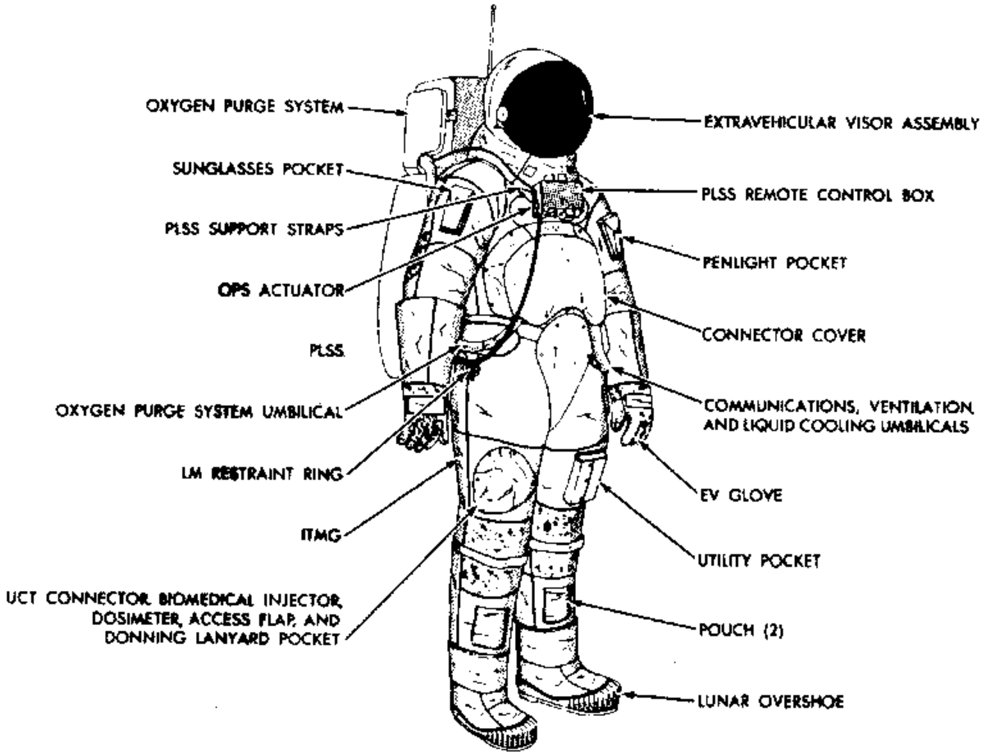

Integral Thermal Micrometeoroid Garment

which provides protection against solar radiation and space particles. The EVVA is held snug to the PGA helmet by a tab-and-strap arrangement that allows the visors to be rotated approximately 90° up or down, as desired. An EVVA for each astronaut is stowed on the floor at his station during launch. When the LM is occupied, the EVVA's are stowed in the PGA helmet bags secured on the ascent engine cover.

PORTABLE LIFE SUPPORT SYSTEM

The PLSS is a self-contained, self-powered, rechargeable environmental control system. In the extravehicular configuration of the EMU, the PLSS is worn on the astronaut's back. The PLSS supplies pressurized oxygen to the PGA, cleans and cools the expired gas, circulates cool liquid in the LCG through the liquid transport loop, transmits astronaut biomedical data, and functions as a duel VHF transceiver for communication.

The PLSS has a contoured fiberglass shell to fit the back, and a thermal micrometeoroid protective cover. It has three control valves, and, on a separate remote control unit, two control switches, a volume control, and a five-position switch for the dual VHF transceiver. The remote control unit is set on the chest.

The PLSS attaches to the astronaut's back, over the ITMG; it is connected by a shoulder harness assembly. When not in use, it is stowed on the floor or in the left-hand midsection. To don the PLSS, it is first hooked to the overhead attachments in the left-hand midsection ceiling. The astronaut backs against the pack, makes PGA and harness connections, and unhooks the PLSS straps from the overhead attachment.

The PLSS can operate for 4 hours, with a maximum of 4,800 Btu, in space environment before oxygen and feedwater must be replenished

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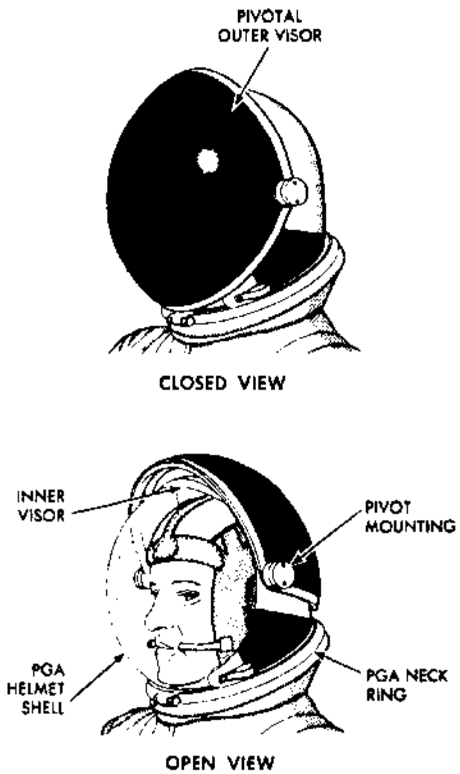
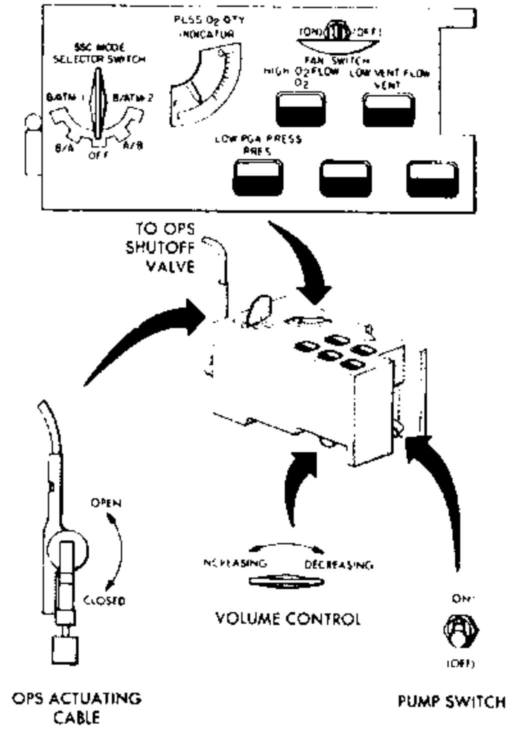


R-22

Extravehicular Visor Assembly



R-23

PLSS Remote Control Unit

and the battery replaced. The basic systems and loops of the PLSS are primary oxygen subsystem, oxygen ventilation loop, feedwater loop, liquid transport loop, and electrical system.

The space suit communicator (SSC) in the PLSS provides primary and secondary duplex voice communication and physiological and environmental telemetry. All EMU data and voice must be relayed through the LM and CM and transmitted to MSFN via S-band. The VHF antenna is permanently mounted on the oxygen purge system (OPS). Two tone generators in the SSC generate audible 3- and 1.5-kHz warning tones to the communications cap receivers. The generators are automatically turned on by high oxygen flow, low vent flow, or low PGA pressure. Both tones are readily distinguishable.

PLSS REMOTE CONTROL UNIT

The PLSS remote control unit is a chest-mounted instrumentation and control unit. It has a fan switch, pump switch, SSC mode selector switch, volume control, PLSS oxygen quantity indicator, five status indicators, and an interface for the OPS actuator.

