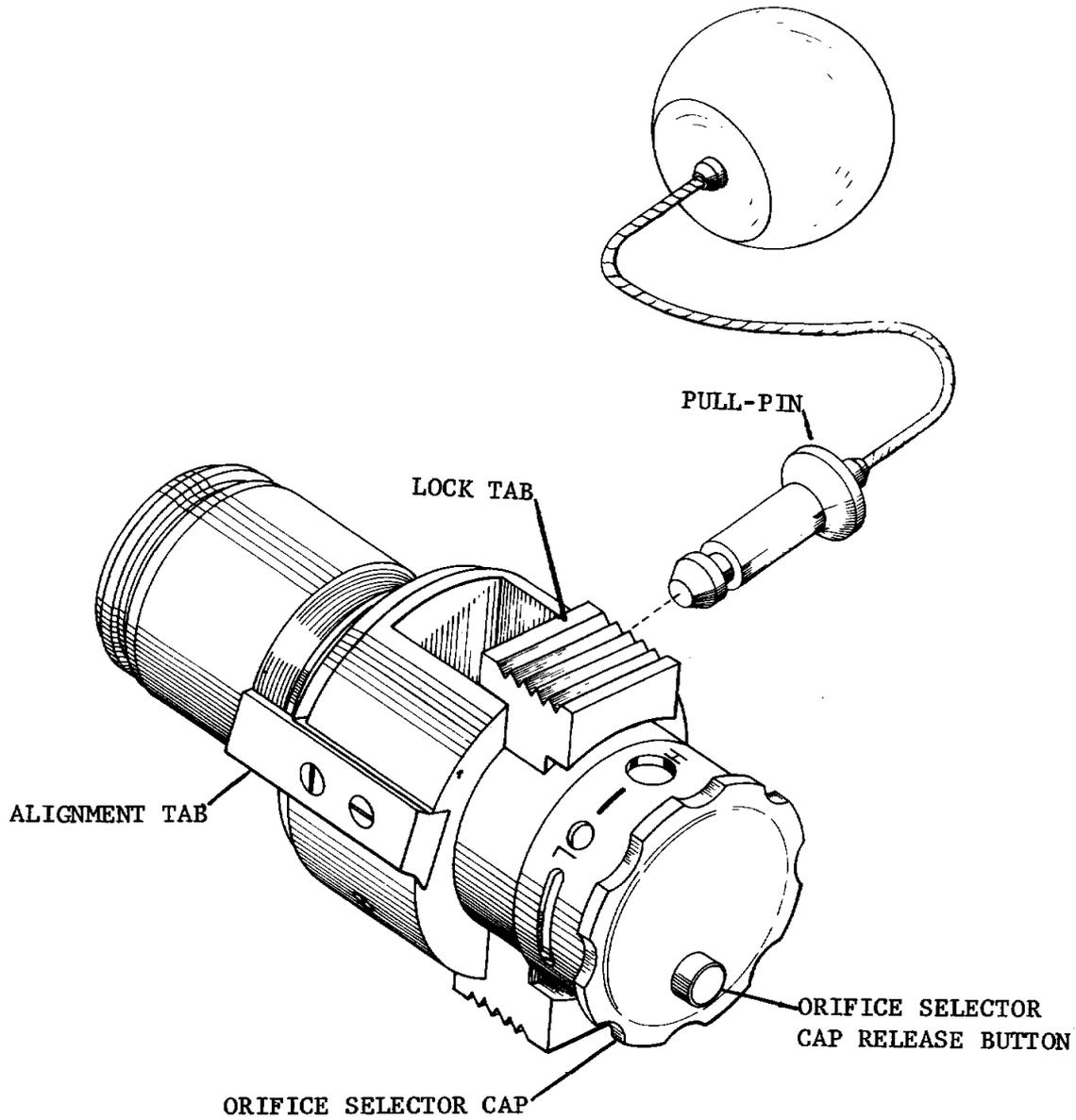


Figure I-29. - Dual position purge valve.

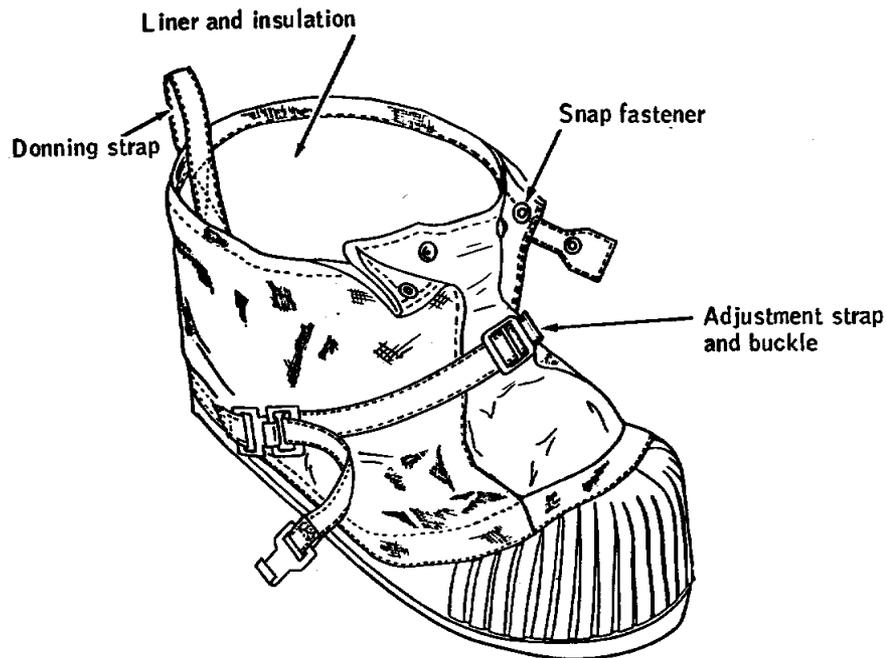


Figure I-30. - Lunar boots.

Except for the sole, the outer layer of a lunar boot is fabricated from metal woven fabric and the tongue area from Teflon-coated Beta cloth. Ribs project from the bottom of the silicone rubber sole to increase thermal insulation qualities, to provide lateral rigidity, and to improve traction.

The inner layers (from the Chromel-R working inward) consist of two layers of Super Kapton followed by five layers of aluminumized perforated Mylar separated by four layers of nonwoven Dacron followed by an inner liner of Teflon-coated Beta cloth.

2.3

CONSTANT WEAR GARMENT

The CWG shown in figure I-31 is a cotton fabric undergarment worn next to the skin during intravehicular CM operation. It provides general comfort and perspiration absorption, and holds the bioinstrumentation system. In the CM, the CWG is worn under the PGA or under the ICG.

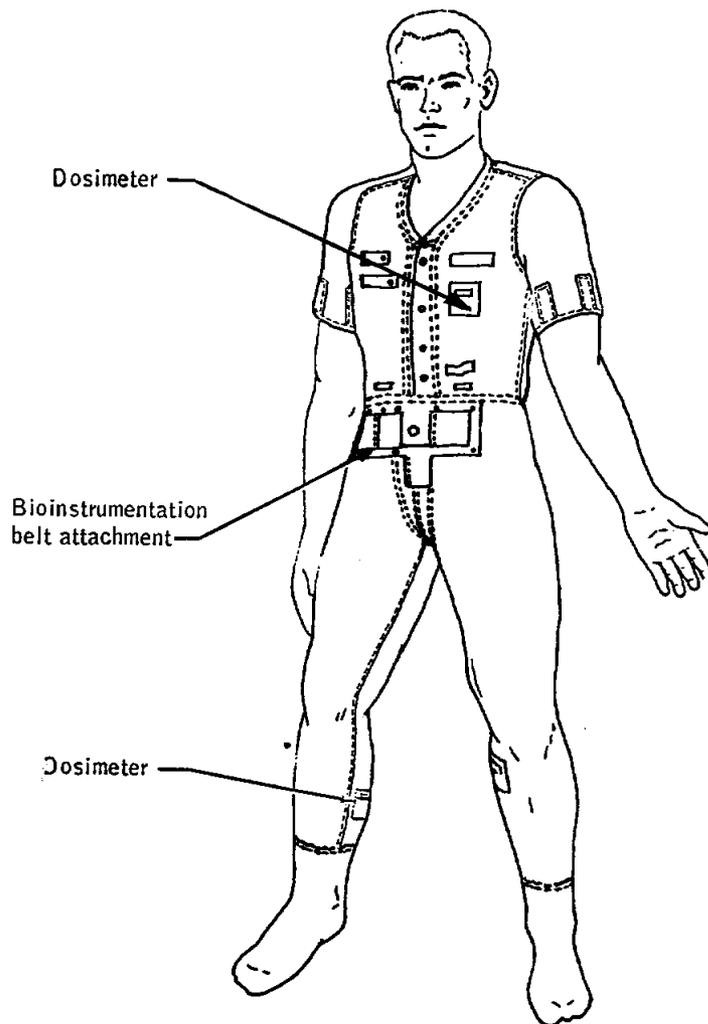


Figure I-31. - Constant wear garment.

Waste management provisions are provided by a fly opening and a rear buttock port in the CWG to allow urination and defecation to the CM waste management system without removing the garment. Snaps are provided to attach the biobelt which contains the bioinstrumentation.

2.3.1

Constant Wear Garment Electrical Harness

A CWG electrical harness (fig. I-26) is provided to be used as a substitute for the PGA electrical harness when the PGA is not donned. The harness is worn with the CWG and provides electrical interface between the crewman's bioinstrumentation and communications and the spacecraft systems.

2.4 INFLIGHT COVERALL GARMENT

The inflight coverall garment (fig. I-32) is a three-piece suit, consisting of a jacket, trousers, and boots, which is worn over the CWG during flight when the PGA is not required. The inflight coverall garment is entirely fabricated from 100-percent woven Teflon fabric. The PGA detachable pockets

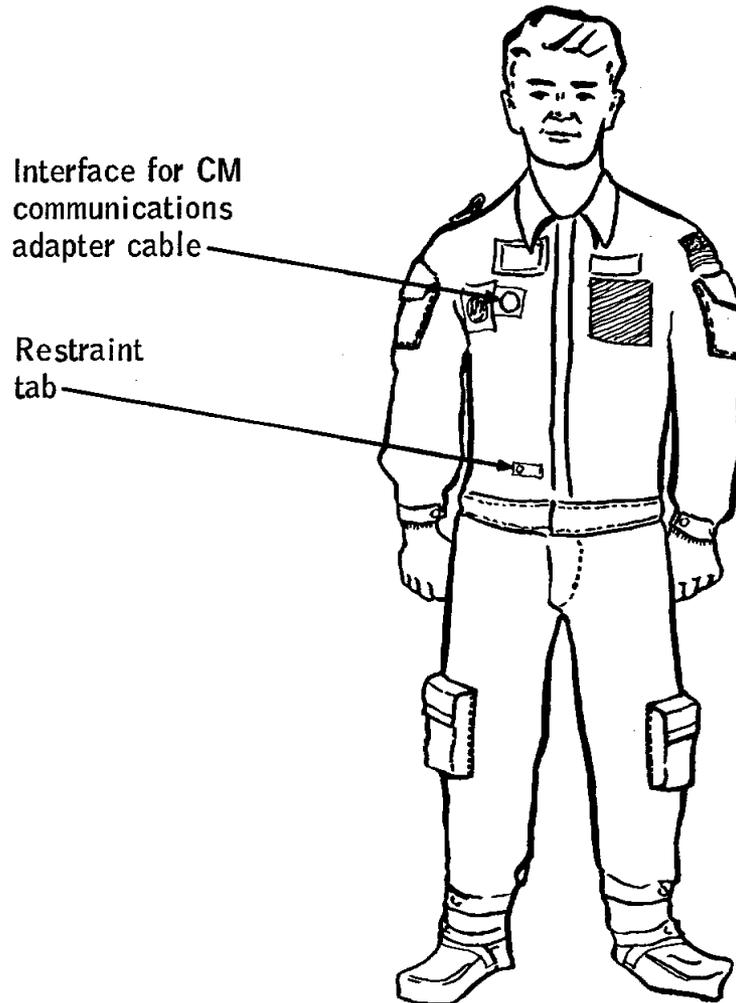


Figure I-32. - Inflight coverall garment.

can also be used on this garment for stowage of various pieces of equipment. Restraint tabs are incorporated to interface with the CM communications adapter cable holding the cable in the proper place.

2.5 LIQUID COOLING GARMENT

The LCG is worn next to the skin under the PGA during LM and EV activities. The LCG (fig. I-33) is made of nylon-spandex knitted material and provides for general comfort, perspiration absorption, and thermal transfer between the crewman's body and the garment's cooling media. The garment provides a continuous flow of temperature-controlled water through a network of polyvinylchloride (PVC) tubing stitched to the inside surface of the open-mesh fabric garment. A light-weight nylon comfort liner separates the body from the tubing network. Front closure is by a zipper.

The LCG coolant system is shown in figure I-34. The coolant water from the PLSS passes through the inlet passage of the multiple water connector and circulates through the manifold and the tubing network. The LCG can also be supplied with coolant water from the LM 192 package.

The network of tubing has a parallel flow path providing maximum surface coverage for optimum cooling. Although the LCG has attached, custom-sized socks, the socks do not incorporate the cooling tubes. The coolant water is warmed by heat transfer from the crewman's body. The warm water returns to the PLSS through the outlet channel of the multiple water connector. The LCG can remove heat at a maximum rate of 1800 Btu/hr. (This parameter is dependent upon PLSS design and man workload.) Leading particulars of the LCG are given in table I-III.

Evaporative cooling by spacecraft ECS or the PLSS oxygen systems also occurs through the nylon comfort liner fabric of this garment.

Eight snap fasteners are provided on the abdominal area of the LCG for securing the biomedical belt.

TABLE I-III.- LEADING PARTICULARS OF THE LIQUID COOLING GARMENT
AND MULTIPLE WATER CONNECTOR

Item	Value
<u>Liquid Cooling Garment</u>	
Weight (charged)	^a 4.60 lb
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	3.35
4.0 lb/min at 70° F ± 10° F inlet	3.2 psi including both halves of connector
Leak rate	
19.0 psid at 45° F	0.58 cc/hr
<u>Multiple Water Connector</u>	
Pressure drop	
4.0 lb/min at 70° F ± 10° F, both halves, both directions	1.45 psi

^aDesign value.