OXYGEN PURGE SYSTEM

The OPS is a self-contained, independently powered, high-pressure, nonrechargeable emergency oxygen system that provides 30 minutes of regulated purge flow. The OPS consists of two interconnected spherical high-pressure oxygen bottles, an automatic temperature control module, an oxygen pressure regulator assembly, a

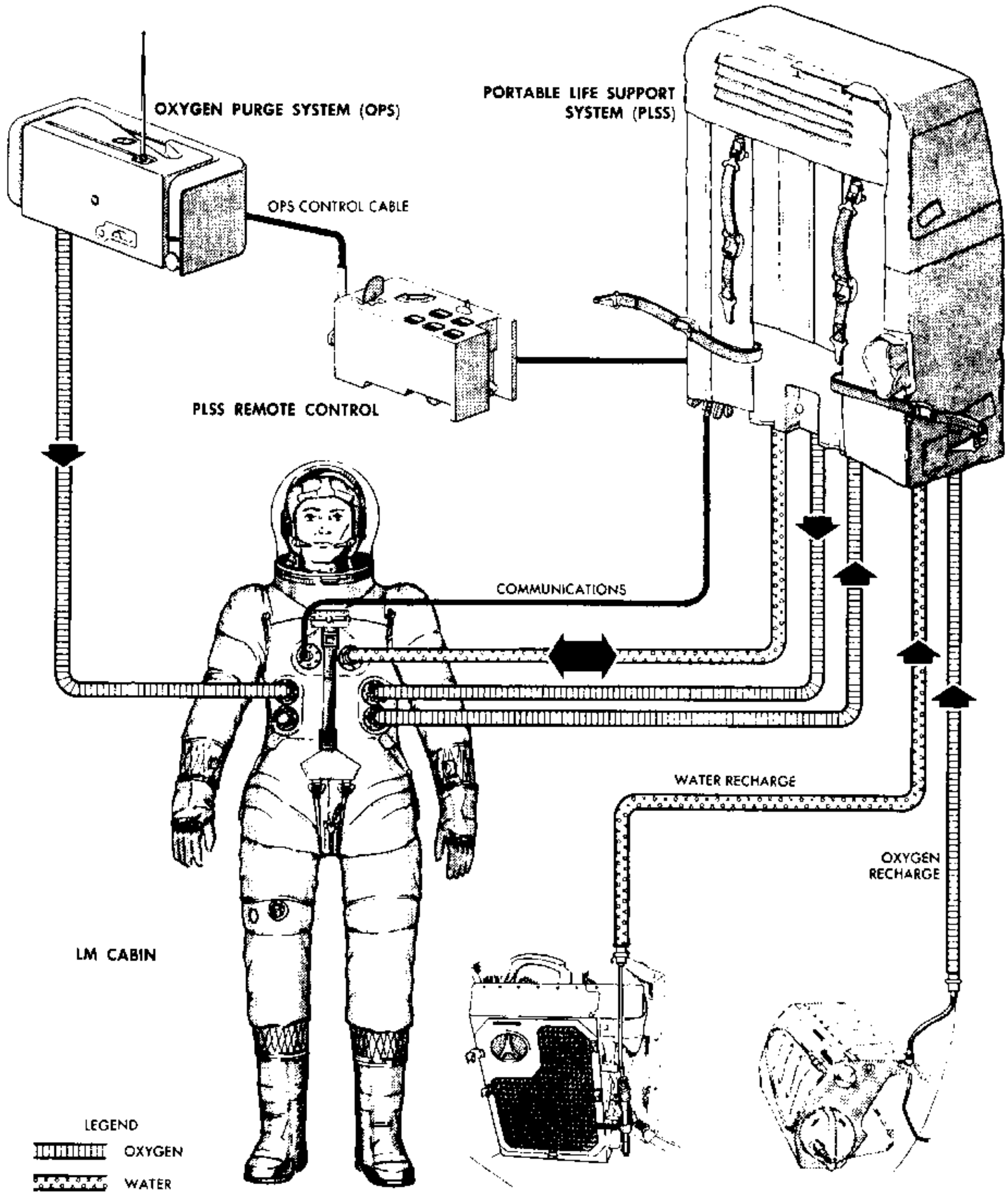


Diagram of the Portable Life Support System

Grumman

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battery, an oxygen connector, and checkout instrumentation. In the normal extravehicular configuration, the OPS is mounted on top of the PLSS and is used with PLSS systems during emergency operations. In the contingency extravehicular configuration, the OPS is attached to the PGA front lower torso and functions independently of the PLSS. The OPS has no communications capability, but provides a hard mount for the SSC VHF antenna. Two OPS's are stowed in the LM.

UMBILICAL ASSEMBLY

The umbilical assembly consists of hoses and connectors for securing the PGA to the ECS, Communications Subsystem (CS), and Instrumentation Subsystem (IS). Separate oxygen and electrical umbilicals connect to each astronaut.

The oxygen umbilical consists of Flourel hoses (1.25-inch inside diameter) with wire reinforcement. The connectors are of the quick-disconnect type, with a 1.24-inch, 70° elbow at the PGA end. Each assembly is made up of two hoses and a dual-passage connector at the ECS end and two separate hoses (supply and exhaust) at the PGA end. When not connected to the PGA, the ECS connector end remains attached and the hoses stowed.

The electrical umbilical carries voice communications and biomedical data, and electrical power for warning-tone impulses.

CREW LIFE SUPPORT

The crew life support equipment includes food and water, a waste management system, personal hygiene items, and pills for in-flight emergencies. A potable-water unit and food packages contain sufficient life-sustaining supply for completion of the LM mission.

CREW WATER SYSTEM

The water dispenser assembly consists of a mounting bracket, a coiled hose, and a trigger-actuated water dispenser. The hose and dispenser extend approximately 72 inches to dispense water from the ECS water feed control assembly. The ECS water feed control valve is opened to permit water flow. The dispenser assembly supplies water at +50° to +90° for drinking or food preparation and fire extinguishing. The water for drinking and food preparation is filtered through a bacteria filter. The water dispenser is inserted directly into the mouth for drinking. Pressing the trigger-type control supplies a thin stream of water for drinking and food preparation. For firefighting, a valve on the dispenser is opened. The valve provides a greater volume of water than that required for drinking and food preparation.

FOOD PREPARATION AND CONSUMPTION

The astronaut's food supply (approximately 3,500 calories per man per day) includes liquids and solids with adequate nutritional value and low waste content. Food packages are stowed in the LM midsection, on the shelf above PLSS No. 1 and the right-hand stowage compartment.

The food is vacuum packed in plastic bags that have one-way poppet valves into which the water dispenser can be inserted. Another valve allows food passage for eating. The food bags are packaged in aluminum-foil-backed plastic bags for stowage and are color coded: red (breakfast), white (lunch), and blue (snacks).

Food preparation involves reconstituting the food with water. The food bag poppet-valve cover is cut with scissors and pushed over the water dispenser nozzle after its protective cover is removed. Pressing the water dispenser trigger releases water. The desired consistency of the food determines the quantity of water added. After withdrawing the water dispenser nozzle, the protective cover is replaced and the dispenser returned to its stowage position. The food bag is kneaded for approximately 3 minutes, after which the food is considered reconstituted. After cutting off the neck of the food bag, food can be squeezed into the mouth through the food-passage valve. A germicide tablet, attached to the outside of the food bag, is inserted into the bag after food consumption, to prevent fermentation

"ApolloNewsRef LM E.CPE07.PICT" 388 KB 1999-02-02 dpi: 360h x 367v pix: 2660h x 3766v

and gas formation. The bag is rolled to its smallest size, banded, and placed in the waste disposal compartment.

EMU WASTE MANAGEMENT SYSTEM

The EMU waste management system provides for the disposal of body waste through use of a fecal containment system and a urine collection and transfer assembly, and for neutralizing odors. Personal hygiene items are stowed in the right-hand stowage compartment.

Waste fluids are transferred to a waste fluid collector assembly by a controlled difference in pressures between the PGA and cabin (ambient). The primary waste fluid collector consists of a long transfer hose, control valve, short transfer hose, and a 8,900-cc multilaminate bag. The long transfer hose is stowed on a connector plate when not in use. To empty his in-suit urine container, the astronaut attaches the hose to the PGA quick-disconnect, which has a visual flow indicator. Rotating the handle of the spring-loaded waste control valve controls passage of urine to the assembly. The 8,900-cc bag is in the PLSS LiOH storage unit, the short transfer hose is connected between the waste control valve and the bag.

With cabin pressure normal (4.8 psia), the long transfer hose is removed from the connector stowage plate and attached to the PGA male disconnect. The PGA is overpressurized by 0.8°0.2 psia and the waste control valve is opened. Urine flows from the PGA to the collector assembly at a rate of approximately 200 cc per minute. When bubbles appear in flow indicator, the valve indicator is released and allowed to close.