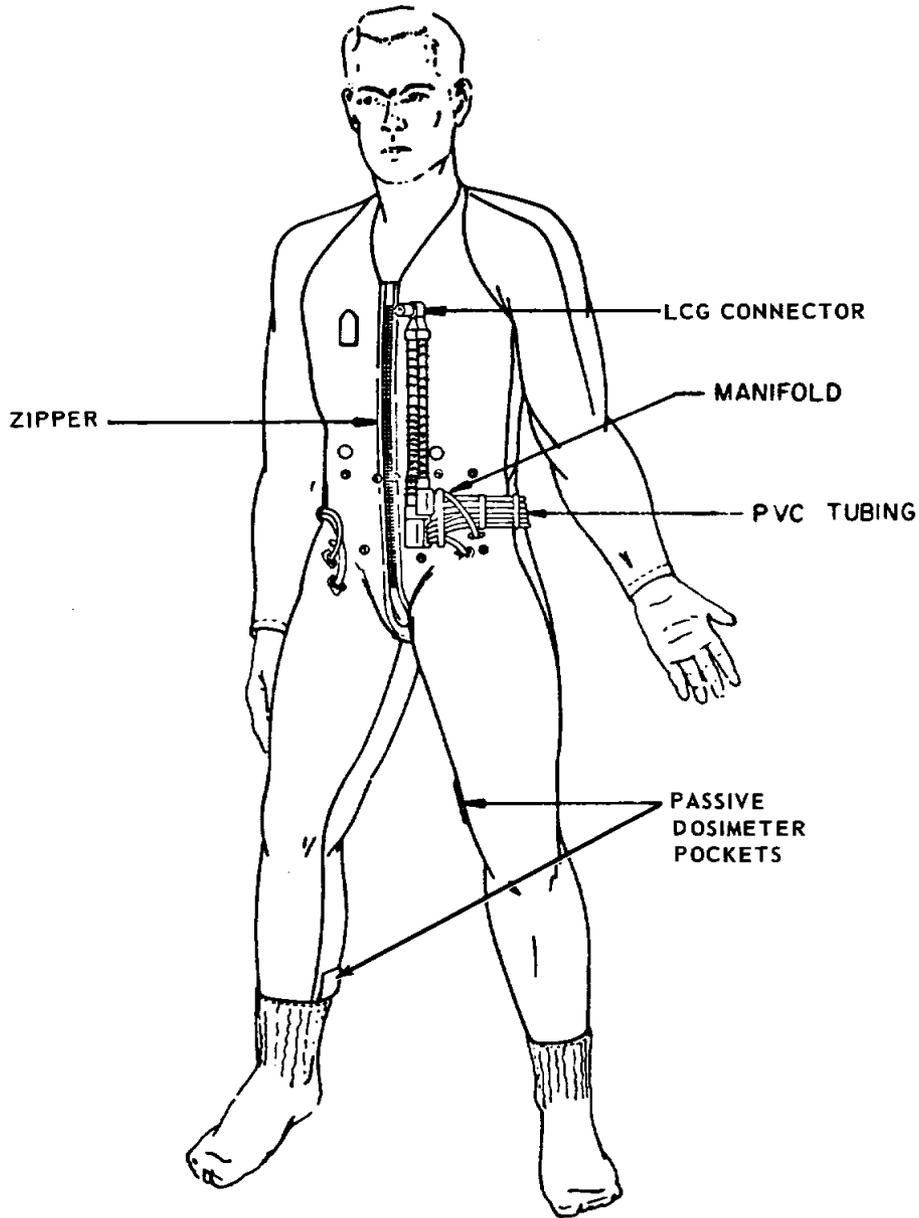


Figure I-33. - Liquid cooling garment.

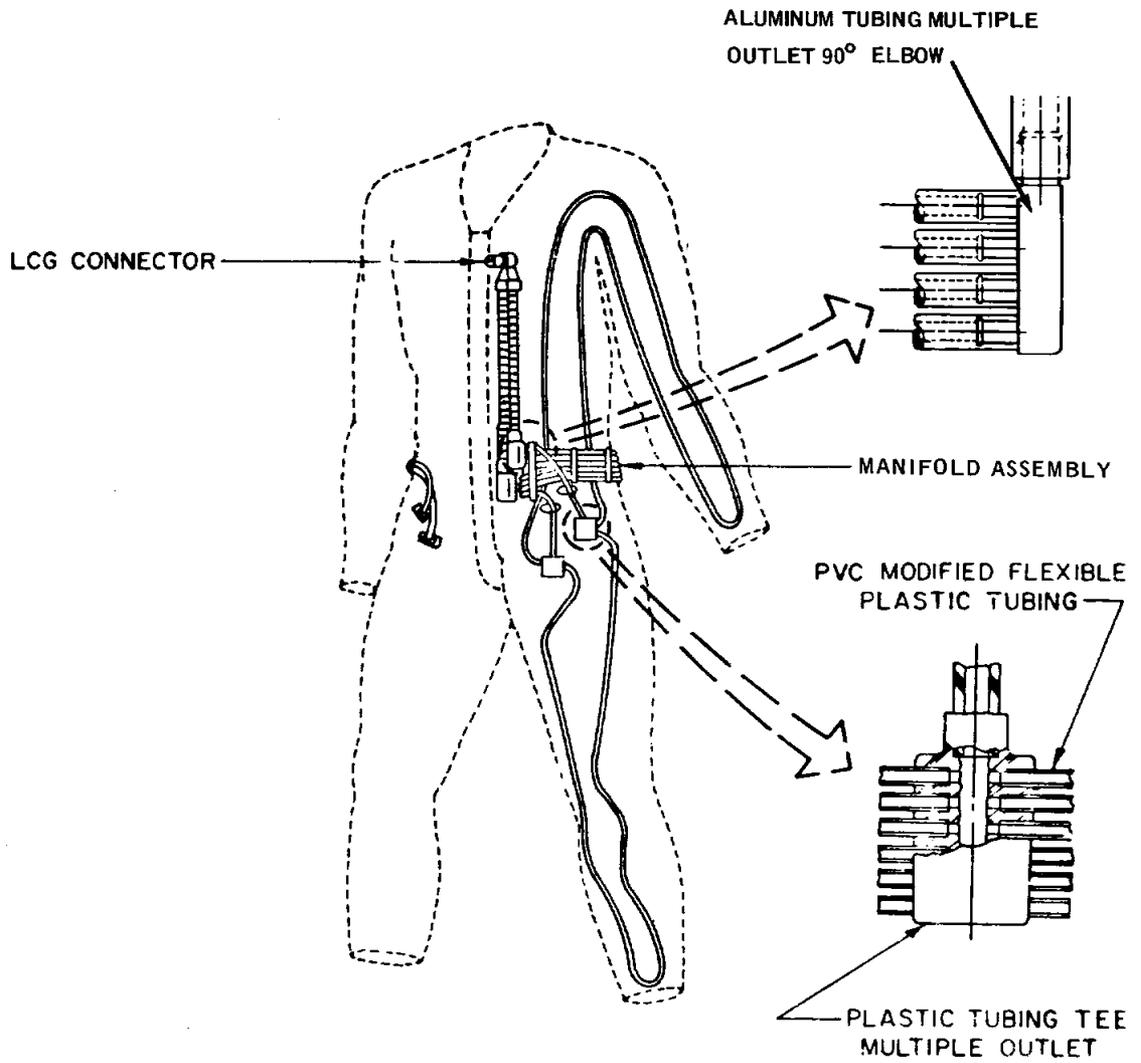


Figure I-34. - Liquid cooling system.

2.6 LUNAR EXTRAVEHICULAR VISOR ASSEMBLY

The LEVA (fig. I-35) furnishes visual, thermal, and mechanical protection to the crewman's helmet and head. It is composed of a plastic shell, three eyeshades (left, center, and right), and two visors. The outer or sun visor is made of polysulfone plastic. The inner or protective visor is made of UV stabilized polycarbonate plastic. The outer visor filters visible light and rejects a significant amount of ultraviolet and infrared rays. The inner visor filters ultraviolet rays, rejects infrared and in combination with the sun visor and pressure helmet forms an effective thermal barrier. The two visors in combination with the helmet protect the crewmember from micrometeoroid damage and from damage in the event of impact with the lunar surface. A hard shell protects the sun visor during nonuse periods. The eyeshades are adjusted by the crewman to prevent glare from hampering vision during EVA.

The sun visor and eyeshades may be individually positioned anywhere between "full up" and "full down," but the protective visor must be in the "full down" position for EV operations. The required force for moving either visor or eyeshades is 2 to 4 pounds. This force has been determined as necessary to prevent inadvertent movement of either the visor or eyeshades from a selected position. A single crewman can attach or detach the LEVA from his helmet without the aid of tools. A latching mechanism allows the lower rim of the LEVA to be tightened and secured around the neck area of the pressure helmet. The mechanism consists of an overcenter latch which locks on the lower rim, draws the two sides together, and holds them secure. The LEVA shell separation should be aligned with the helmet "engaged" marks before the latch is secured. The LEVA/PGA interface collar provides thermal and dust protection for the neck ring.

The commander's LEVA has a red stripe lying along the vertical center line of the center eyeshade and the fiber-glass shell into which it recedes when in the up position. This is to aid in positive identification of the crew commander at all times during EVA.

2.7 WASTE MANAGEMENT SYSTEMS

Management of body waste when the PGA is donned is accomplished through the fecal containment subsystem and the urine collection and transfer assembly.

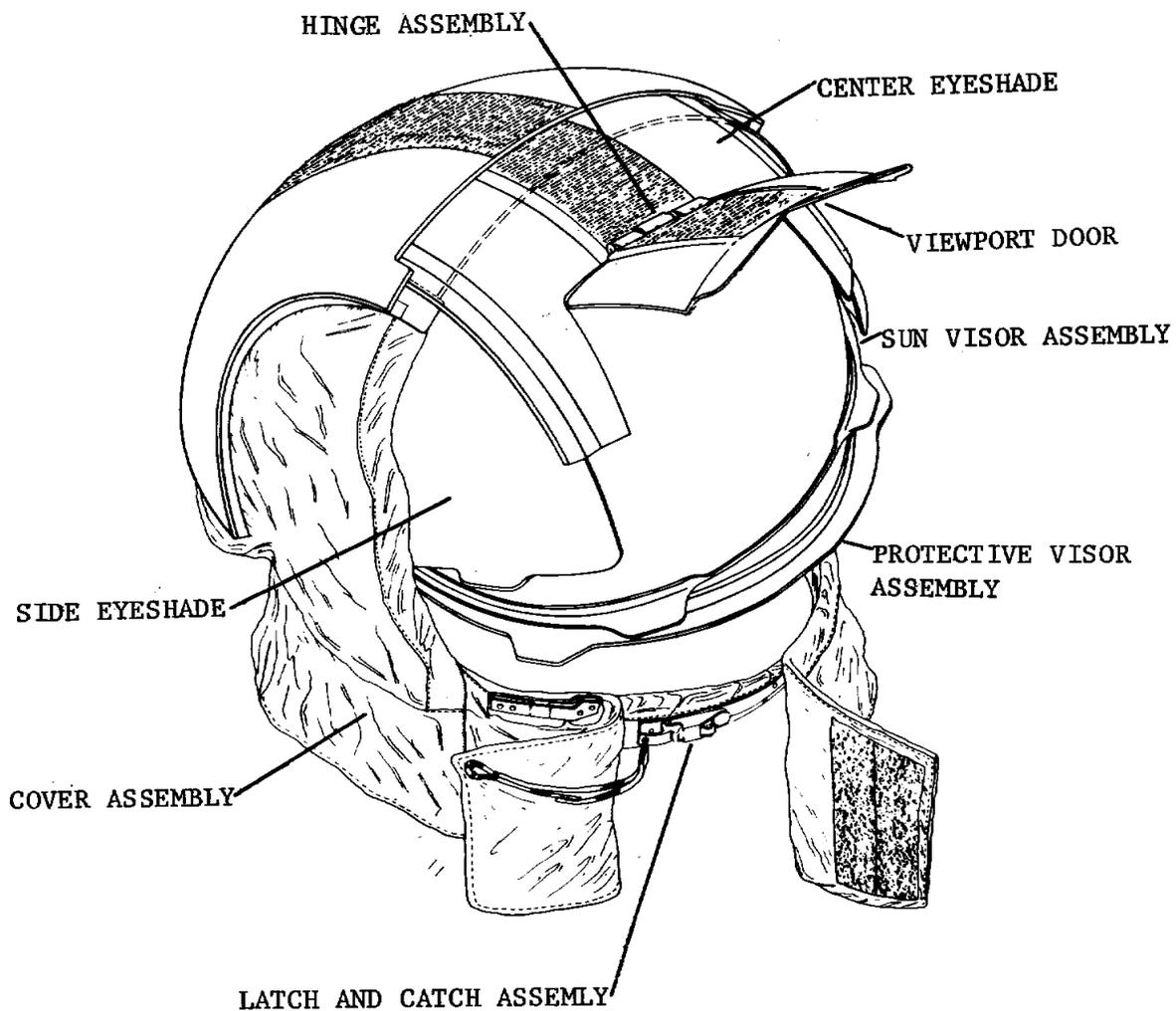


Figure I-35. - Lunar extravehicular visor assembly.

The CM and the LM have provisions for feces collection while the PGA is doffed in a pressurized cabin environment during zero-g portions of the mission. The CM also provides facilities for urination while the PGA is doffed.

2.7.1 Fecal Containment Subsystem

The FCS (fig. I-36) consists of elastic underwear with an absorbent liner around the buttock area. This system is worn under the LCG or CWG to allow emergency defecation when the PGA is pressurized. The system weighs 0.50 pound and has a capacity of 1000 cc of solids.

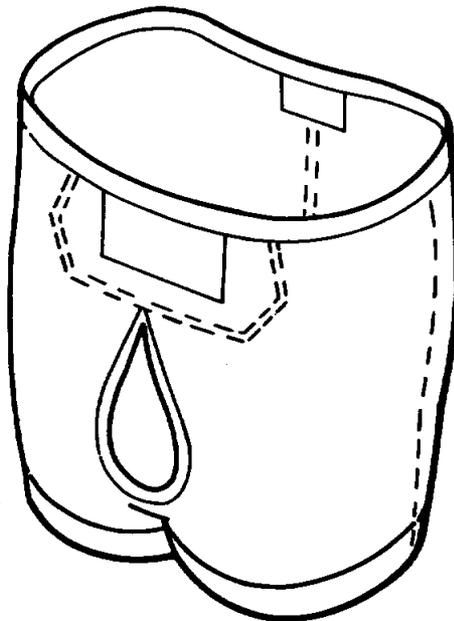


Figure I-36. - Fecal containment subsystem.

2.7.2 Urine Collection and Transfer Assembly

The UCTA (fig. I-37) collects and provides intermediate storage of a crewman's urine during launch, EVA, or emergency modes when the spacecraft waste management system cannot be used. The UCTA will accept urine at rates up to 30 cc/sec with a maximum stored volume of 950 cc. No manual adjustment

or operation by the crewman is required while the UCTA is collecting urine. Pressure relief valves are incorporated in the urine collection bag to prevent exposure of the penis to pressure differentials of ± 1 inch of H_2O between the collection bag and the PGA. The valves open automatically

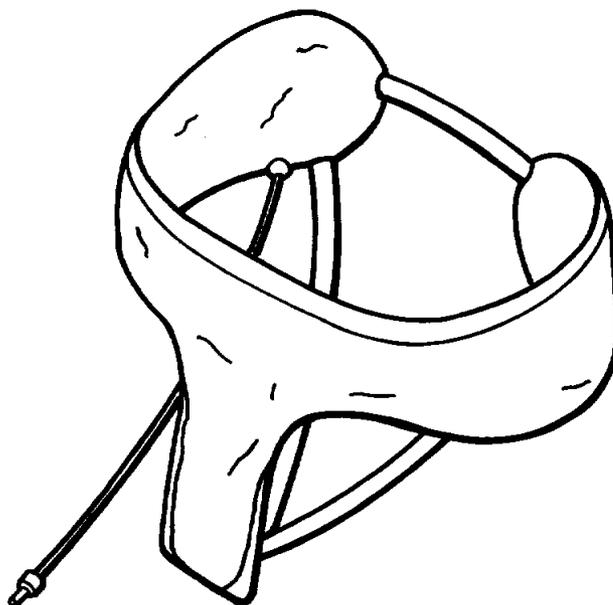


Figure I-37. - Urine collection and transfer assembly.

as required to increase pressure within the collection bag. A flapper check valve prevents reverse flow from the collection bag to the urinal portion of the UCTA. The stored urine can be transferred through the suit wall by hose when feasible to the CM or IM during both pressurized and depressurized cabin operation.

The UCTA is worn over the CWG or the LCG and is connected by hose to the urine transfer connector on the PGA. This urine transfer connector is a quick-disconnect fitting which is used for the transfer of urine from the UCTA to the spacecraft waste management system.

A UCTA transfer adapter is provided on board the CM for use by the crewmen to dump the UCTA after the PGA's have been doffed.

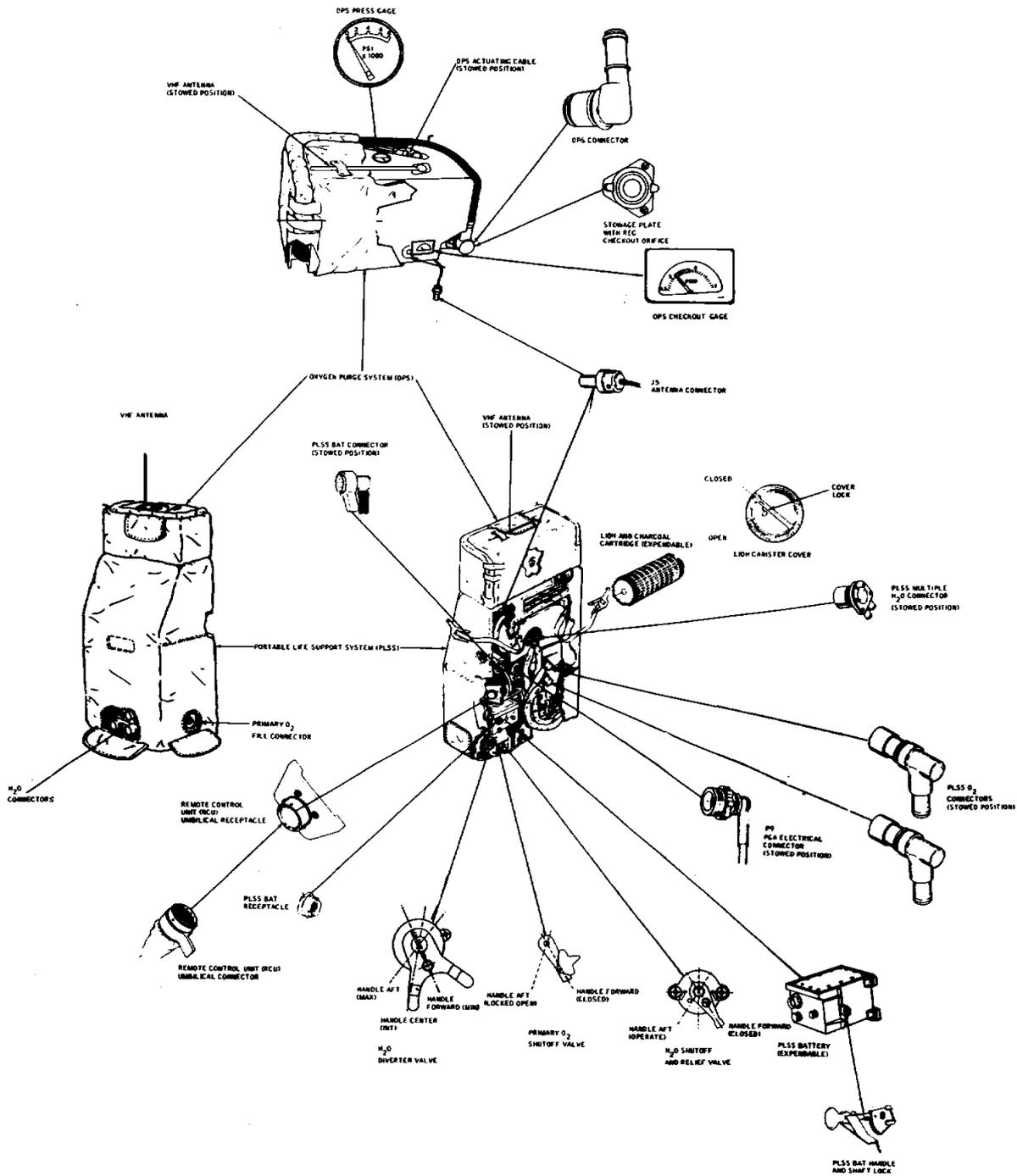


Figure I-38. - Portable life support system.

2.8 PORTABLE LIFE SUPPORT SYSTEM

The PLSS (Fig. I-38) contains all required life support equipment for extravehicular EMU operation including expendables, communication and telemetry equipment, and operating controls and displays. The PLSS supplies oxygen at 3.7 to 4.0 psid to the PGA and cooling water to the LCG. The PLSS also removes solids and gas contaminants from the returning oxygen in order to maintain a clean supply of gas.

The PLSS is worn on the back of a suited astronaut in "knapsack" fashion, and attached to the PGA with harnesses.

The PLSS system contains an oxygen ventilating circuit, feedwater loop, liquid transport loop, primary oxygen subsystem, main power supply, communications system, displays and sensors, electrical switches and controls, cover and closures, and thermal insulation. The basic structure to which all other components are attached is the feedwater reservoir and LiOH canister assembly. A cover fits over the assembled unit and supports the OPS mounting plate on top of the PLSS and the conformal pads. The whole system is covered with a thermal insulation jacket. The system schematic of the -6 model PLSS is shown in figure I-39.

2.8.1 Oxygen Ventilation Circuit

The oxygen ventilating circuit (fig. I-40) circulates a fresh, refrigerated oxygen supply through the PGA. Oxygen from the PGA enters the oxygen ventilating circuit of the PLSS through the PLSS inlet oxygen connector. The PLSS delivers a minimum flow of 5.5 acfm with a pressure rise of 1.5 inches H₂O.

The oxygen passes to the contaminant 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 contaminant 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. The fan/motor assembly operates at a speed of 18 000 ± 600 rpm with an input voltage of 16.8 ± 0.8 V dc. A carbon dioxide sensor is shunted around the fan and samples the vent flow to monitor the level of carbon dioxide (Apollo 14 and 15).

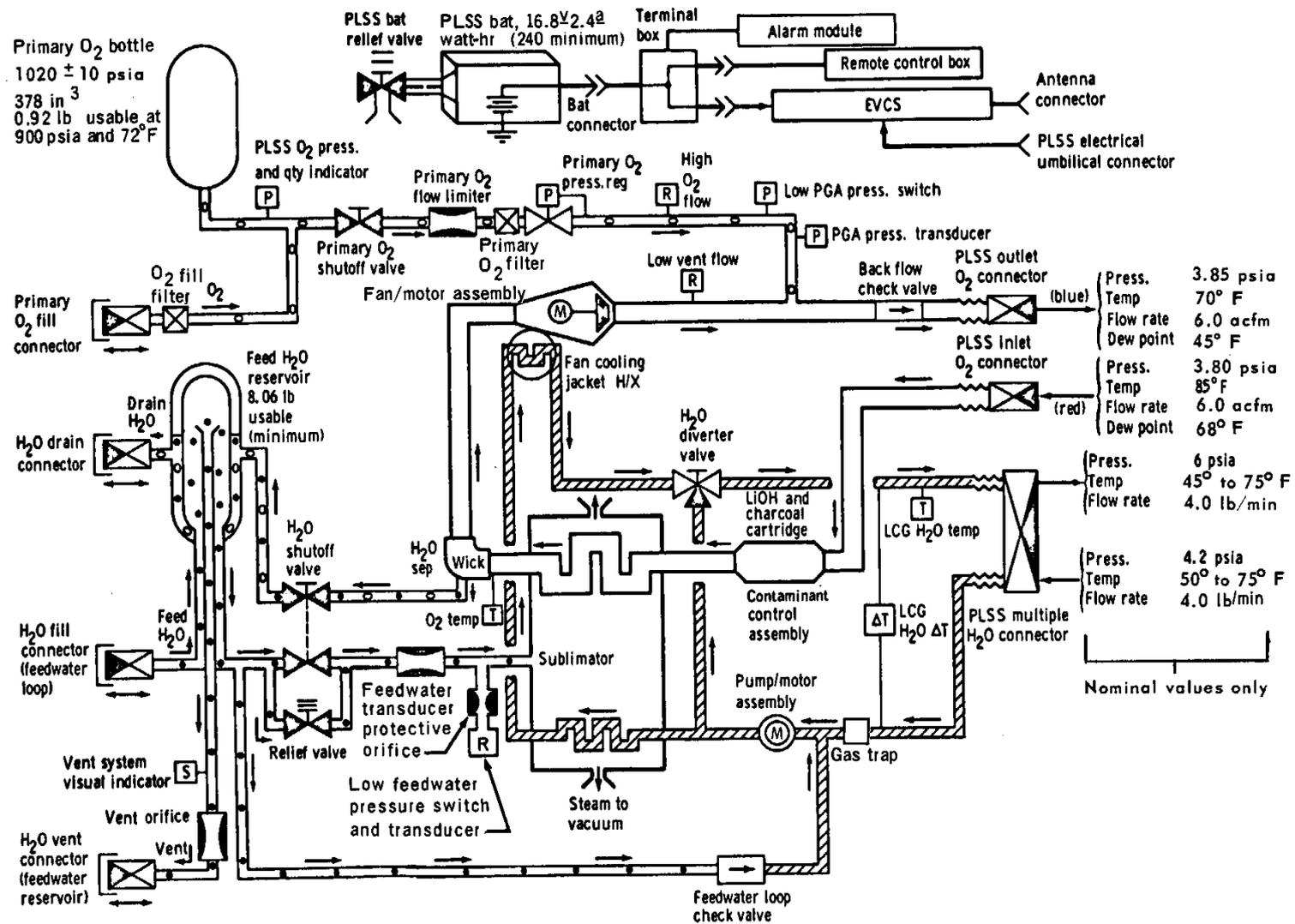


Figure I-39. - Schematic of PLSS -6.

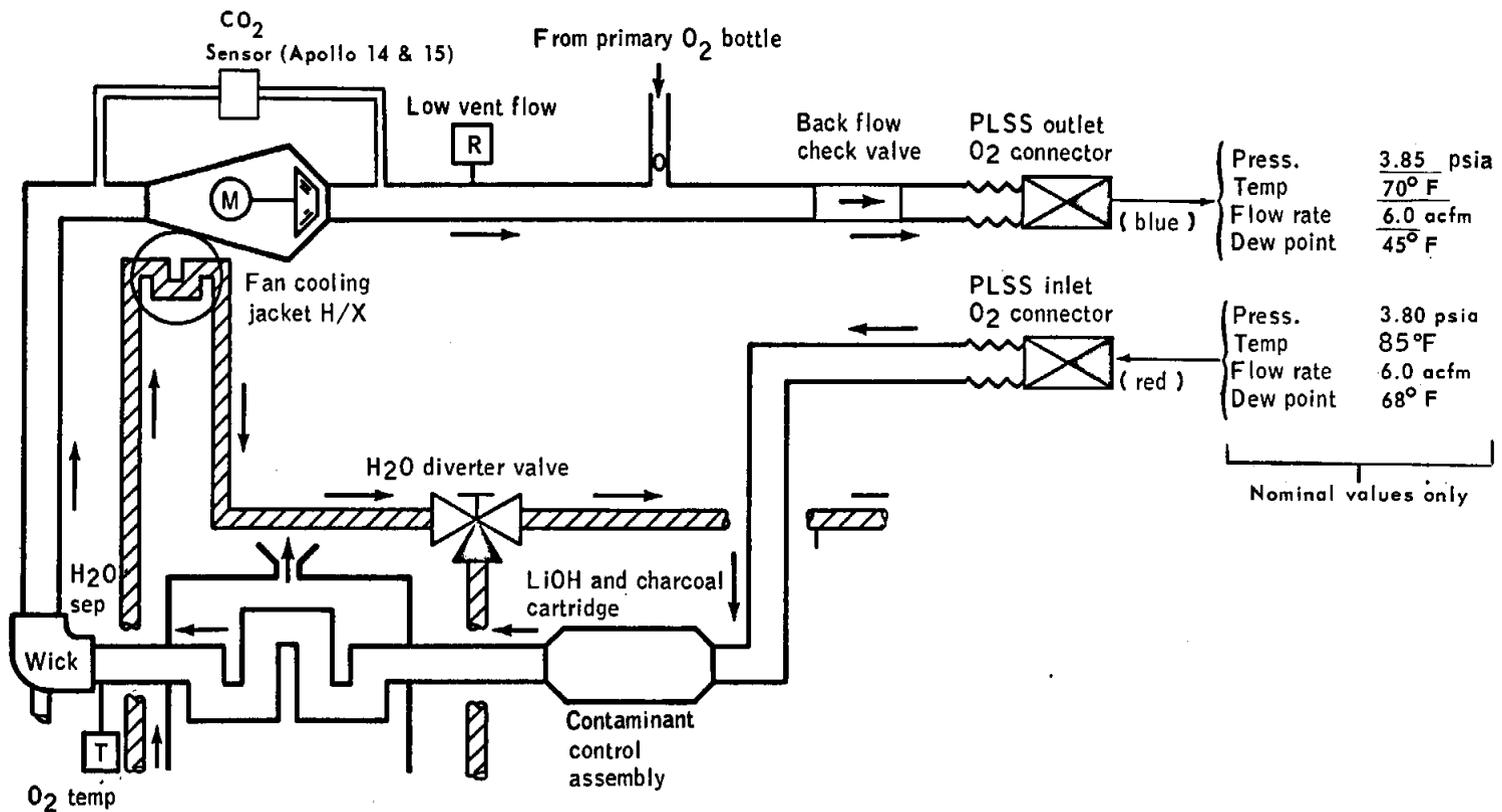


Figure I-40. - Oxygen ventilating circuit.

A ventilation flow sensor has been incorporated into the oxygen ventilation circuit. This sensor provides an input signal to the 1.5-kHz alarm module and RCU warning indicators in the PLSS -6 when the ventilation flow is between 4.0 and 5.3 acfm. A 5-second time delay is incorporated in the circuit.

The fan/motor assembly forces the oxygen through the PLSS outlet oxygen connector with a minimum flow rate of 5.5 acfm to the PGA with a minimum positive outlet delta pressure of 1.5 inches H_2O , and a temperature of 77° F with a dewpoint of 50° F maximum. The drain water from the water separator is ducted to the outer section of the feedwater reservoir through the water shutoff valve.

The PLSS maintains the outlet pressure of 3.7 to 4.0 psid for the EMU oxygen makeup flow requirements of 0.07 to 2.0 lb/hr.

2.8.2

Feedwater Loop

The feedwater loop (fig. I-41) is rechargeable and supplies expendable water to the porous plate sublimator and stores condensation removed by the water separator in a reservoir. The reservoir is a bladder-type rechargeable tank which provides a minimum of 8.3 pounds of expendable feedwater for sublimation. Water from the water separator is stored in the volume between the reservoir housing and bladder. The bladder contains a vent line for removal of entrapped gas to assure a full charge. (A sight glass is used as a visual indicator to assure a full charge.) A manually operated water shutoff and relief valve allows feedwater to flow to the sublimator and, when closed, acts as a pressure relief device for feedwater reservoir overpressurization protection. This valve relieves at a maximum of 65 psid and reseats at 40.0 psid minimum. The combination of the stored drain water and oxygen ventilation loop pressure through the water shutoff valve pressurizes the feedwater bladder to 3.3 psid.

A water fill connector and a water drain connector allow access to both sides of the reservoir bladder to facilitate recharge and drain. Since the reservoir contains a bladder, both fill and drain operations are performed simultaneously. Recharge time is less than 10 minutes.

A pressure transducer provides system telemetry monitoring to identify sublimator breakthrough and feedwater depletion.