A secondary waste fluid collector system provides 900-cc waste fluid containers, which attach directly to the PGA. Urine is transferred directly from the PGA, through the connectors, to the bags. These bags can then be emptied into the 8,900-cc collector assembly.

FECAL DEVICE

The fecal containment system consists of an outer fecal/emesis bag (one layer of Aclar) and a smaller inner bag. The inner bag has waxed tissue on its inner surface. Polyethylene-backed toilet tissue and a disinfectant package are stored in the inner bag.

To use, the astronaut removes the inner bag from the outer bag. After unfastening the PGA and removing undergarments, the waxed tissue is peeled off the bag's inner surface and the bag is placed securely on the buttocks. After use, the used toilet tissue is deposited in the used bag and the disinfectant package is pinched and broken inside the bag. The bag is then closed, kneaded, and inserted in the outer bag. The wax paper is removed from the adhesive on the fecal/emesis bag and the bag is sealed then placed in the waste disposal compartment.

PERSONAL HYGIENE ITEMS

Personal hygiene items consist of wet and dry cleaning cloths, chemically treated and sealed in plastic covers. The cloths measure 4 by 4 inches and are folded into 2-inch squares. They are stored in the food package container.

MEDICAL EQUIPMENT

The medical equipment consists of biomedical sensors, personal radiation dosimeters, and emergency medical equipment.

Biomedical sensors gather physiological data for telemetry. Impedance pneumographs continuously record heart beat (EKG) and respiration rate. Each assembly (one for each astronaut) has four electrodes which contain electrolyte paste; they are attached with tape to the astronaut's body.

Six personal radiation dosimeters are provided for each astronaut. They contain thermoluminescent powder, nuclear emulsions, and film that is sensitive to beta, gamma, and neutron radiation. They are placed on the forehead or right temple, chest, wrist, thigh, and ankle to detect radiation to eyes, bone marrow, and skin. Serious, perhaps critical, damage results if radiation dosage exceeds a predetermined level. For quick, easy reference each astronaut has a dosimeter mounted on his EMU.

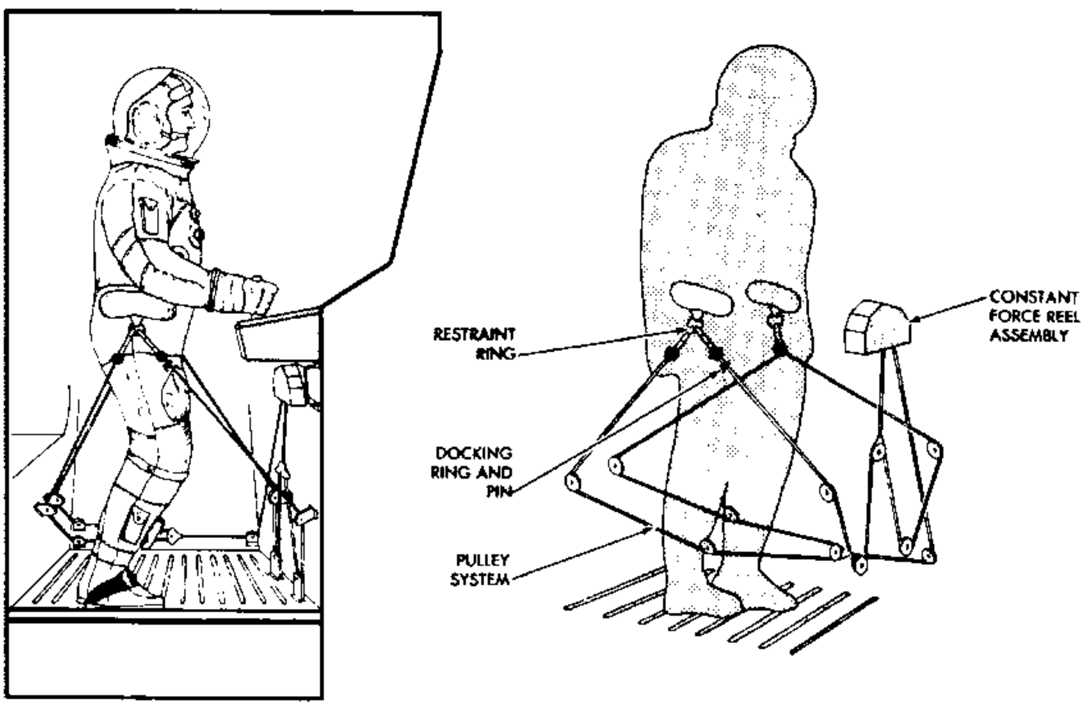
The emergency medical equipment consists of a kit of six capsules: four are pain killers (Darvon) and two are pep pills (Dexedrine). The kit is attached to the interior of the flight data file, readily accessible to both astronauts.

CREW SUPPORT AND RESTRAINT EQUIPMENT

The crew support and restraint equipment includes armrests, handholds (grips), Velcro on the floor to interface with the boots, and a restraint assembly operated by a rope-and-pulley arrangement that secures the astronauts in an upright position under zero-g conditions.

The armrests, at each astronaut position, provide stability for operation of the thrust/translation controller assembly and the attitude controller assembly, and restrain the astronaut laterally. They are adjustable (four positions) to accommodate the astronaut; they also have stowed (fully up) and docking (fully down) positions. The armrests, held in position by spring-loaded detents, can be moved from the stowed position by grasping them and applying downward force. Other positions are selected by pressing latch buttons on the armrest forward area. Shock attenuators are built into the armrests for protection against positive-g forces (lunar landing). The maximum energy absorption of the armrest assembly is a 300-pound force, which will cause a 4-inch armrest deflection.

The handholds, at each astronaut station and at various locations around the cabin, provide support for the upper torso when activity involves turning, reaching, or bending; they attenuate movement in any direction. The forward



R-25

Restraint Equipment

panel handholds are single upright, peg-type, metal grips. They are fitted into the forward bulkhead, directly ahead of the astronauts, and can be grasped with the left or right hand.

The restraint assembly consists of ropes, restraint rings, and a constant-force reel system. The ropes attach to D-rings on the PGA sides, waist high. The constant-force reel provides a downward force of approximately 30 pounds, it is locked during landing or docking operations. When the constant-force reel is locked, the ropes are free to reel in. A ratchet stop prevents paying out of the ropes and thus provides zero-g restraint. During docking maneuvers, the Commander uses pin adjustments to enable him to use the crewman optical alignment sight (COAS) at the overhead (docking) window.

DOCKING AIDS AND TUNNEL HARDWARE

Docking operations require special equipment and tunnel hardware to effect linkup of the LM with the CSM. Docking equipment includes the crewman's optical alignment sight (COAS) and a docking target. A drogue assembly, probe assembly, the CSM forward hatch, and hardware inside the LM tunnel enable completion of the docking maneuver.

The COAS provides the Commander with gross range cues and closing rate cues during the docking maneuver. The closing operation, from 150 feet to contact, is an ocular, kinesthetic coordination that requires control with minimal use of fuel and time. The COAS provides the Commander with a fixed line-of-sight attitude reference image, which appears to be the same distance away as the target.

The COAS is a collimating instrument. It weighs approximately 1.5 pounds, is 8 inches long, and operates from a 28-volt d-c power source. The COAS consists of a lamp with an intensity control, a reticle, a barrel-shaped housing and mounting track, and a combiner and power receptacle. The reticle has vertical and horizontal 10° gradations in a 10° segment of the circular combiner glass, on an elevation scale (right side) of -10° to +31.5°. The COAS is capped and secured to its mount above the left window (position No. 1).

To use the COAS, it is moved from position No. 1 to its mount on the overhead docking window frame (position No. 2) and the panel switch is set from OFF to OVHD. The intensity control is turned clockwise until the reticle appears on the combiner glass; it is adjusted for required brightness.