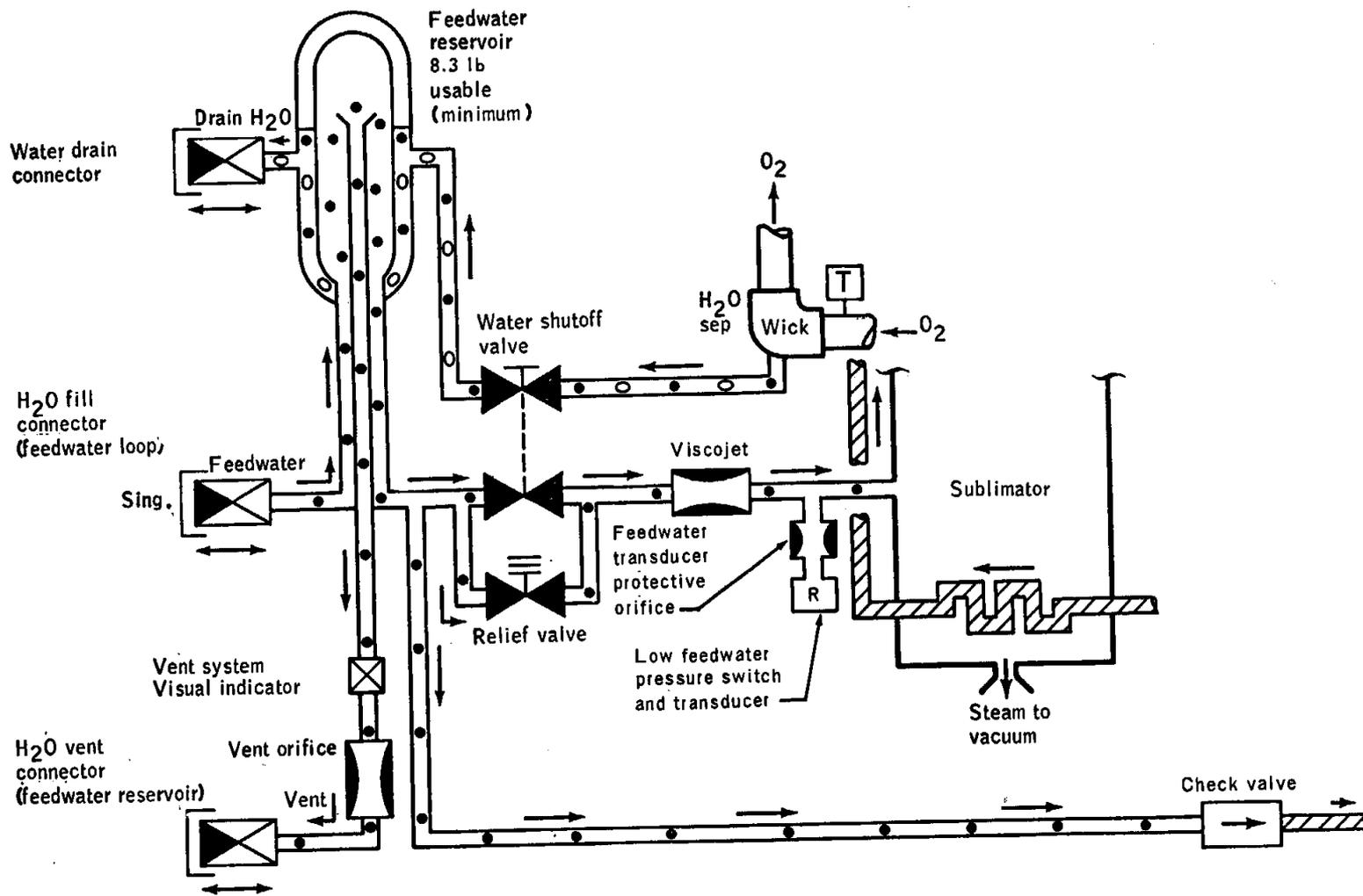


Figure I-41. - Feedwater loop.

The transducer also contains a switch which actuates an audible warning tone when feedwater pressure drops to 1.3 to 1.6 psia.

A protective orifice is located between the transducer and the feedwater line to preclude feedwater freezing around the transducer sensing element when feedwater flow is stopped to the sublimator which is exposed to a vacuum.

2.8.3 Liquid Transport Loop

The recirculating liquid transport loop (fig. I-42) provides thermal control of the crewman by dissipating heat through conduction to the sublimator. The pump/motor assembly circulates the chilled water through the liquid transport loop and the LCG with a minimum flow rate of 3.5 lb/min. The pump creates a minimum pressure rise of 1.90 psi (including the LCG connector). The differential temperature of the LCG water entering and leaving the PLSS is sensed by the water differential temperature transducer, and the LCG water temperature is sensed by the LCG inlet temperature transducer, both of which supply electrical inputs to the telemetry system. After the water passes through the sublimator from the LCG, it circulates around the fan motor to cool the electronics package. A gas trap immediately upstream of the water pump can extract a minimum of 30 acc of gas. Should cooling performance degrade because of additional gas, the trap can be manually vented to ambient and readied for further entrapment.

The coolant flow through the sublimator is regulated by the PLSS three-position water diverter valve. In the minimum position, the valve diverts the flow allowing the majority of flow to bypass the sublimator. In the maximum position, the entire flow passes through the sublimator for maximum cooling before returning to the LCG. The intermediate position provides a midrange cooling capability.

The PLSS feedwater loop and liquid transport loop are inter-connected with a check valve.

2.8.4 Primary Oxygen Subsystem

The rechargeable primary oxygen subsystem of the PLSS stores oxygen and regulates the oxygen pressure in the PLSS oxygen ventilating circuit to 3.85 ± 0.15 psid. The initial ground charge is 1020 ± 10 psia. Fully recharged during flight, the system contains 1.08 to 1.23 pounds of usable oxygen at

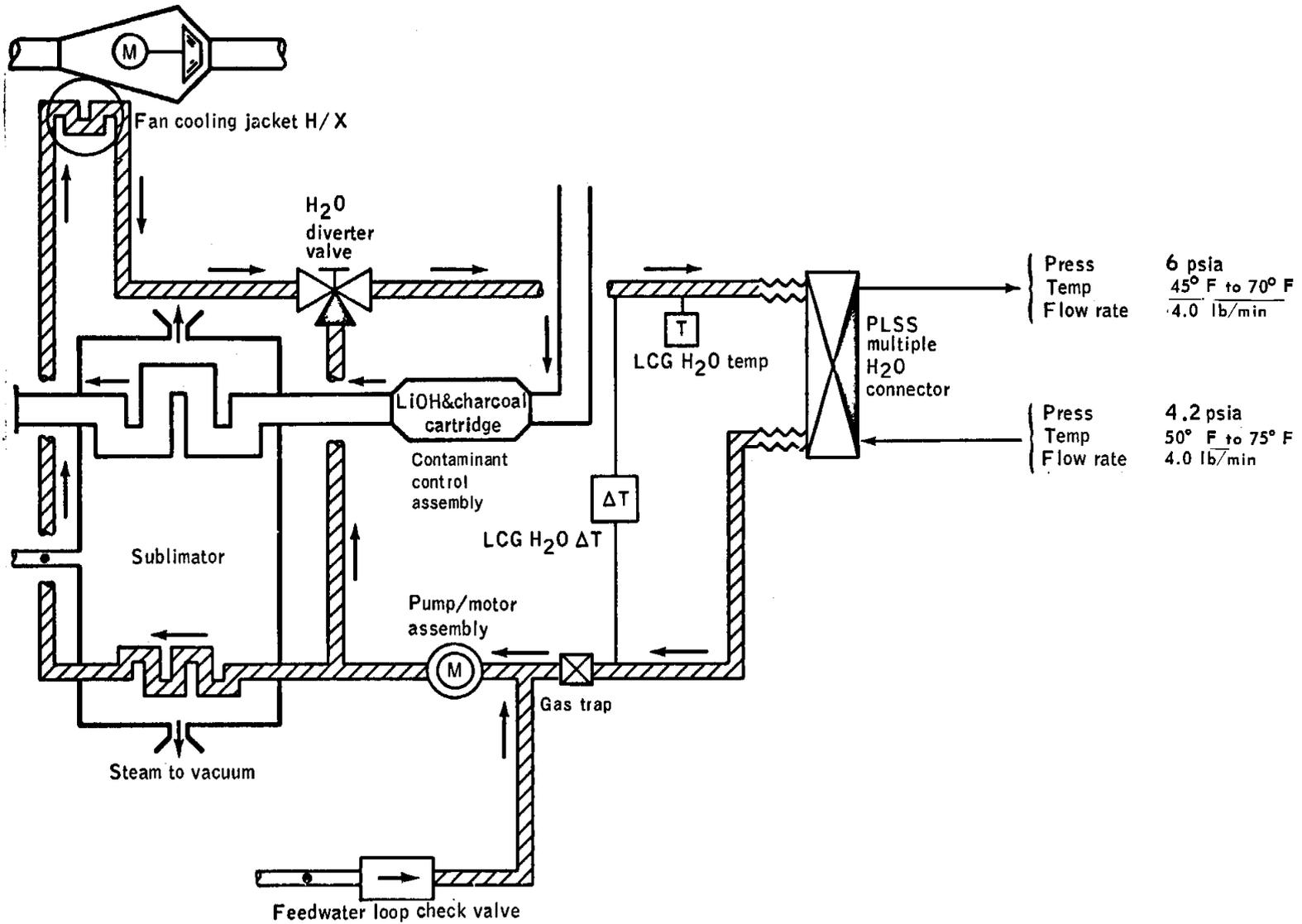


Figure I-42. - Liquid transport loop.

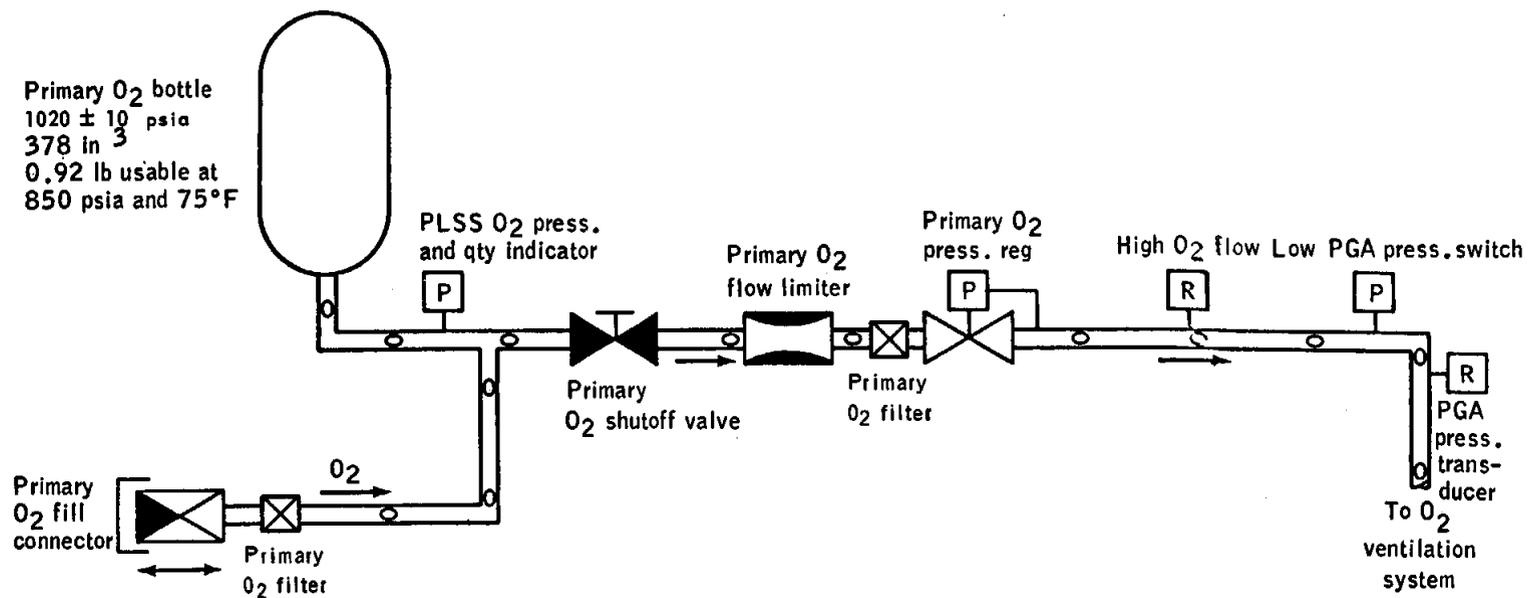


Figure I-43. - Primary oxygen subsystem.

980 ± 20 psia and approximately 70° F. This supplies the adequate makeup oxygen to satisfy a 1200 Btu/hr metabolic load plus EMU leakage for 4 hours. The primary oxygen subsystem (fig. I-43) consists of a primary oxygen bottle, fill connector, pressure regulator, shutoff valve, and connecting tubing. The primary oxygen bottle is a welded stainless steel cylinder with cryogenically formed hemispherical ends. High pressure, corrosion resistant, steel tubes and fittings connect the primary oxygen bottle to its oxygen regulator assembly. A shutoff valve to the primary oxygen regulator assembly is actuated by an operating lever at the lower right front corner of the PLSS when on the crewman's back. The oxygen shutoff valve is closed when the PLSS is not in use, or when the primary oxygen subsystem is being charged.

The flow of oxygen through the regulator assembly is limited to a maximum of 4.2 lb/hr at 1030 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 primary oxygen bottle and fill connector. The fill connector is a leak-proof, self-sealing, quick-disconnect-type connector used for recharging the primary oxygen subsystem. Recharge time from a 950 psia source at 0° to 60° F is a nominal 70 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.

2.8.5 Electrical Power Subsystem

The electrical power subsystem provides dc electrical power through the appropriate connectors to the fan/motor assembly, the pump/motor assembly, and communications and instrumentation. The power is supplied by a 16.8 ± 0.8 V dc, 11-cell, silver-zinc alkaline battery with 290 watt-hours. (Minimum capacity is 240 watt-hours.)

The power consumption profile is as follows:

Pump	10.00 watts max.
Fan	32.50 watts max.
EVCS	12.80 watts max.

Current limiters protect selected electrical circuits against overcurrents which could result in fires. These limiters will pass transient currents in excess of a normal load, but will open at sustained overload.

The limiters are listed in table I-IV.

The battery current transducer and the battery voltage transducer are continuously monitored by telemetry.

2.8.6 Extravehicular Communications System

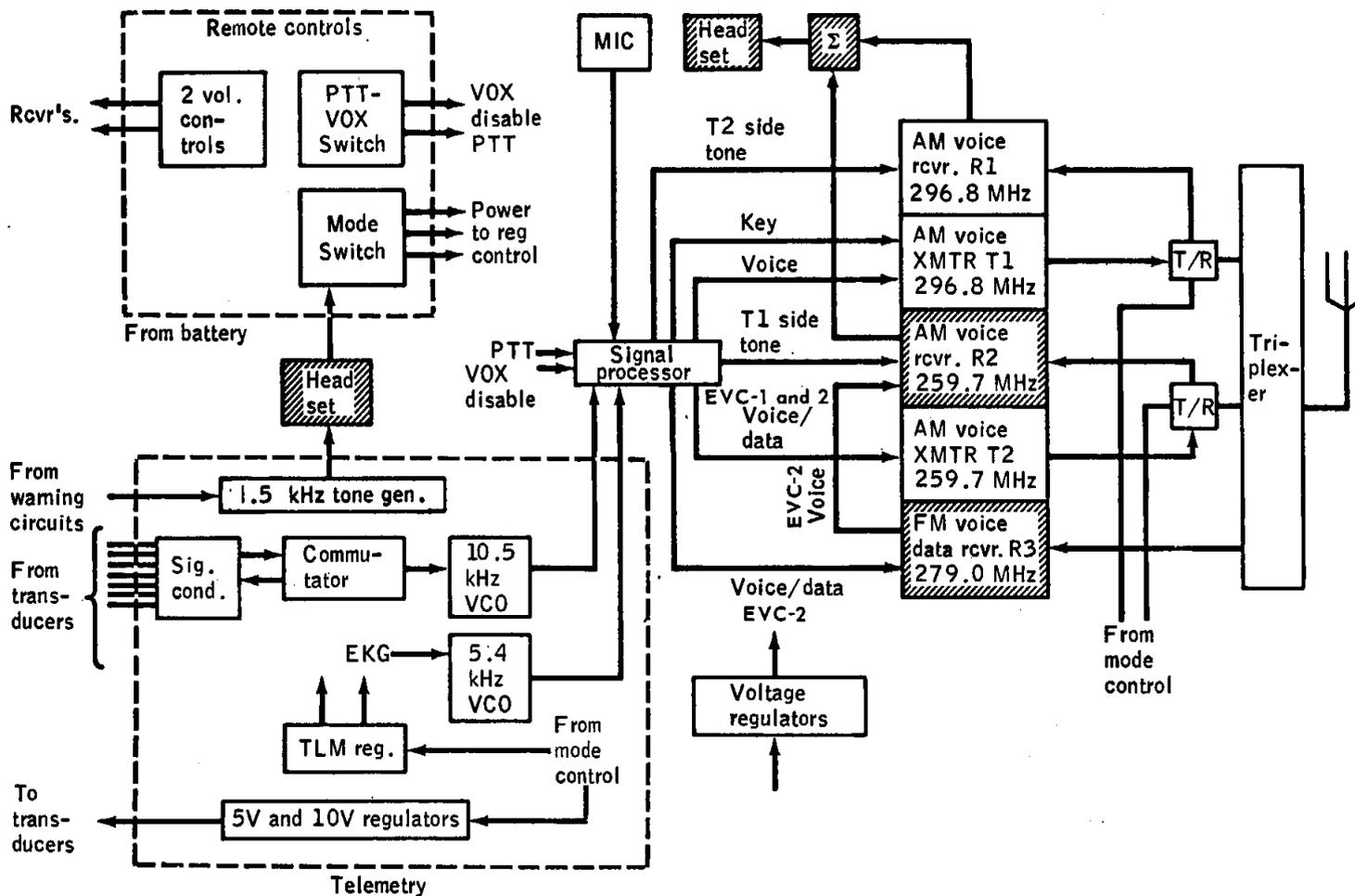
The extravehicular communications system (EVCS) shown in figure I-44 has the following basic capabilities.

- 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. Provision of 30 telemetry channels, $30 \times 1\text{-}1/2$ PAM, per each extravehicular communicator (EVC), with 26 channels available for status information
- e. Provision of separate subcarrier frequencies for continuously monitoring each crewman's EKG during EVA
- f. Generation of an audible alarm for 10 ± 2 seconds in the event of an unsafe condition (If the EVC mode selector switch position is changed, the warning tone will come on again for 10 ± 2 seconds if the unsafe condition still exists.)

TABLE I-IV.- THE PLSS/EVCS CURRENT LIMITER VALUES (AMPS)

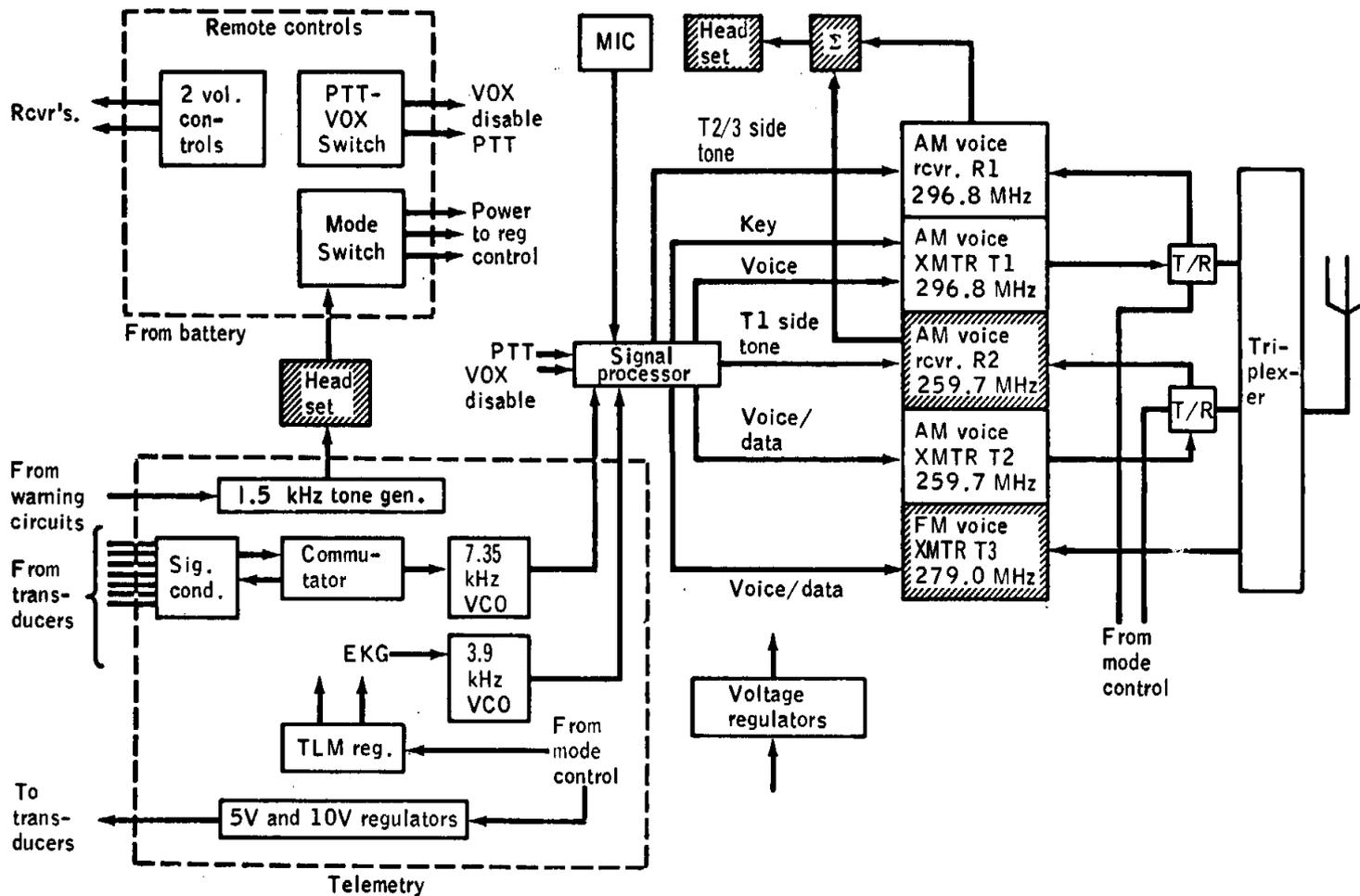
Component	-6 configuration
Fan	*#22 gage wire (Current protection is not provided.)
Pump	*#22 gage wire (Current protection is not provided.)
EKG	1/4 amp with series 32.4 - 39.2 ohm, 1/2 watt resistor
Left mike	1/8 amp with series 32.4 - 39.2 ohm, 1/2 watt resistor
Right mike	1/8 amp with series 32.4 - 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
EVCT/M	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

*The maximum overload current of #22 gage copper wire is 40 amps.



(a) The EVC-1.

Figure I-44. - Extravehicular communications system.



(b) The EVC-2.

Figure I-44. - Concluded.

The EVCS consists of a pair of extravehicular communicators which are an integral part of the PLSS. The EVC-1 consists of two AM transmitters, two AM receivers, one 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 it has an FM transmitter instead of an FM receiver.

The EVCS has four manually selected modes of operation, and each EVC can be controlled 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. 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 of 500 mW. The composite signal from the EVC-2 is received at EVC-1, mixed with a 0.3- to 2.3-kHz voice and two IRIG subcarriers (5.4 and 10.5 kHz), and transmitted to the LM on a 259.7-MHz AM link. This composite signal of 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 extravehicular 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-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 separated 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: 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 IM. 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, and low feedwater pressure) will key the tone, which alerts the astronaut to check his remote control unit for a visual indication of the problem area to be investigated. The warning system operation is independent of mode selection.

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

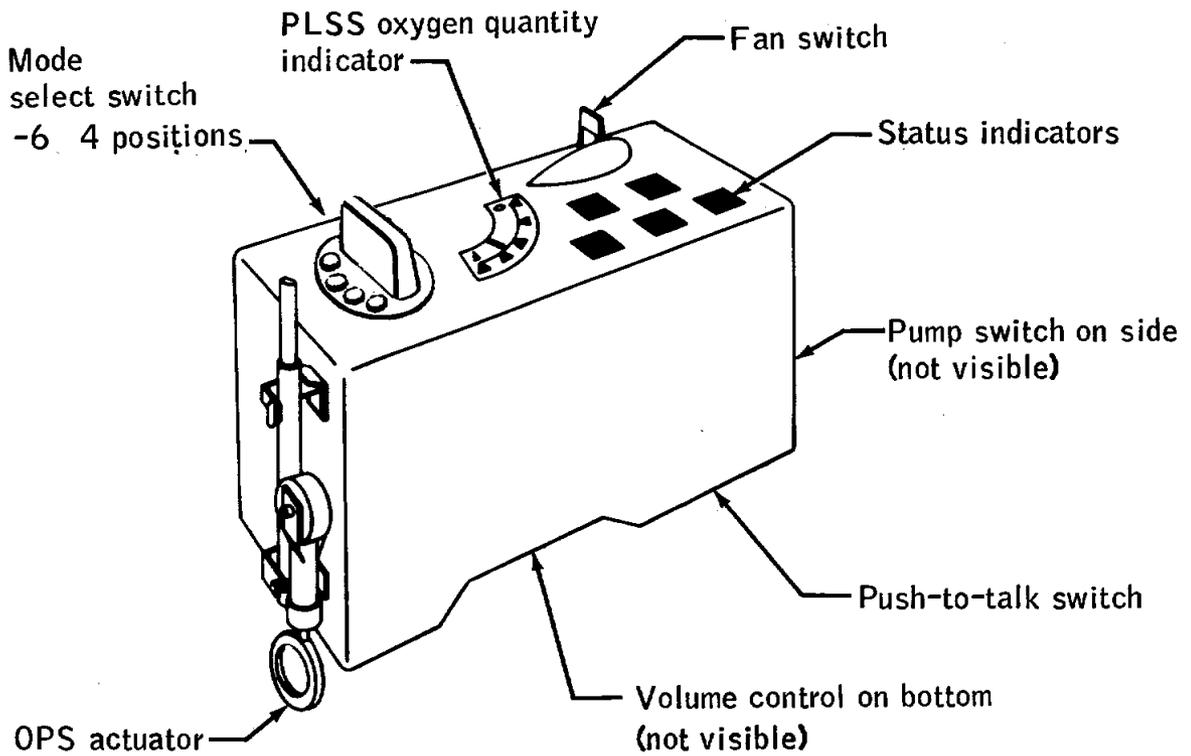
2.8.7

Remote Control Unit

The remote control unit (figs. I-45(a) and I-45(b)) is a chest-mounted instrumentation and controls unit which provides the crewman with easy access to controls and displays. These controls and displays consist of: fan switch, pump switch, communications mode selector switch and volume control, PLSS oxygen quantity indicator, five status indicators, and an interface for the OPS actuator.

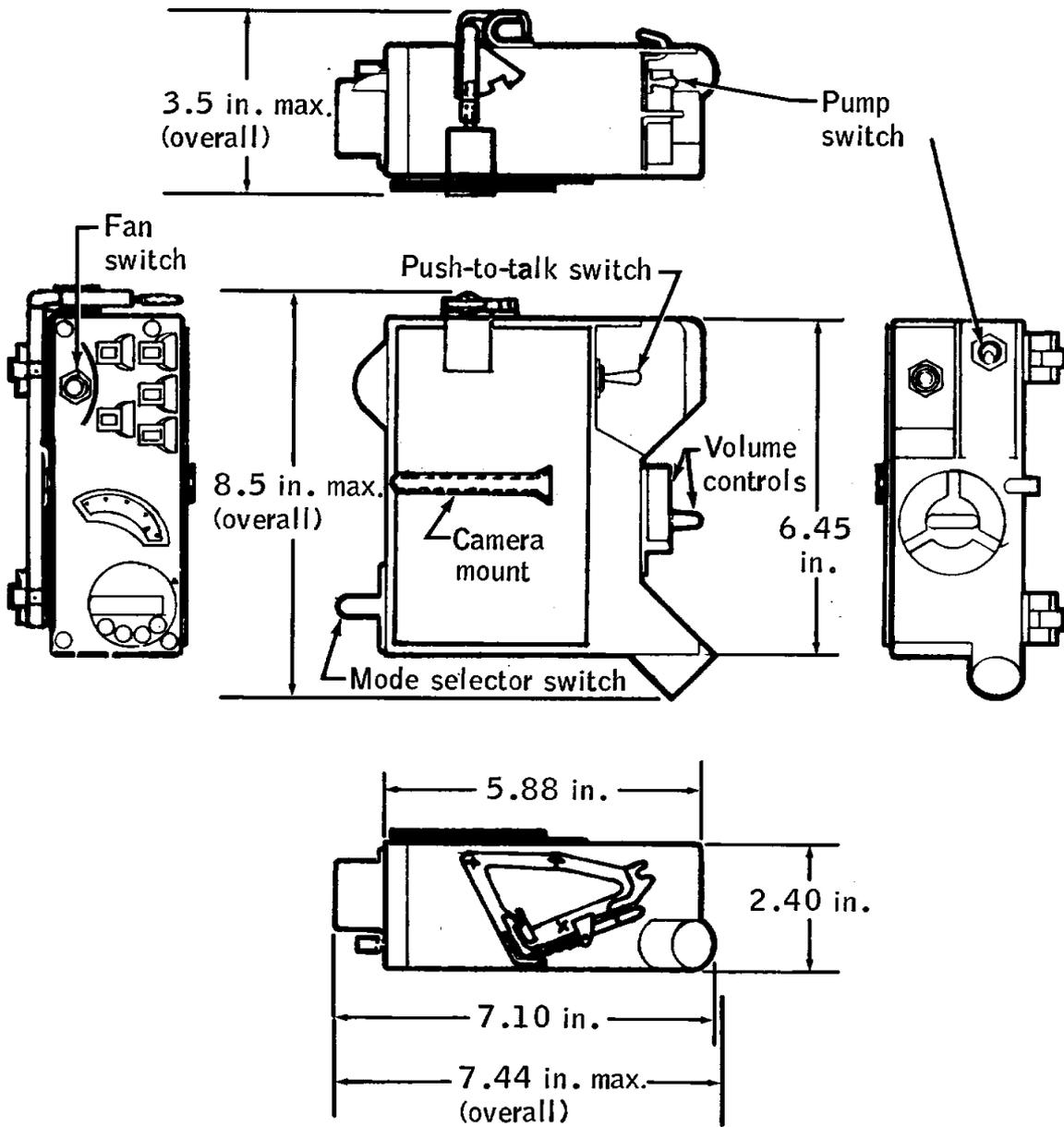
TABLE I-V.- THE PLSS/EVCS COMMUNICATIONS TELEMETRY CHARACTERISTICS

Measurement title	Instrumentation range	Discriminator output voltage range, 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 diff. 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 O ₂ pressure	0 to 1110 psia	0 to 5	12,13,23,28
CO ₂ partial pressure	0.1 to 30 mmHg	0 to 5	7,14,18,25
Synchronization	- -	Double width pulse	29,30



(a) Pictorial view of main elements.

Figure I-45. - Remote control unit.



(b) Dimensions.

Figure I-45. - Concluded.