The docking target permits docking to be accomplished on a three-dimensional alignment basis. The target consists of an inner circle and a standoff cross of black with self-illuminating disks within an outer circumference of white. The target-base diameter is 17.68 inches. The standoff cross is centered 15 inches higher than the base and, as seen at the intercept, is parallel to the X-axis and perpendicular to the Y-axis and the Z-axis.

The drogue assembly consists of a conical structure mounted within the LM docking tunnel. It is secured at three points on the periphery of the tunnel, below the LM docking ring. The LM docking ring is part of the LM midsection outer structure, concentric with the X-axis. The drogue assembly can be removed from the CSM end or LM end of the tunnel.

Basically, the assembly is a three-section aluminum cone secured with mounting lugs to the LM tunnel ring structure. A lock and release mechanism on the probe, controls capture of the CSM probe at CSM-LM contact. Handles are provided to release the drogue from its tunnel mounts.

The tunnel contains hardware essential to final docking operations. This includes connectors for the electrical umbilicals, docking latches, probe-mounting lugs, tunnel lights, and deadfacing switches.

The probe assembly provides initial CSM-LM coupling and attenuates impact energy imposed by vehicle contact. The probe assembly may be folded for removal and for stowage within either end of the CSM transfer tunnel.

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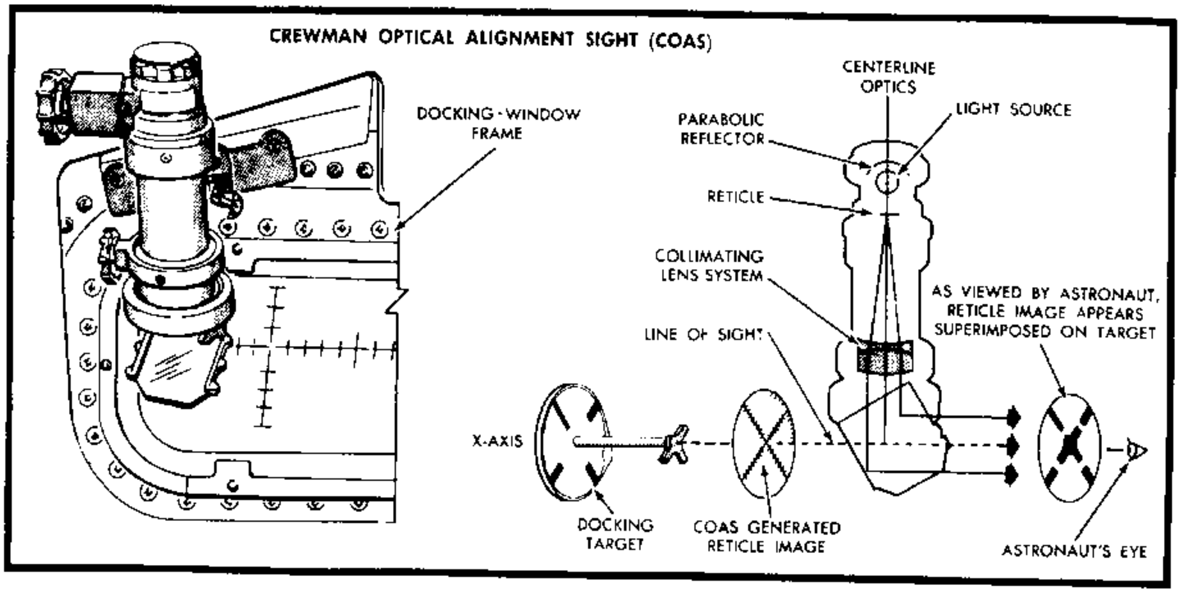

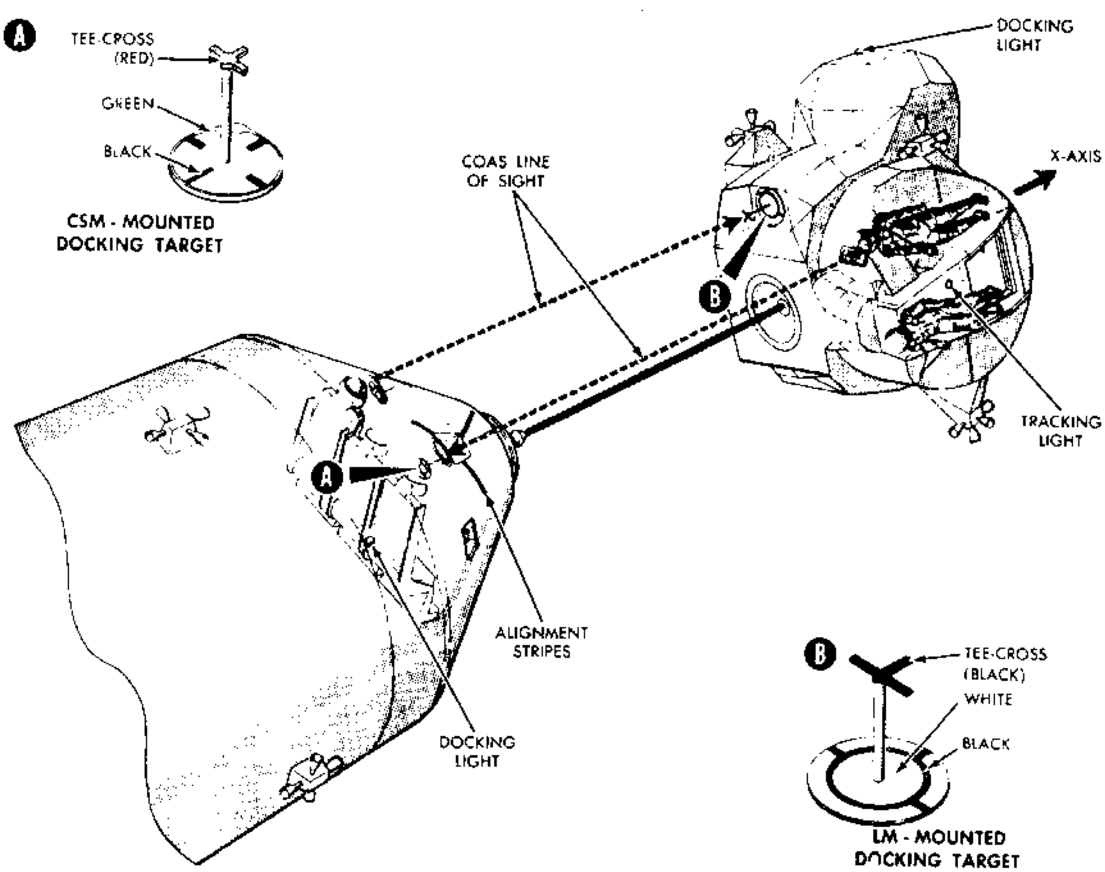

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Docking Aids

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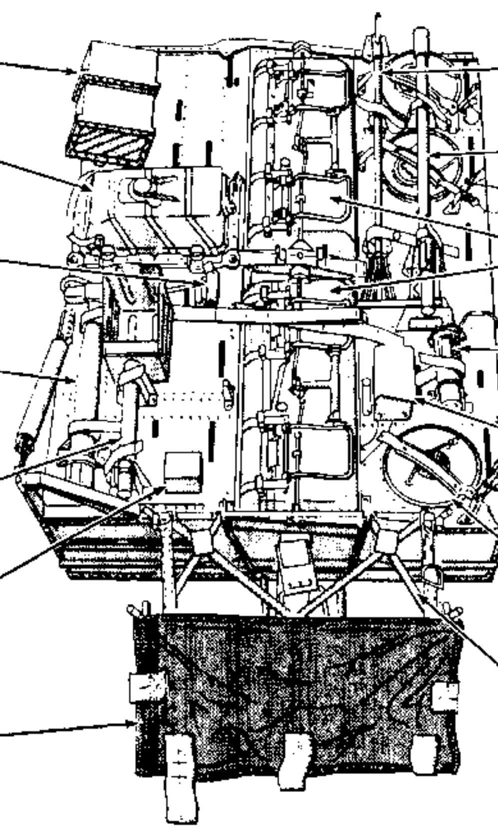
CREW MISCELLANEOUS EQUIPMENT

Miscellaneous equipment required for completion of crew operations consists of in-flight data with checklists, emergency tool B, and window shades.

The in-flight data are provided in a container in the left-hand midsection. The Commander's checklist is stowed at his station. The in-flight data kit is stowed in a stowage compartment. The packages include the flight plan, experiments data and checklist, mission log and data book, systems data book and star charts.

Tool B (emergency wrench) is a modified Allen-head L-wrench. It is 6.25 inches long and has a 4.250-inch drive shaft with a 7/16-inch drive. The wrench can apply a torque of 4,175 inch-pounds; it has a ball-lock device to lock the head of the drive shaft. The wrench is stowed on the right side stowage area inside the cabin. It is a contingency tool for use with the probe and drogue, and for opening the CM hatch from outside.

Window shades are used for the overhead (docking) window and forward windows. The window shade material is Aclar. The surface facing outside the cabin has a highly reflective metallic coating. The shade is secured at the bottom (rolled position). To cover the window, the shade is unrolled, flattened against the frame area and secured with snap fasteners.



R-27

Modularized Equipment Stowage Assembly

MODULARIZED EQUIPMENT STOWAGE ASSEMBLY

The MESA pallet is located in quad 4 of the descent stage. The pallet is deployed by the extravehicular astronaut when the LM is on the lunar surface. It contains fresh PLSS batteries and LiOH cartridges, a TV camera and cable, tools for obtaining lunar geological samples, and containers in which to store the samples. It also has a folding table on which to place the sample return containers. The folding table also functions as a bracket on which to hang the transfer bag, which is used to transfer the PLSS batteries and the cartridges to the cabin.

EARLY APOLLO SCIENTIFIC EXPERIMENTS PAYLOAD (EASEP)

The EASEP, a 171 pound package of scientific equipment, is carried in the LM on the initial lunar landing mission. It contains three experiments:

- Passive seismometer
- Solar wind experiment
- Laser ranging retro-reflector

PASSIVE SEISMOMETER

The passive seismometer is a self-contained station, with a direct earth-lunar communications link. Its solar cells and radioisotope nuclear generator heaters are designed for a 1-year lifetime.

SOLAR WIND EXPERIMENT

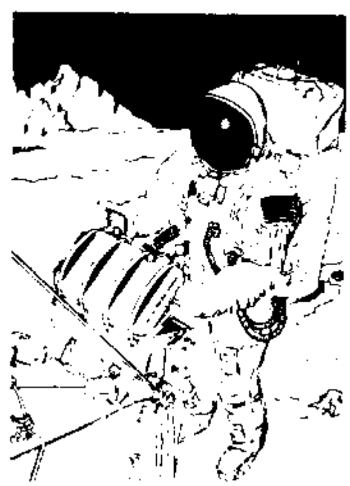
The solar wind experiment is designed to isolate exotic gases such as argon, krypton, xenon, neon, and helium in the solar wind. A sheet of aluminum foil, used to entrap the gases will be returned to earth for analysis.

LASER RANGING RETRO-REFLECTOR

The laser ranging retro-reflector is a passive experiment with an array of optical reflectors that serve as targets for laser-pointing systems on earth. The experiment is designed to accurately measure the distance between earth and the moon.

ASTRONAUT PLACING EQUIPMENT TRANSFER BAG ON MESA TABLE

ASTRONAUT STOWING LiOH CARTRIDGE IN EQUIPMENT TRANSFER BAG



ASTRONAUT PLACING LUNAR SAMPLE IN SAMPLE RETURN CONTAINER

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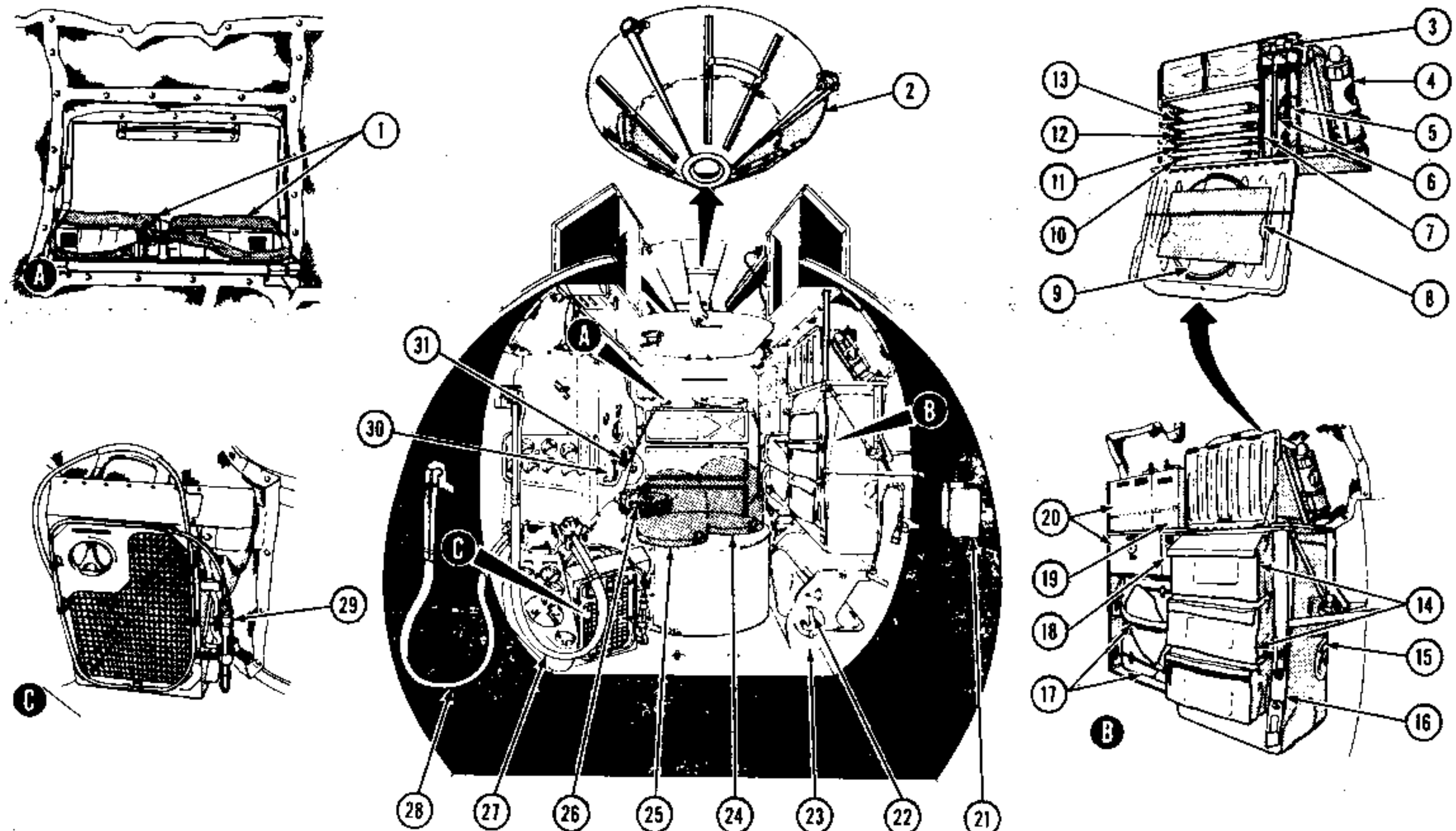
Application of MESA on Lunar Surface

APOLLO NEWS REFERENCE



ITEM	NOMENCLATURE	LOCATION
1	PLSS REMOTE CONTROL UNIT (2)	CENTER 227 BULKHEAD
2	DOCKING DROGUE	INSIDE DOCKING TUNNEL (LAUNCH POSITION)
3	LM MEDICAL PKG	ONBOARD DATA FILE
4	RADIATION SURVEY METER	ONBOARD DATA FILE
5	LM HARD-SUIT HANDBOOK	ONBOARD DATA FILE
6	LM SOFT-SUIT HANDBOOK	ONBOARD DATA FILE
7	LM PROCEDURES	ONBOARD DATA FILE
8	MERCATOR LUNAR STAR CHART	ONBOARD DATA FILE
9	POLAR LUNAR STAR CHART	ONBOARD DATA FILE
10	LUNAR DESCENT AIDS	ONBOARD DATA FILE
11	LM SYSTEMS DATA	ONBOARD DATA FILE
12	FLIGHT PLAN	ONBOARD DATA FILE