All five status indicators and the PLSS oxygen quantity indicator are illuminated by Beta particle capsules requiring no electricity. When activated, a cylinder rotates revealing the illuminated symbol underneath. The symbol is a key to emergency corrective action as follows:

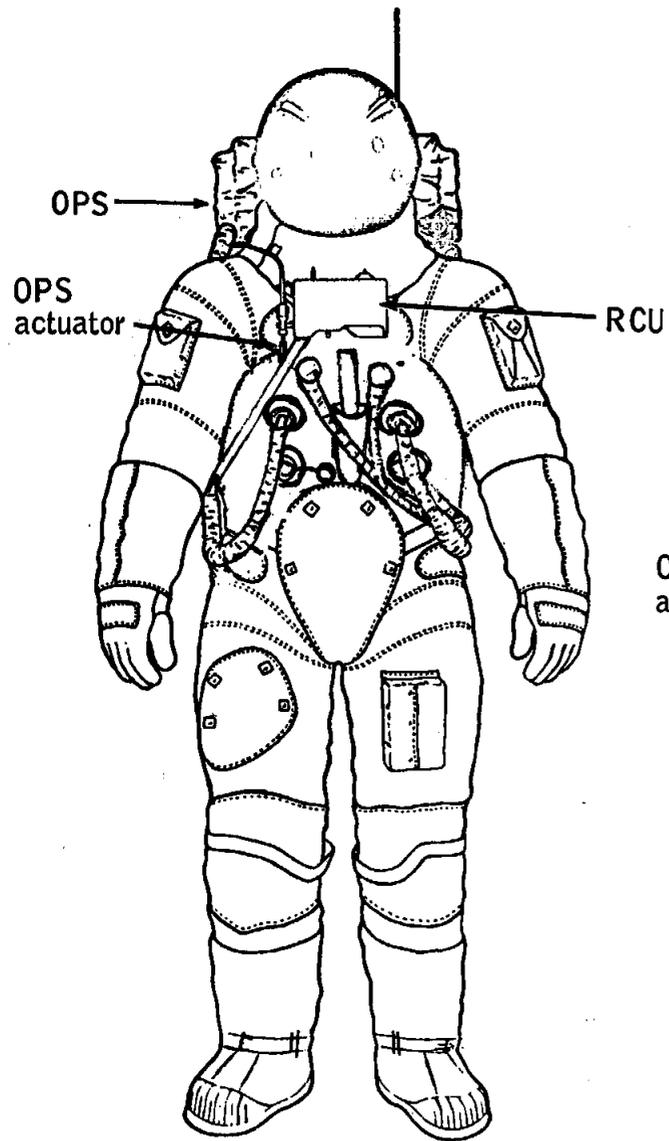
<u>Function</u>	<u>Indicator label</u>	<u>Window symbol</u>	<u>Indicated action</u>
High oxygen flow	O ₂	O	Actuate OPS
Low PGA pressure	Pressure	O	Actuate OPS
Low vent flow	Vent	P	Purge
Low feedwater pressure	H ₂ O	A	Abort
*High CO ₂	CO ₂	P	Purge

*Not presently operational.

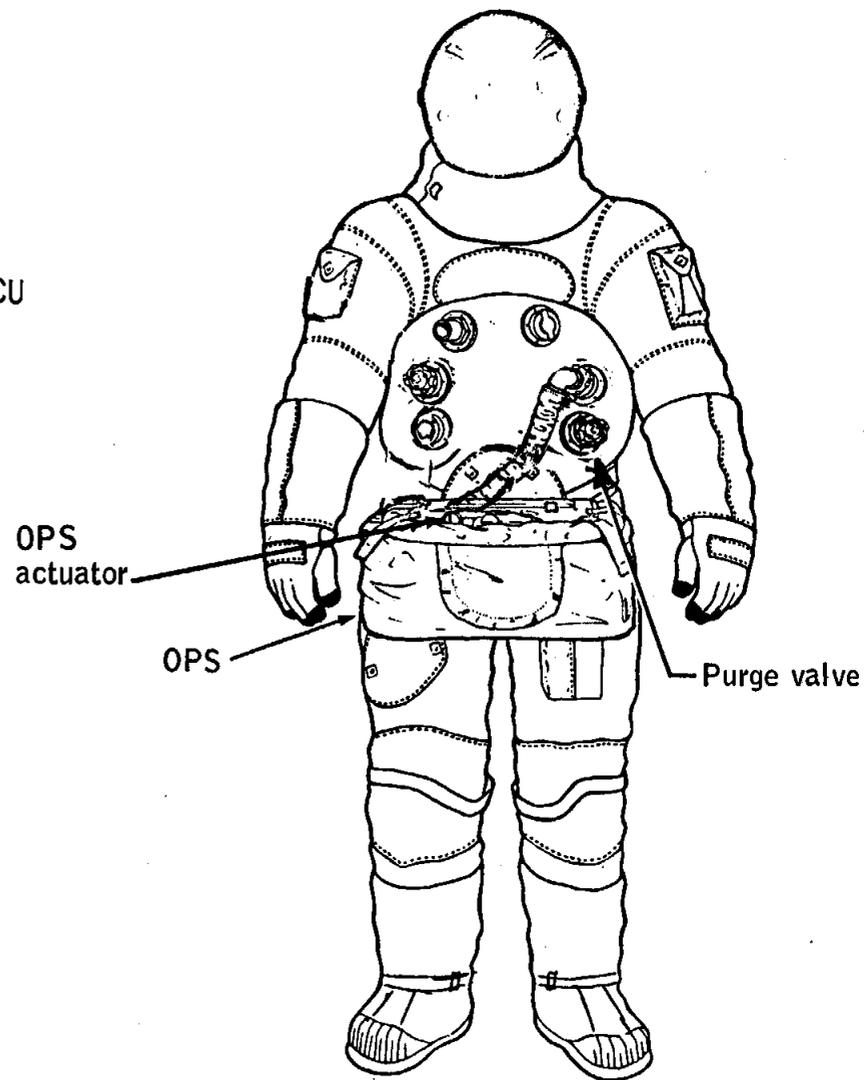
2.9 EMERGENCY LIFE SUPPORT SYSTEMS

2.9.1 Oxygen Purge System

The OPS provides the EMU with an oxygen supply and pressure control for certain failure modes of the PLSS or PGA during EVA. In the normal EVA configuration, the OPS is mounted on top of the PLSS (fig. I-46(a)) and is used independently or in conjunction with the PLSS systems during emergency operations. In a contingency extravehicular configuration, the OPS is attached to the PGA front lower torso (fig. I-46(b)) and functions independently of the PLSS. The OPS is self-contained and nonrechargeable in flight. The OPS provides 30 minutes of regulated (3.7 ± 0.3 psid) purge flow at a flow of 8.1 ± 0.3 lb/hr (6 to 7 cfm approximately) to prevent excessive CO₂ buildup and to provide limited cooling; or it can provide 75 minutes of regulated (3.7 ± 0.3 psid) purge flow at a flow of 4.0 ± 0.2 lb/hr (3 cfm approximately) to prevent excessive CO₂ buildup (cooling supplied by PLSS transport loop or BSLSS); or it may be used to apply makeup O₂ to the PLSS ventilation loop via the PGA at 0.07 to 2.0 lb/hr.



(a) Extravehicular mode.



(b) Contingency mode.

Figure I-46. - Extravehicular and contingency positions of the oxygen purge system.

The system (fig. I-47) consists of two interconnected spherical high-pressure oxygen bottles (each with 2.075 ± 0.025 pounds of usable oxygen at 5880 ± 80 psia at 70° F), a pressure regulator assembly, oxygen connectors, and necessary checkout instrumentation. The OPS has no communications capability but provides the hard mount for the PLSS vhf antenna.

The OPS oxygen pressure regulator assembly is a single-stage variable orifice regulator that keeps PGA inlet oxygen pressure to 3.7 ± 0.3 psid within a flow range of 0.07 to 8.4 lb/hr.

The regulator has a preoperational checkout system. The OPS pressure gage monitors the interconnected OPS oxygen bottles source pressure and is used for both ground fill and preoperational checkout. The OPS regulation pressure gage verifies regulated flow through a 0.07- to 0.36-lb/hr orifice mounted on the stowage plate.

The OPS can be mounted on the PLSS at zero g and one-sixth g in either a pressurized or unpressurized cabin.

2.9.2

Buddy Secondary Life Support System

The BSLSS enables two EVA crewmen to share the water cooling provided by one of their PLSS's following loss of this capability in the other PLSS.

The system (fig. I-48) 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 this double hose
- c. A flow dividing connector on the other end of this 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
- 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

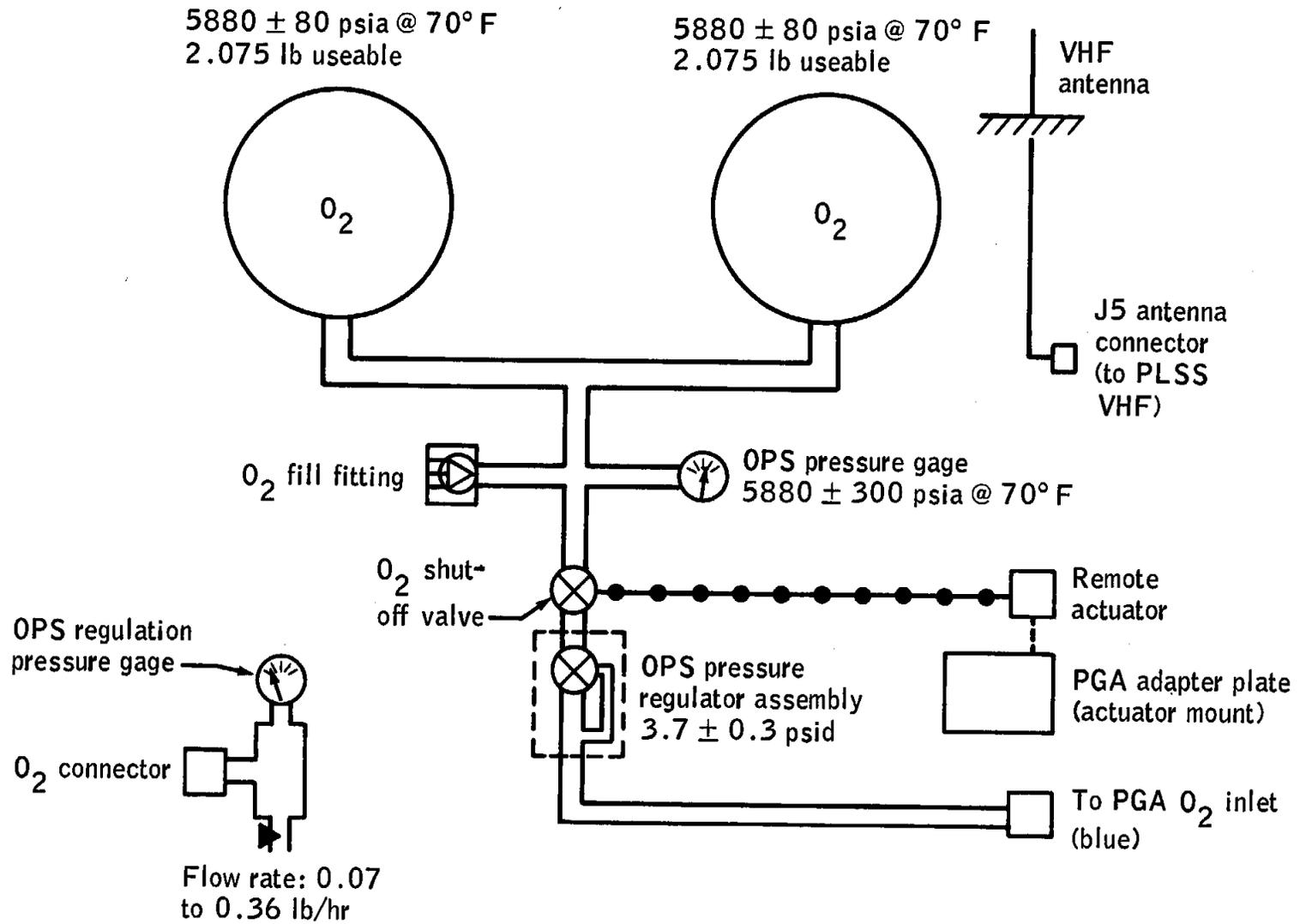


Figure I-47. - Schematic of oxygen purge system.

BUDDY - SLSS

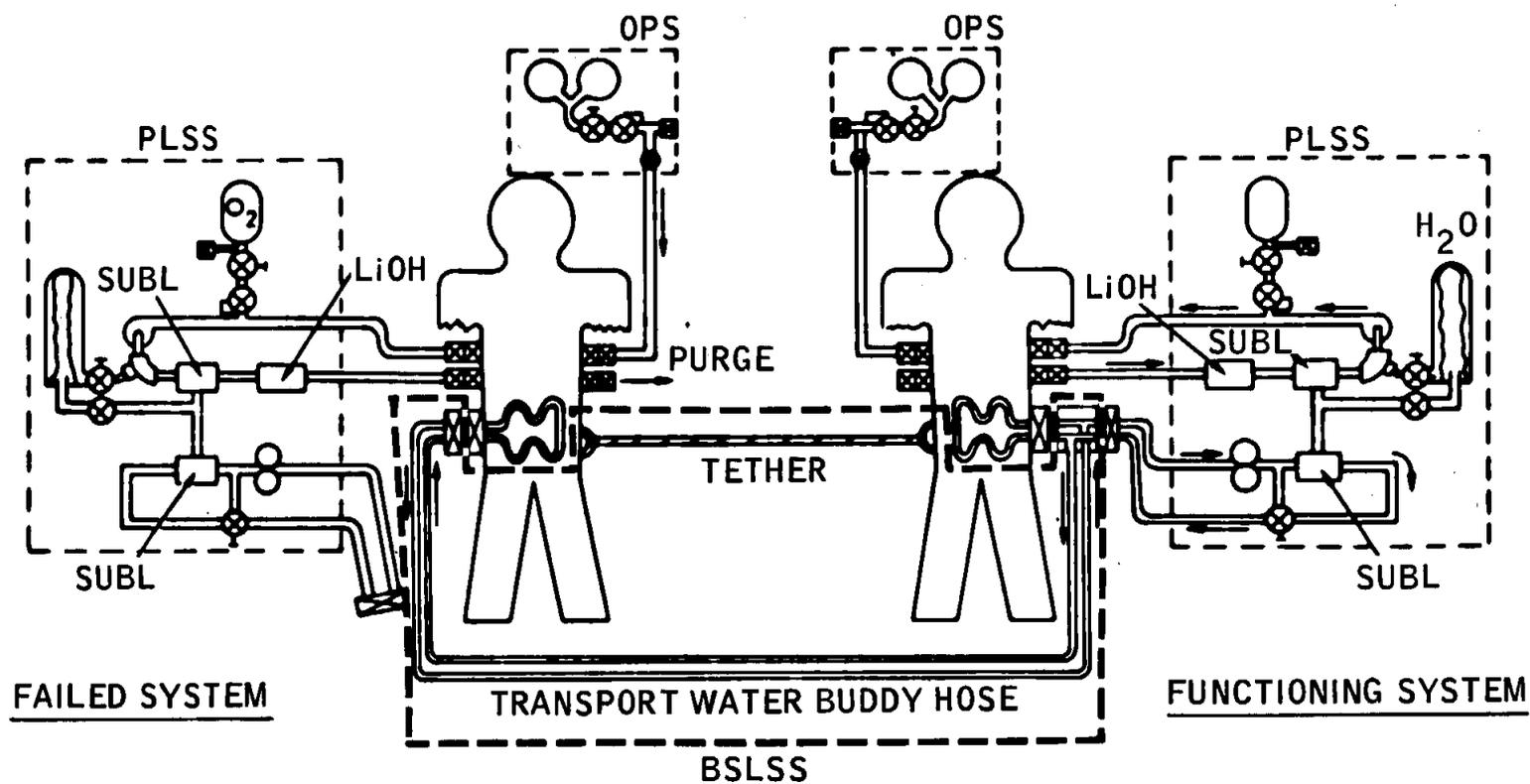


Figure I-48. - Buddy-SLSS system.