ITEM	NOMENCLATURE	LOCATION
13	CREW LOG	ONBOARD DATA FILE
14	UTILITY LIGHT ASSEMBLY (2)	IN INTERIM STOWAGE ASSEMBLY
15	PLSS	RECHARGE STATION
16	INTERIM STOWAGE ASSEMBLY	FRONT OF PLSS (POSITION NO. 2)
17	OXYGEN PURGE SYSTEM (2) AND SRC-OPS ADAPTER	AFT OF PLSS
18	PILOT'S PREFERENCE KIT	ABOVE OPS
19	FOOD (3 PKG; 2 MAN DAYS	LH MIDSECTION
20	LUNAR OVERSHOES (2 PAIR)	LH MIDSECTION
21	DATA STORAGE ELECTRONICS ASSEMBLY	- 227 BULKHEAD
22	URINE-COLLECTION ASSEMBLY	IN WASTE MANAGEMENT SECTION
23	WASTE MANAGEMENT SECTION	LH MIDSECTION

ITEM	NOMENCLATURE	LOCATION
24	LMP'S HELMET STOWAGE BAG, EVVA, EV GLOVES, PURGE FITTING	ASCENT ENGINE COVER (POSITION 2)
25	CDR'S HELMET STOWAGE BAG, EVVA, EV GLOVES, EMU MAINTENANCE KIT, PURGE FITTING	ASCENT ENGINE COVER (POSITION 2)
26	LiOH CANISTER	MIDSECTION, AFT OF ASCENT ENGINE COVER
27	O_2 UMBILICAL ASSEMBLY (CDR)	RH MIDSECTION
28	O_2 UMBILICAL ASSEMBLY (LMP)	RH SIDE
29	WATER DISPENSER FIRE-EXTINGUISHING ASSEMBLY	FORWARD OF ENGINE COVER
30	LiOH CARTRIDGE (ECS)	RH AFT MIDSECTION
31	LiOH CARTRIDGE (PLSS)	RH AFT MIDSECTION

Crew Miscellaneous Equipment (Sheet 1)

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CPE-14

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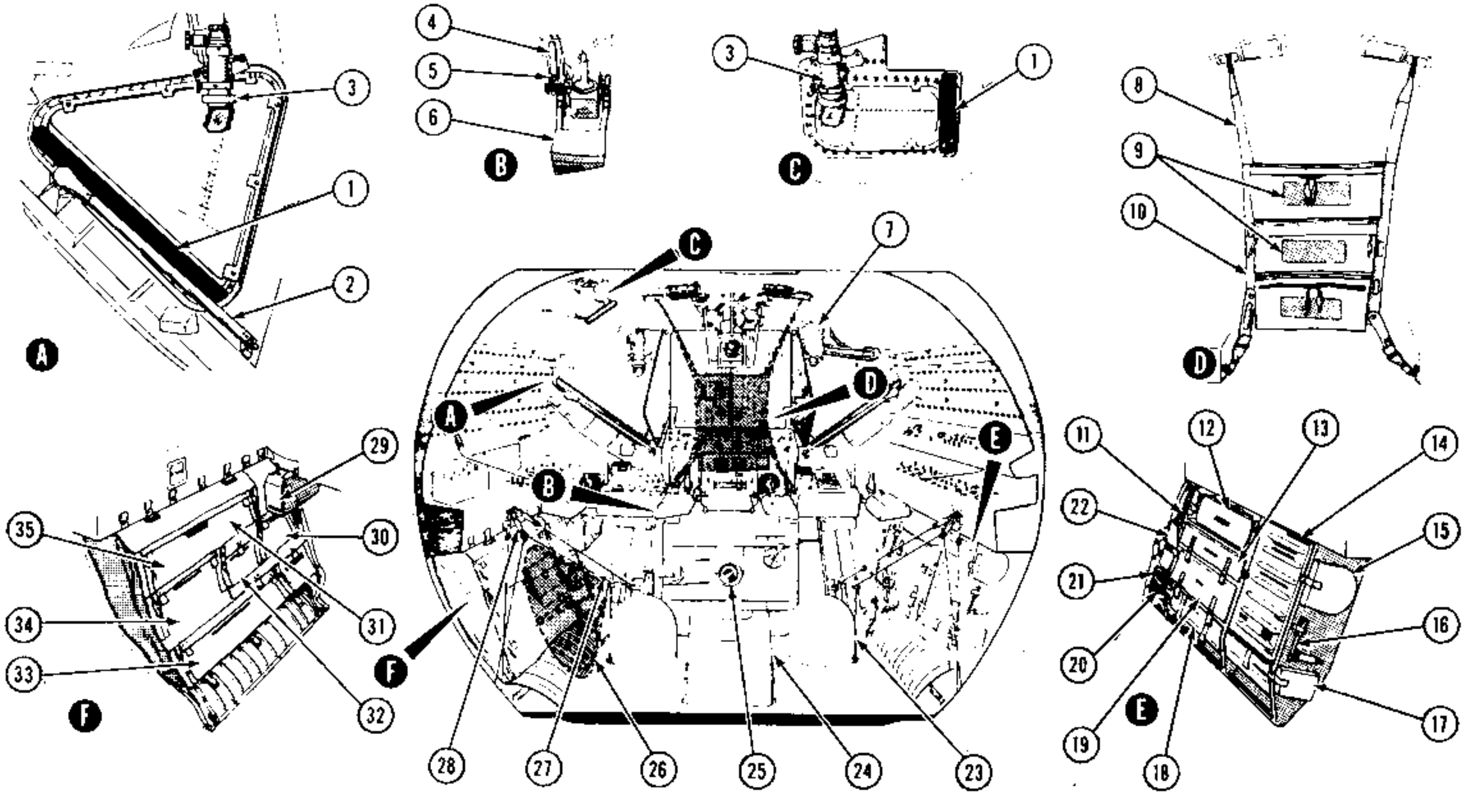

ITEM	NOMENCLATURE	LOCATION
1	WINDOW SHADE (3)	FORWARD AND OVERHEAD WINDOWS
2	CRASH BAR (2)	FORWARD WINDOWS
3	COAS	LEFT WINDOW (POSITION NO. 1) OVERHEAD WINDOW (POSITION NO. 2)
4	HANDGRIP (4)	FORWARD OF CDR'S AND LMP'S STATIONS
5	RESTRAINT REEL CONTROLS (2)	LOWER RIGHT PANEL 5, LOWER LEFT PANEL 6
6	ARMRESTS (4)	CDR'S AND LMP'S STATIONS
7	16-MM DATA ACQUISITION CAMERA 18-MM LENS, 16-MM MAGAZINE, POWER CABLE	ABOVE RIGHT WINDOW
8	INTERIM STOWAGE ASSEMBLY	POSITION NO. 1)
9	UTILITY LIGHT ASSEMBLY (2)	INTERIM STOWAGE ASSY
10	LUNAR ORBITAL MAP AND STAR CHART	INTERIM STOWAGE ASSY
11	MIRROR	RHSSC
12	70-MM HASSELBLAD CAMERA CONTAINER, 70-MM FILM MAGAZINE (2)	RHSSC

ITEM	NOMENCLATURE	LOCATION
13	DEFECATION COLLECTING DEVICE, EMESIS BAG (4)	RHSSC
14	16-MM FILM MAGAZINE, S.W. ANGLE CAMERA, 16-MM FILM MAGAZINE CONTAINER, HASSELBLAD MAGAZINE, EVA CAMERA TETHER, POLARIZING FILTER, 16-MM MAGAZINE CONTAINER	COMPARTMENT, CAMERA
15	PLSS CHECKOUT CABLE	
16	EMERGENCY TOOL B	RHSSC
17	LM UTILITY TOWEL ASSEMBLY	
18	FOOD (3 PKG) 2 MAN DAYS	RHSSC
19	LARGE AND SMALL URINE COLLECTION ASSEMBLIES (2 EACH)	RHSSC
20	COAS LIGHT BULB	RHSSC
21	ACFT EYEGUARD ASSEMBLY AND HIGH-DENSITY FILTER	RHSSC

ITEM	NOMENCLATURE	LOCATION
22	EVA WAIST TETHER ASSY AND LUNAR EQUIP CONV ASSY	RHSSC
23	HELMET STOWAGE BAG (2)	CDR'S AND LMP'S STATIONS (POSITION NO. 1)
24	PLSS	BETWEEN CREW FLIGHT STATIONS
25	ANTIBACTERIA FILTER STOWAGE	
26	DOCKING DROGUE	LEFT OF CDR'S STATION (STOWED POSITION)
27	DOCKING RESTRAINT RINGS	ON RESTRAINT HARNESS CABLE
28	RESTRAINT CABLES AND HOOKS	CDR'S AND LMP'S STATIONS
29	CDR'S CHECKLIST	BELOW TTC
30	DISPOSABLE CONTAINER ASSEMBLY	DISPOSAL BAG — THESE ITEMS ARE DISPOSED OF ON LUNAR SURFACE
31	ECS LiOH CANISTER	DISPOSAL BAG — THESE ITEMS ARE DISPOSED OF ON LUNAR SURFACE
32	SMALL URINE COLLECTION ASSY (2)	DISPOSAL BAG — THESE ITEMS ARE DISPOSED OF ON LUNAR SURFACE
33	PLSS CONDENSATE CONTAINER	DISPOSAL BAG — THESE ITEMS ARE DISPOSED OF ON LUNAR SURFACE
34	PLSS LiOH CARTRIDGE	DISPOSAL BAG — THESE ITEMS ARE DISPOSED OF ON LUNAR SURFACE
35	LARGE URINE COLLECTION ASSY (2)	DISPOSAL BAG — THESE ITEMS ARE DISPOSED OF ON LUNAR SURFACE

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Crew Miscellaneous Equipment (Sheet 2)

Grumman

CPE-15

“ApolloNewsRef LM E.CPE15.PICT” 743 KB 1999-02-02 dpi: 499h x 510v pix: 529h x 735v

ENVIRONMENTAL CONTROL

QUICK REFERENCE DATA

Atmosphere revitalization section (ARS)	
Cabin pressure	4.8 ± 0.2 psia (normal, steady-state)
Suit circuit pressure	
Cabin mode	4.8 ± 0.2 psia (may exceed 5.0 psia during powered flight)
Egress mode	3.8 ± 0.2 psia (4.7 psia maximum during powered flight)
Suit inlet temperature range	With suit temperature control valve in full cold position, temperature ranges from +38° to +65° F; in full hot position, from +42° to 100° F.
Cabin temperature	+55° to +90° F
Relative humidity	40% to 80%
Suit circuit fan flow	At 4.8 psia - 36.0 pounds per hour (minimum) At 3.8 psia - 28.4 pounds per hour (minimum)
Oxygen supply and cabin pressure control section (OSCPCS)	
Suit pressure increase	First 1-psi increase may occur in less than 1 second. Each succeeding 1-psi increase occurs in not less than 8 seconds.
Cabin repressurization and emergency oxygen valve delivery rate	
Descent mode	4 pounds per minute (maximum)
Ascent mode	8 pounds per minute at 700 psia
PLSS refill	0.91 pound/refill at 850 psia; can only be partially filled at lower pressures
Cabin volume	235 cubic feet
Dump valve bacteria filter efficiency	Removes 95% of all bacteria larger than 0.5 micron
Manual cabin pressure dump rate (without oxygen inflow)	Dump valve in forward hatch, with bacteria filter, from 5.0 psia down to 0.08 psia in 310 seconds, overhead hatch, without filter, in 180 seconds; both valves, without filter, 90 seconds
Number of cabin repressurizations	4 at 6.6 pounds each
Cabin repressurization time	2 minutes
Cabin pressure switch settings	When cabin pressure drops to 3.7 to 4.45 psia, contacts close. When cabin pressure increases to 4.40 to 5.0 psia, contacts open.

Oxygen supply and cabin pressure control section (cont)

Descent oxygen tank	
Capacity	48.01 pounds at 2,730 psia and +70° F (residual oxygen: 1.0 pound)
Burst pressure	4,500 psia
Ascent oxygen tanks	
Capacity	2.43 pounds (each tank) at 854 psia and +80° F (residual oxygen: 0.14 pounds (each tank) at 50 psia and +70° F
Burst pressure	1,500 psia
Bypass relief valve	
Full flow pressure	3,030 psig (minimum) at +75° F
Cracking pressure	2,875 psig (maximum) at +75° F
Reseat pressure	2,850 psig (minimum) at +75° F
Overboard relief valve	
Full flow pressure	1,090 psig (maximum) at +75° F
Cracking pressure	1,025 psig (minimum) at +75° F
Reseat pressure	985 psig (minimum) at +75° F
High-pressure regulator	
Outlet pressure with primary and secondary regulators operating normally	At inlet pressure of 1,100 to 3,000 psig and flow of 0.1 to 4.0 pounds per hour, and inlet pressure of 975 to 1,100 psig and flow of 0.1 pound per hour, will regulate to 875 to 960 psig at 75° F

Water management section (WMS)

Descent water tank	
Capacity	333 pounds at 0.75 fill ratio
Initial fill pressure	48.2 psia (maximum) at +80° F
Residual water	6.66 pounds
Pressure upon expulsion of all expellable water	11.0 psia (minimum) at +35° F
Ascent water tanks	
Capacity	42.5 pounds (each tank) at 0.75 fill ratio
Initial fill pressure	48.2 psia (maximum) at +80° F
Residual water	0.85 pound (each tank)
Pressure regulator discharge pressure	0.5 to 1.0 psi above ARS gas pressure
PLSS refill (each)	9.15 pounds of water

Heat transport section (HTS)

Coolant	Solution of ethylene glycol and water (35% and 65%, respectively, by weight) with inhibitors Approximately 35 pounds of coolant is used in HTS.
Coolant slush point	-3° F
Coolant pump rated flow	Flow rate of 222 pounds per hour (minimum) at +40° F, 30 psid, and 28-vdc input voltage

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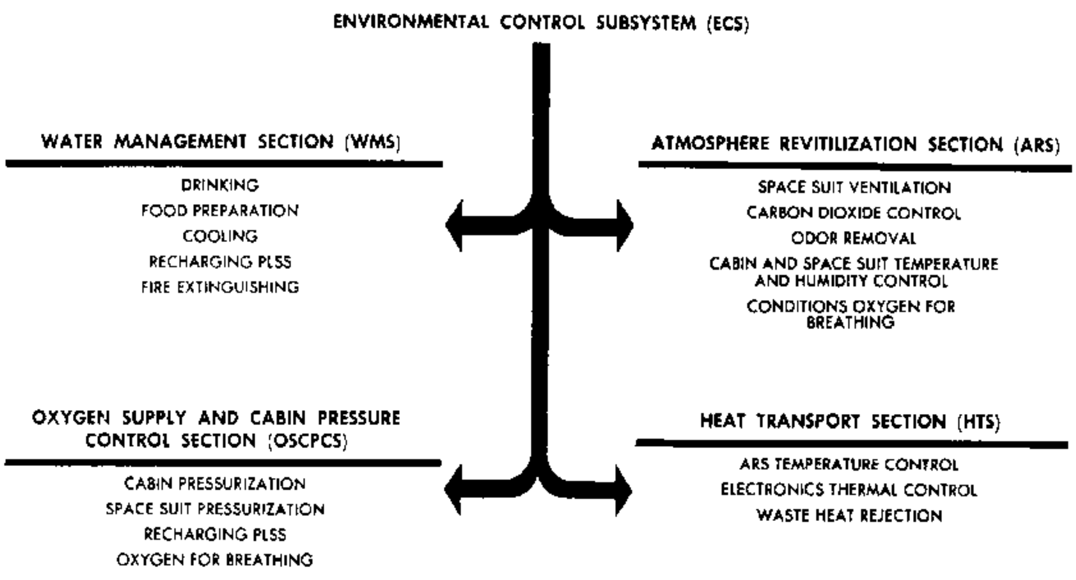
Heat transport section (HTS) (cont)	
Coolant pump bypass relief valve	
Cracking pressure	33 to 36 psi
Fully open pressure	39 psi
Reseat pressure	1 psi less than cracking
Coolant temperatures	+29° to +120° F
Flow into primary sublimator	+110° F (maximum)
Flow out of sublimator	+29° to +36° F
Flow into secondary sublimator	+60.1° F (minimum)
Flow out of sublimator	+47° F (maximum)
Vacuum fill requirements	HTS withstands internal pressure of 500 microns in sea-level ambient pressure environment.
Primary and secondary coolant filters	
Efficiency	35 microns absolute for primary; 45 microns absolute for secondary
Maximum bypass valve cracking pressure	0.4 psid for primary; 1.0 psid for secondary
Coolant flow	
Primary coolant loop	222 pounds per hour (minimum)
Secondary coolant loop	222 pounds per hour (minimum)
Cold plates	
Coolant inlet operating temperature	+32° to +100° F
Coolant inlet operating pressure	5 to 45 psia
Coolant inlet operating flow	12 to 85 pounds per hour, depending on cold-plate size