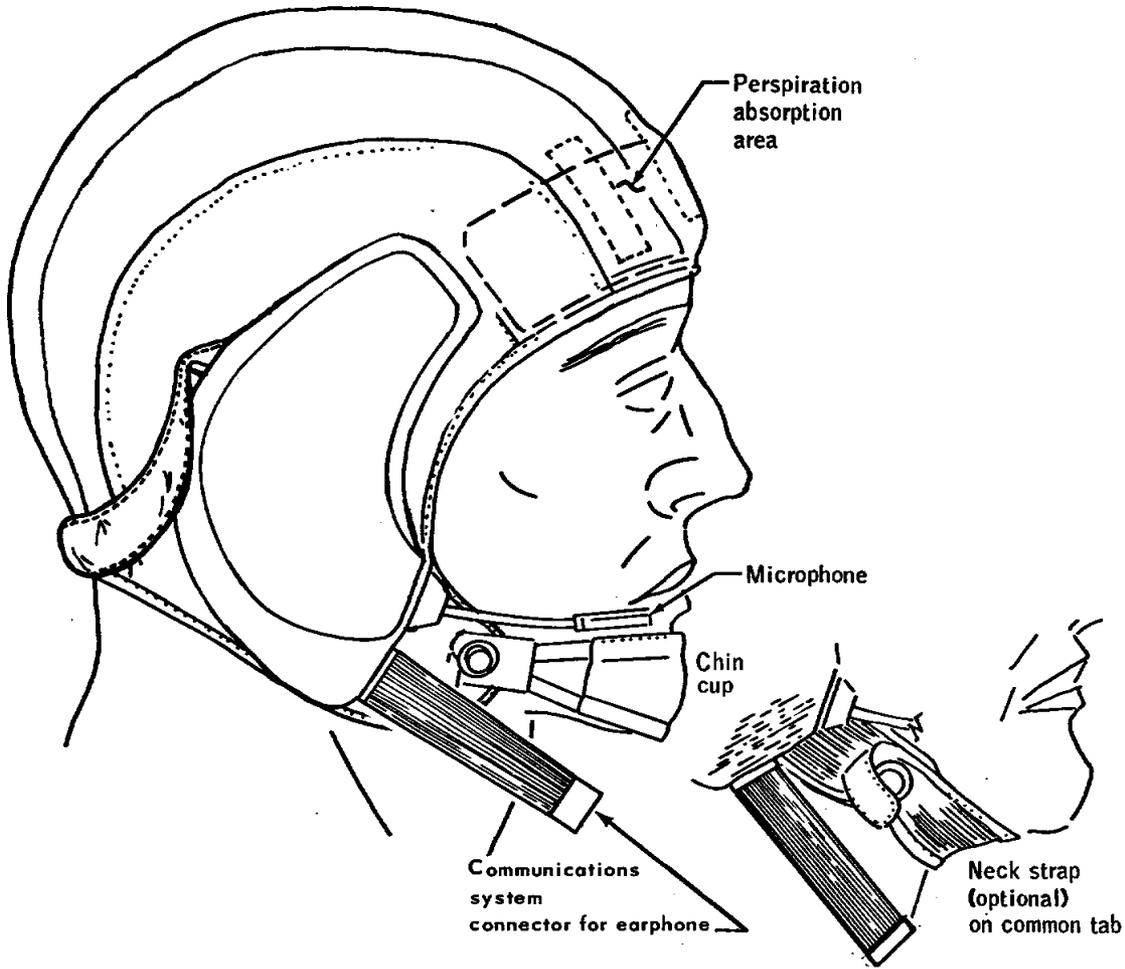


Figure I-49. - Communications carrier, skullcap type.

2.10 COMMUNICATIONS CARRIER

The communications carrier (fig. I-49) is a head-fitted assembly containing microphones and earphones mounted in soft-suspension skull cap. The acoustic isolation between earphone and microphone is 60 dB minimum when the carrier is properly fitted. The electronic 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 means of a 4-1/2-inch 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.

2.11 BIOINSTRUMENTATION SYSTEM

The bioinstrumentation system (fig. I-50) is attached to either the CWG or the LCG and contains the necessary bioinstrumentation for crew status check. The bioinstrumentation, connected to the PGA electrical harness, consists of an EKG signal conditioner, impedance pneumograph (ZPN) signal conditioner, dc-dc converter, and axillary and sternal electrodes.

2.11.1 Electrocardiogram Signal Conditioner

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

2.11.2 Impedance Pneumograph 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.

2.11.3 The dc-dc Power Converter

The dc-dc power converter delivers a +10 and -10 volt power to each signal conditioner. It converts the single-ended 16.8 volt power to the +10 and -10 volt power required by the bioinstrumentation systems.

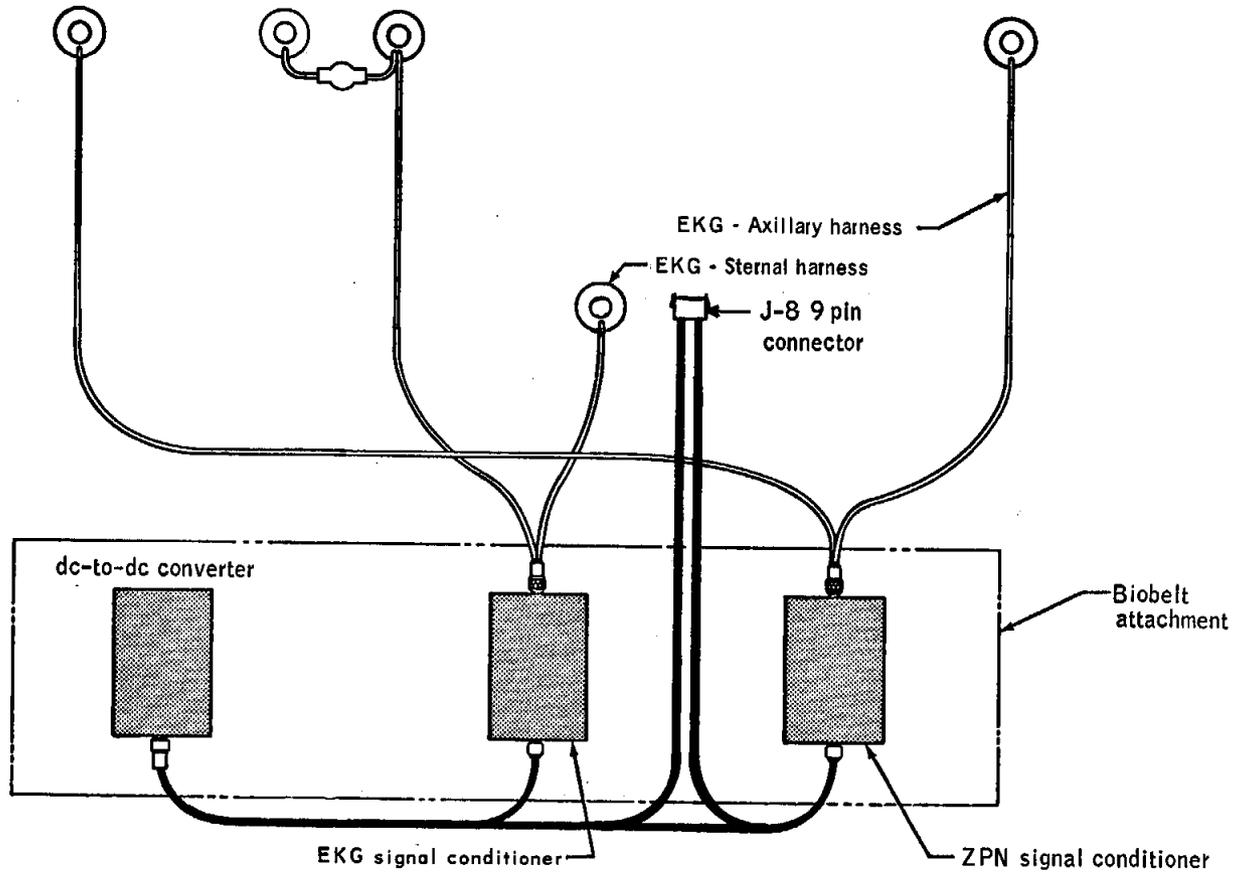


Figure I-50. - Bioinstrumentation system.

2.11.4 Electrodes

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

2.11.5 Biobelt

The biobelt supports the signal conditioners and power converter. The power converter is located in the right-hand pocket (as worn), the EKG signal conditioner in the center pocket, and the ZPN signal conditioner in the left-hand pocket. The connector ends of these units are colored red, blue, and yellow, respectively. When installing or re-installing the units, the above order is maintained because of electrode harness lengths. When transferring the belt between the LCG and the CWG, the color-coded electrode harnesses are disconnected at the units and the units retained in the belt. The bioharness need not be disconnected from the belt. Electrodes are not removed to change garments.

2.12 LEVA HELMET STOWAGE BAG

The LHSB (fig. I-51) is constructed of a Teflon-coated Beta fabric attached to a polycarbonate base. The bag contains the EMU maintenance kit, extravehicular gloves, and lunar extravehicular visor assembly when they are not in use. The LHSB prevents the free movement of this equipment through the LM cabin. The bag also protects this equipment from damage due to vibration and impact shock.

2.13 INFLIGHT HELMET STOWAGE BAG

The inflight HSB (fig. I-52) is used for temporary helmet stowage in the CM. It is constructed of a Teflon-coated Beta fabric and is conformal to helmet size.

2.14 THE EMU MAINTENANCE KIT

The maintenance kit (fig. I-53) is a lightweight compact assembly containing cleaning, replacement, and repair parts

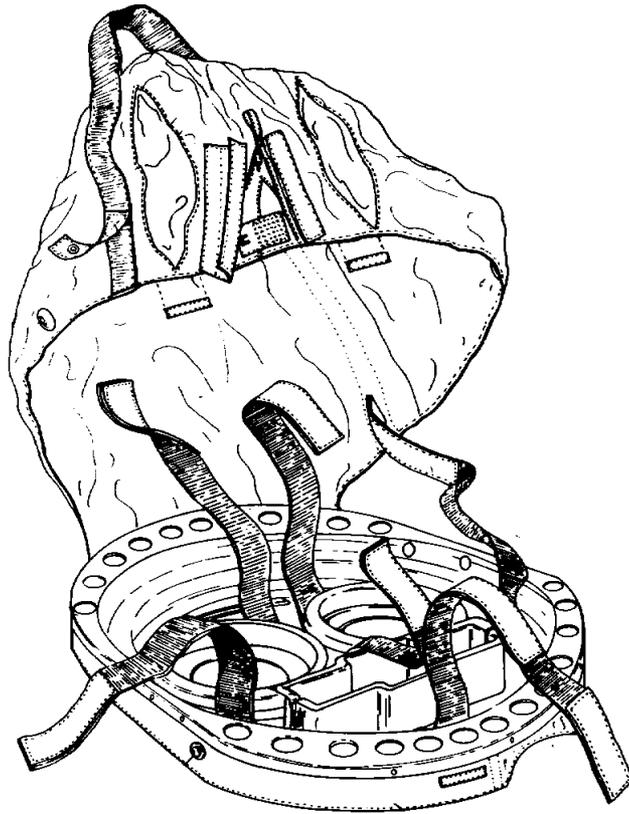


Figure I-51. - LEVA helmet stowage bag.



Figure I-52. - Inflight helmet stowage bag.

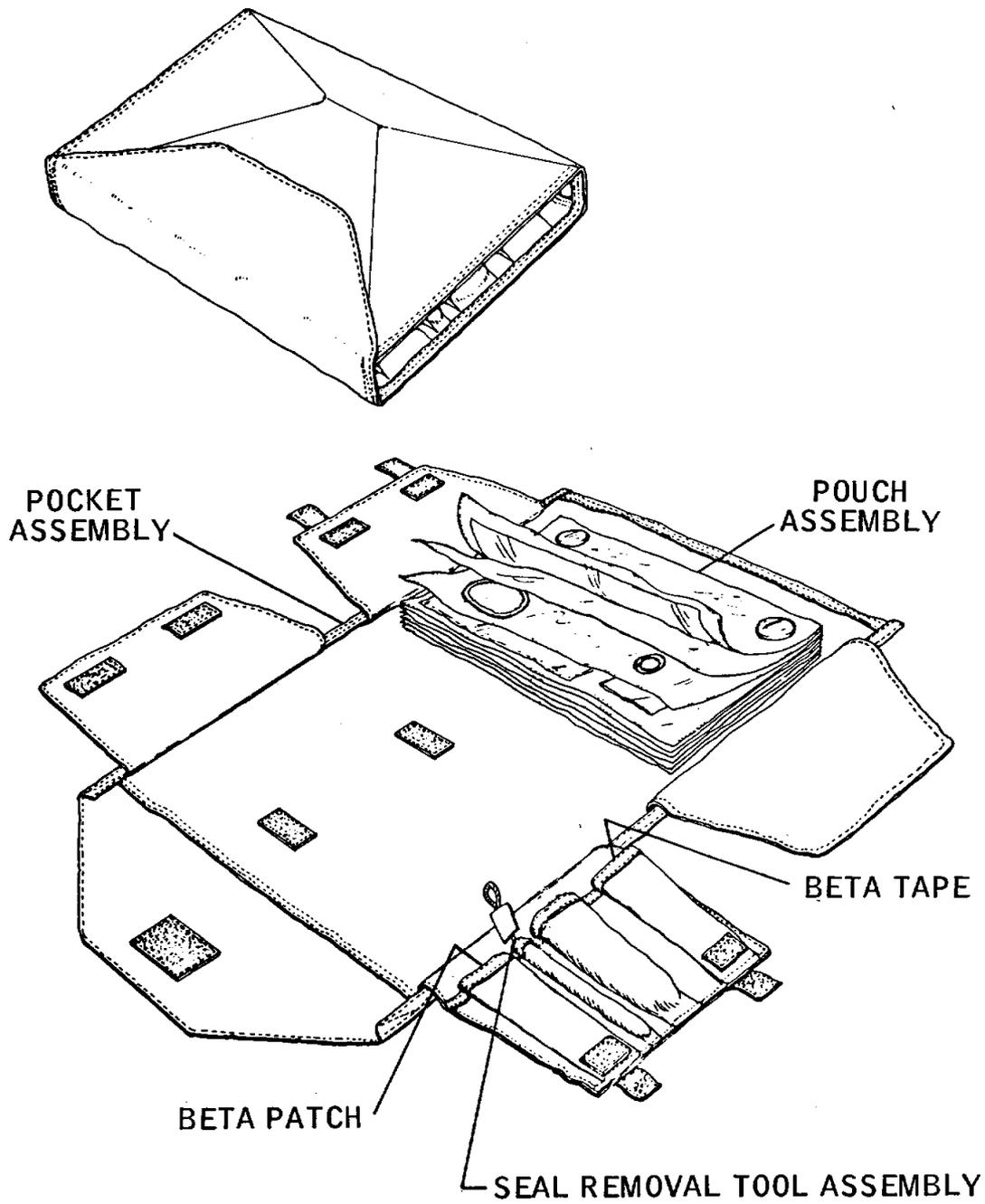


Figure I-53. - Maintenance kit for pressure garment assembly.

for inflight maintenance of the PGA and LEVA. The maintenance kit compartments are stored in a Teflon-coated Beta cloth roll and the kit is stowed in the helmet stowage bag. Inside the kit are two flaplike pockets which contain the seal removal tool and transparent pouches containing replacement parts and lubricant pads.

The seal removal tool is a nylon rod with a preformed tip for removal of O-rings. The tool has a lanyard with an attached pile fastener strip which may be secured to any hook strip for temporary stowage.

The lubricant pads are saturated with lubricant which is to be used on the pressure sealing slide fastener, seals, O-rings, and shoulder cable.

The first pouch contains three repair patches made of pressure-sensitive tape designed to seal accidental punctures in the PGA. The second pouch has two compartments; one for the spare gas connector "O" ring (inlet and outlet), and the other for the spare feed port "O" ring. The third pouch contains a replacement seal for the suit-side large wrist disconnect (left or right). The fourth pouch contains a replacement seal for the suit-side small wrist disconnect (left or right). The fifth pouch contains five applicator pads saturated with a cleaning and defogging solution. The sixth and seventh pouches each contain five drying towels made of lint-free paper, and the eighth pouch contains usage instructions for the entire maintenance kit.

2.15 THE PLSS FEEDWATER COLLECTION BAG

The PLSS feedwater collection bag is capable of containing the feedwater remaining in the PLSS upon completion of lunar activity. The bag contains a connector which mates with the PLSS feedwater fill connector. After accepting the surplus feedwater, the bag maintains it in a sealed condition. The bag is designed to be used with a spring-type scale to measure the amount of feedwater collected. The weighing operation is performed in the lunar environment by a suited astronaut. Accuracy of the scale is verified by calibration with dead loads and shall be no worse than 3 percent of full scale in one-sixth g.

The PLSS feedwater collection bag is constructed of two layers. The inner layer is neoprene-coated nylon tricot and the outer restraint layer is Nomex cloth. The bag is tubular in shape and has a hole or scale attachment point at one end and a connector which interfaces with the PLSS at the other. The bag holds approximately 5.8 pounds of water at one g.

2.16

Drinking Bag (In-Suit)

A drinking bag is provided to enable the individual crewman to have access to approximately 8 ounces of drinking water during an EVA. The bag is constructed of 10-mil polyurethane and has a surgical rubber tube which extends into the bag and down one side to the bottom. There is a bite valve on the drinking end of the tube. The bag has a fill connector at the top on the other side which is identical to that used on the food bags. This allows the drinking bag to be refilled using the water dispenser/fire extinguisher prior to the next EVA. There is a heat seal along the vertical center line of the bag which does not extend completely to either the top or bottom, and prevents the bag from bulging excessively when it is charged. The top of the heat seal is used as an indication of a complete fill. When the water level within the bag is at the top of the heat seal, the bag contains approximately 8 ounces of water. Nylon Velcro hook and pile is incorporated along the top horizontal edge to provide for mounting the drinking bag between the comfort liner and bladder of the PGA in the chest area. The Velcro of the bag is sandwiched between that of the two suit layers at the neck opening. The drinking bag is installed in the PGA with the drinking tube on the crewman's left. To obtain water, the crewman bites gently on the mouth-piece and sucks the water as if using a straw.

3.0 DESCRIPTION OF EMU FUNCTIONS

3.1 PRESSURIZATION AND VENTILATION SYSTEM

The pressurizable envelope of the PGA consists of an inner nylon-rubber bladder and an outer restraint of nylon cloth except where the shoulder, elbow, thigh, knee, ankle, and wrist convolutes are located. The convolutes are single-layer integrated restraint and bladder structures composed of nylon fabric dipped in a rubber compound. The gloves are constructed similarly to the convolutes. The anthropomorphic envelope is normally pressurized at 3.85 ± 0.15 psid, but will withstand a burst pressure of not less than 10.00 psid. The envelope will not permit external gas leakage in excess of 0.0315 lb/hr when pressurized to 3.9 psid under normal conditions.

If a hypodermic injection is required, it is administered through the biomedical injection patch located on the right 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 which is installed on the right 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 left wrist of the PGA opens and closes from 4.8 to 5.5 psid, and it precludes the possibility of suit pressures in excess of 5.5 psid when using the PLSS.

Within the pressurizable envelope is a ventilation system (figs. I-54 and I-55) constructed of noncrushable ducts that distribute a pressurization and ventilation gas flow from the inlet gas connector(s) to the helmet or torso areas and then from the extremities through ducts to the outlet gas connector(s). The contaminated gas then flows through umbilicals to either the spacecraft ECS system or the PLSS. (Note: The intravehicular configuration uses only one set of gas connectors as shown in figure I-54, but the extravehicular configuration incorporates two sets of gas connectors as shown in figure I-55. The two inlet connectors are interconnected and the two outlet connectors are interconnected to allow for an uninterrupted ventilation flow during transfer between

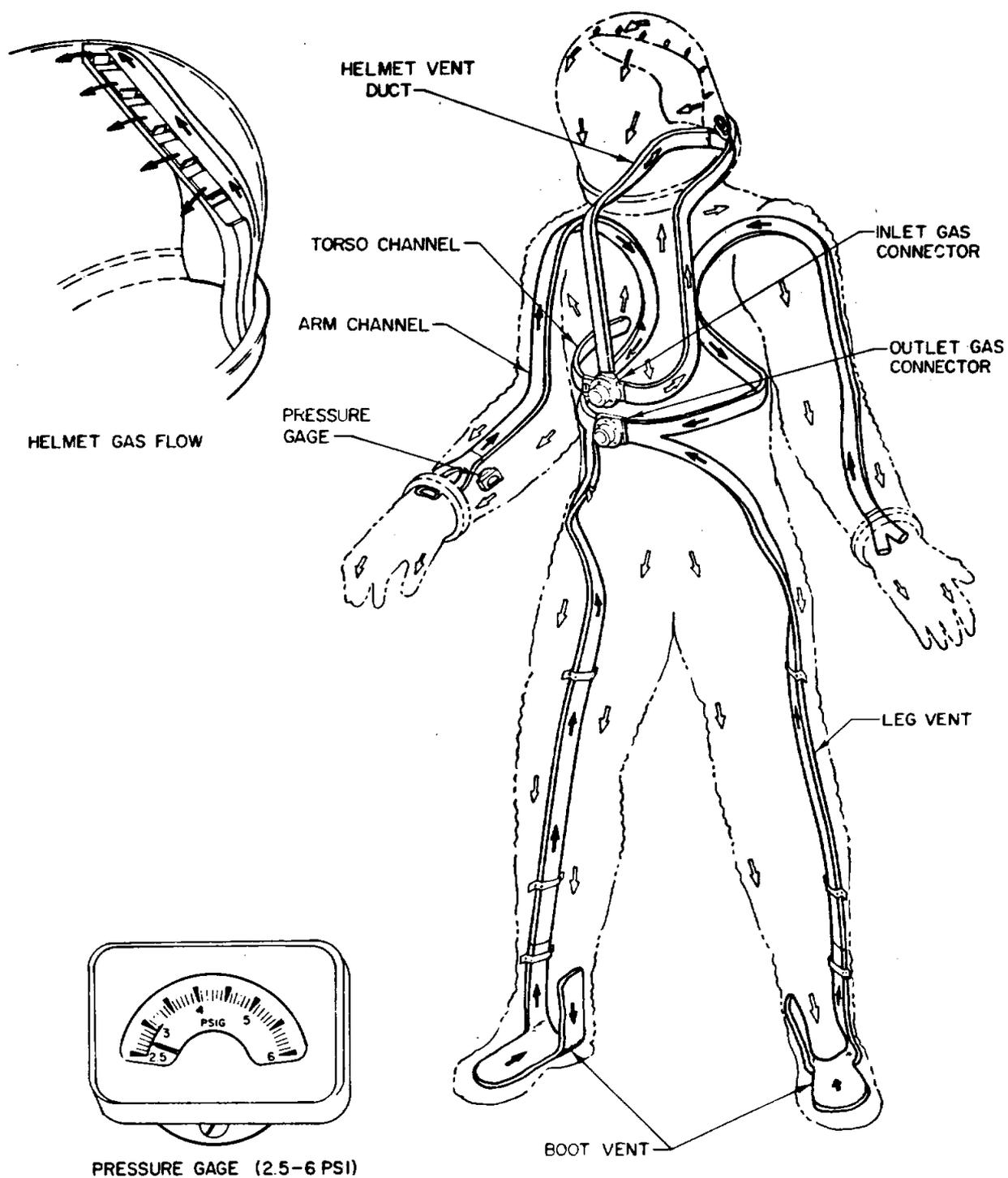


Figure I-54. - The IV pressurization/ventilation system.

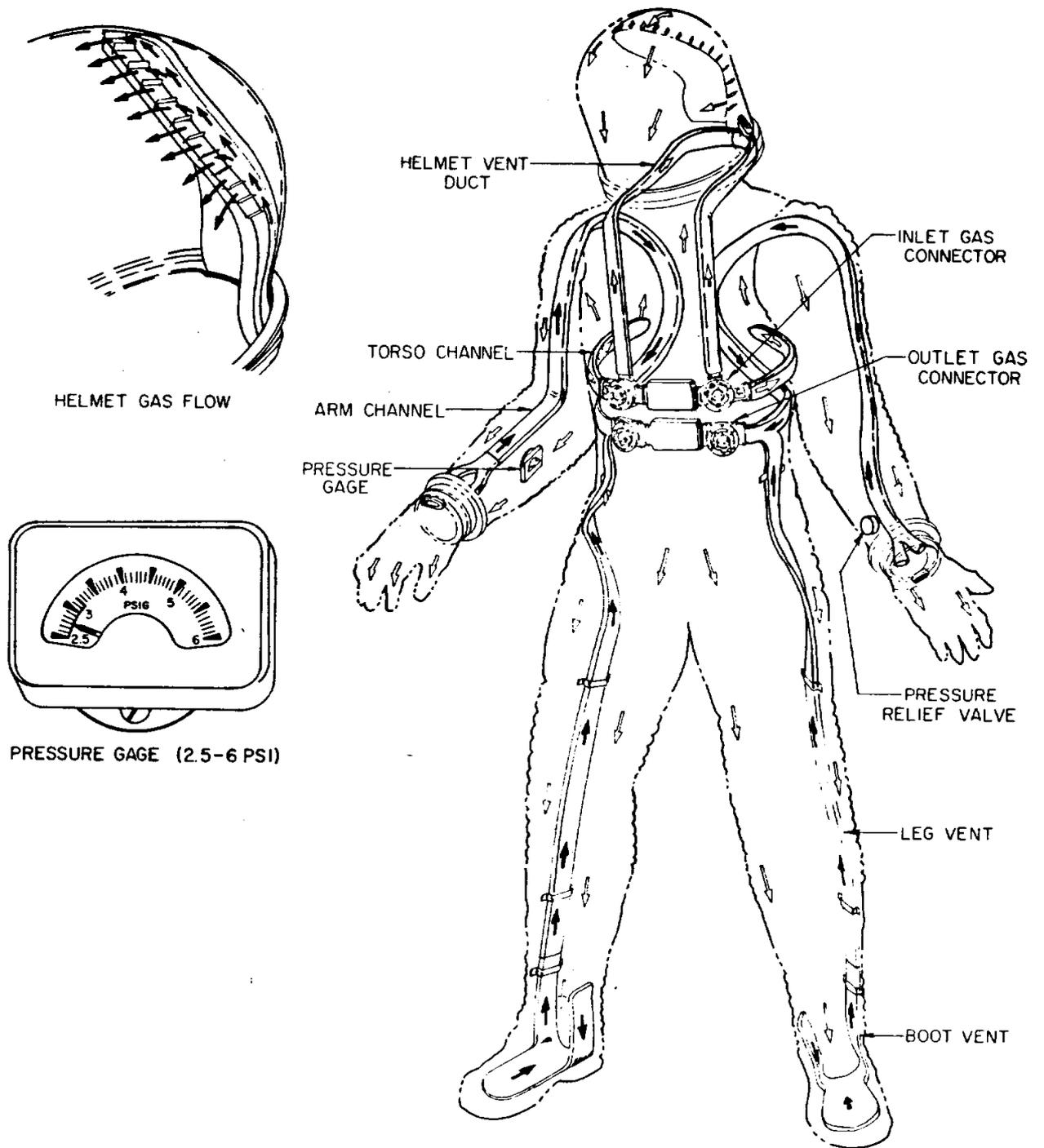


Figure I-55. - The EV pressurization/ventilation system.

ECS systems.) The gas flow to the helmet passes over the inside surface to aid helmet defogging and over the oral-nasal area within the helmet for efficient respiration and CO₂ washout.

As the gas flows over the body it removes heat and transports evolved body gases, toxicants, and moisture out of the PGA.

When the PGA environment is being sustained by the PLSS, the oxygen from the PGA enters the ventilating loop of the PLSS and passes immediately through the contaminant control assembly where body odors are removed by activated charcoal and the CO₂ is removed by chemical reaction with the LiOH. The purified oxygen is then cooled by passing through the sublimator and then the moisture is removed from the cooled oxygen by the water separator. The cooled purified oxygen then returns to the PGA through the PLSS outlet connector and the PGA inlet connector. The suit pressure is maintained and the makeup flow of oxygen is provided by the regulated outlet of the primary oxygen subsystem of the PLSS.

The normal inlet gas flow temperature is expected to be 35° to 80° F. During extravehicular modes of operation with the inlet gas connector diverter valve(s) in the CLOSED (EVA) position, the specified pressure drop across the ventilation system will be a nominal 1.8 inches of water at a 6.0 cfm flow rate of oxygen at 3.9 psia having an inlet temperature of 77° F. During intravehicular modes of operation with the inlet gas connector diverter valve(s) in the OPEN (IVA) position, a nominal pressure drop of 4.7 inches of water will exist with a flow rate of 12.0 cfm of oxygen at 3.9 psia and an inlet gas temperature of 50° F. A ventilation fan provides the pressure rise to maintain flow within the ventilation loop.

The OPS is mounted on the PLSS during extravehicular activity to supply oxygen for emergencies. The OPS will maintain pressure at the OPS outlet gas connector at 3.7 ± 0.3 psid with a stabilized oxygen temperature of 30° to 80° F. The purge valve, located in the right suit outlet gas connector, has two flow positions that allow for low flow or high flow requirements. Low flow capability is 4.0 lb/hr for CO₂ washout when cooling is handled by the normal PLSS system by using the BSLSS. High flow capability gives a flow of 8.0 lb/hr purge flow from the OPS for CO₂ washout and emergency cooling.

When the OPS is used, ventilation will be to the helmet only to ensure adequate CO₂ washout from the oral-nasal area.

3.2 LIQUID COOLING AND CIRCULATION

Although the oxygen ventilation system provides some body cooling because of the inlet temperature and perspiration evaporation, the cooling system of the LCG is the primary means for removing body heat during extravehicular tasks. The cooling water is supplied through the liquid transport loop of the PLSS. A water diverter valve permits the selection of three transport water temperatures at the LCG inlet.

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 PVC 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 water connector to the PLSS for cooling. The water within the PLSS is circulated through the sublimator to provide this 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.

The BSLSS enables the two crewmen to share the circulation and cooling provided by the liquid transport loop of one operating PLSS in the event of loss of liquid loop metabolic cooling by the other PLSS. The BSLSS enables the crewman with the bad system to tap into the other crewman's liquid transport loop with an 8-1/2-foot umbilical. A 4-1/2-foot restraint tether attached to the PGA waist restraint loops of both crewmen is provided to allow them to traverse the lunar surface while preventing damage to the umbilical or either crewman's PGA. The availability of the BSLSS in combination with the 4.0 lb/hr O₂ purge flow rate provides the crewmen with approximately 1 hour of extravehicular time in which to return to the IM in case of EMU malfunction.

3.3 COMMUNICATIONS

The extravehicular communications system (EVCS) is used to provide a communications system for the crewman while in an extravehicular activity. The EVCS provides full-duplexed voice between both EV crewmen and the flight controllers during lunar surface activities. Biomedical and PLSS data from each astronaut are also processed through the EVCS and relayed to the MSFN for monitoring and display. The operation of the EVCS is discussed under EMU component description (PLSS).