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Block Diagram of the Environmental Control Subsystem

The Environmental Control Subsystem (ECS) enables pressurization of the cabin and space suits, controls the temperature of electronic equipment, and provides breathable oxygen for the astronauts. It also provides water for drinking, cooling, fire extinguishing, and food preparation and supplies oxygen and water to the portable life support system (PLSS).

The major portion of the ECS is in the cabin. The peripheral ECS equipment, such as oxygen and water tanks, is located outside the cabin, in the ascent and descent stages. The ECS consists of the following sections:

Atmosphere revitalization section (ARS)

Oxygen supply and cabin pressure control section (OSCPCS)

Water management section (WMS)

Heat transport section (HTS)

The ARS purifies and conditions the oxygen for the cabin and the space suits. Oxygen conditioning consists of removing carbon dioxide, odors, particulate matter, and excess water vapor.

The OSCPCS stores gaseous oxygen and maintains cabin and suit pressure by supplying oxygen to the ARS to compensate for crew metabolic consumption and cabin or suit leakage. An oxygen tank in the descent stage provides oxygen during descent and lunar stay. Two oxygen tanks in the ascent stage are used during ascent and rendezvous.

The WMS supplies water for drinking, cooling, fire extinguishing, and food preparation, and for refilling the PLSS cooling water tank. It also provides for delivery of water from ARS water separators to HTS sublimators and from water tanks to ARS and HTS sublimators.

The water tanks are pressurized before launch, to maintain the required pumping pressure in the tanks. The descent stage tank supplies most of the water required until staging occurs. After staging, water is supplied by the two ascent stage tanks. A self-sealing valve delivers water for drinking and food preparation.

The HTS consists of a primary coolant loop and a secondary coolant loop. The secondary loop serves as a backup loop; it functions if the primary loop fails. A water-glycol solution circulates through each loop. The primary loop provides temperature control for batteries, electronic equipment that requires active thermal control, and for the oxygen that circulates through the cabin and space suits. The batteries and electronic equipment are mounted on cold plates and rails through which coolant is routed to remove waste heat. The cold plates used for equipment that is required for mission abort contain two separate coolant passages: one for the primary loop and one for the secondary loop. The secondary coolant loop, which is used only if the primary loop is inoperative, serves only these cold plates.

In-flight waste heat rejection from both coolant loops is achieved by the primary and secondary sublimators, which are vented overboard. A coolant pump recirculation assembly contains all the HTS coolant pumps and associated check and relief valves. Coolant flow from the assembly is directed through parallel circuits to the cold plates for the electronic equipment and the oxygen-to-glycol heat exchangers in the ARS.

FUNCTIONAL DESCRIPTION

The functional description of each of the four major ECS sections is supported by a functional flow diagram, which, to reduce complexity, does not contain electrical circuitry.

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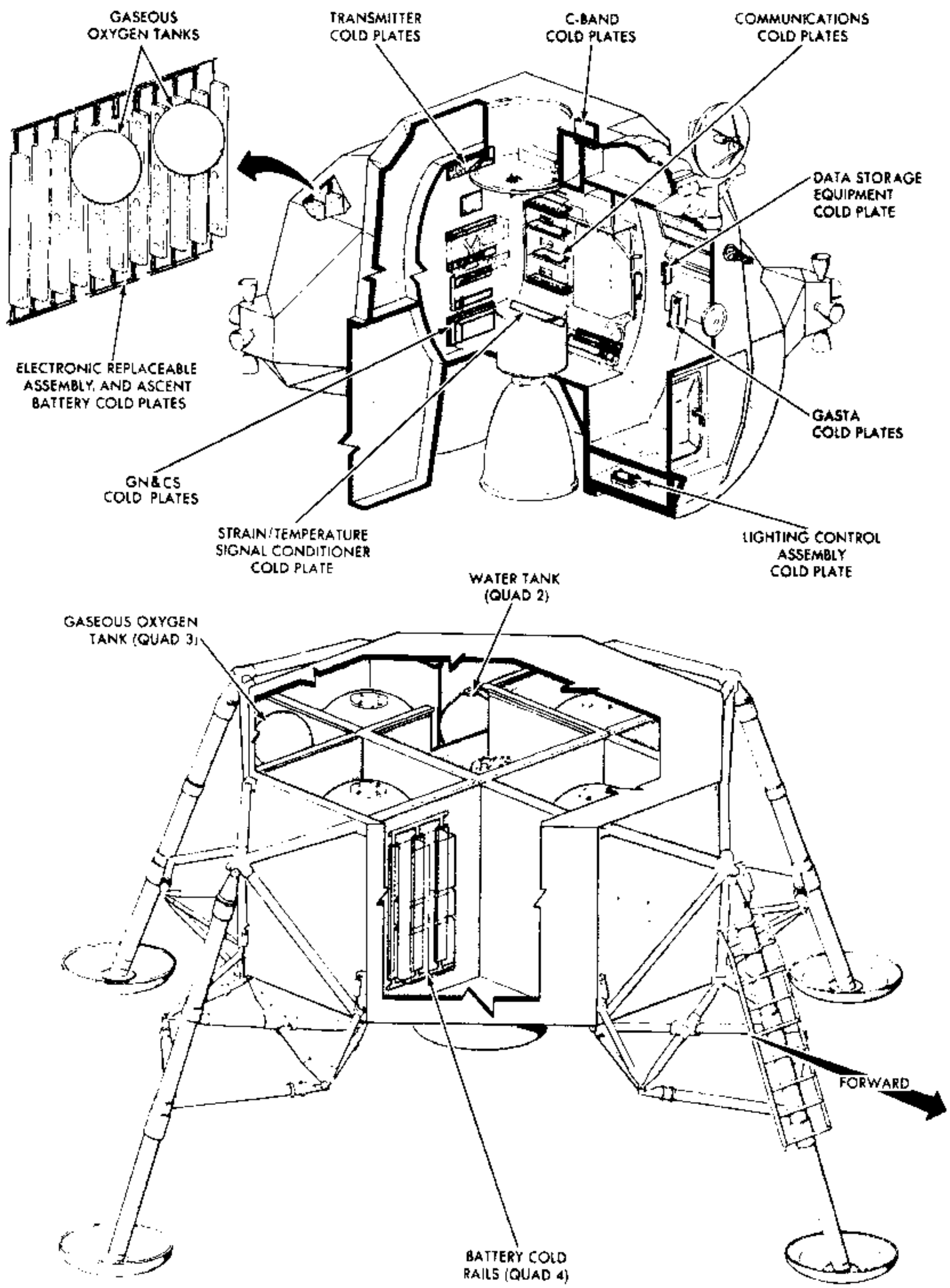

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Environmental Control Subsystem, Component Location (Sheet 1)

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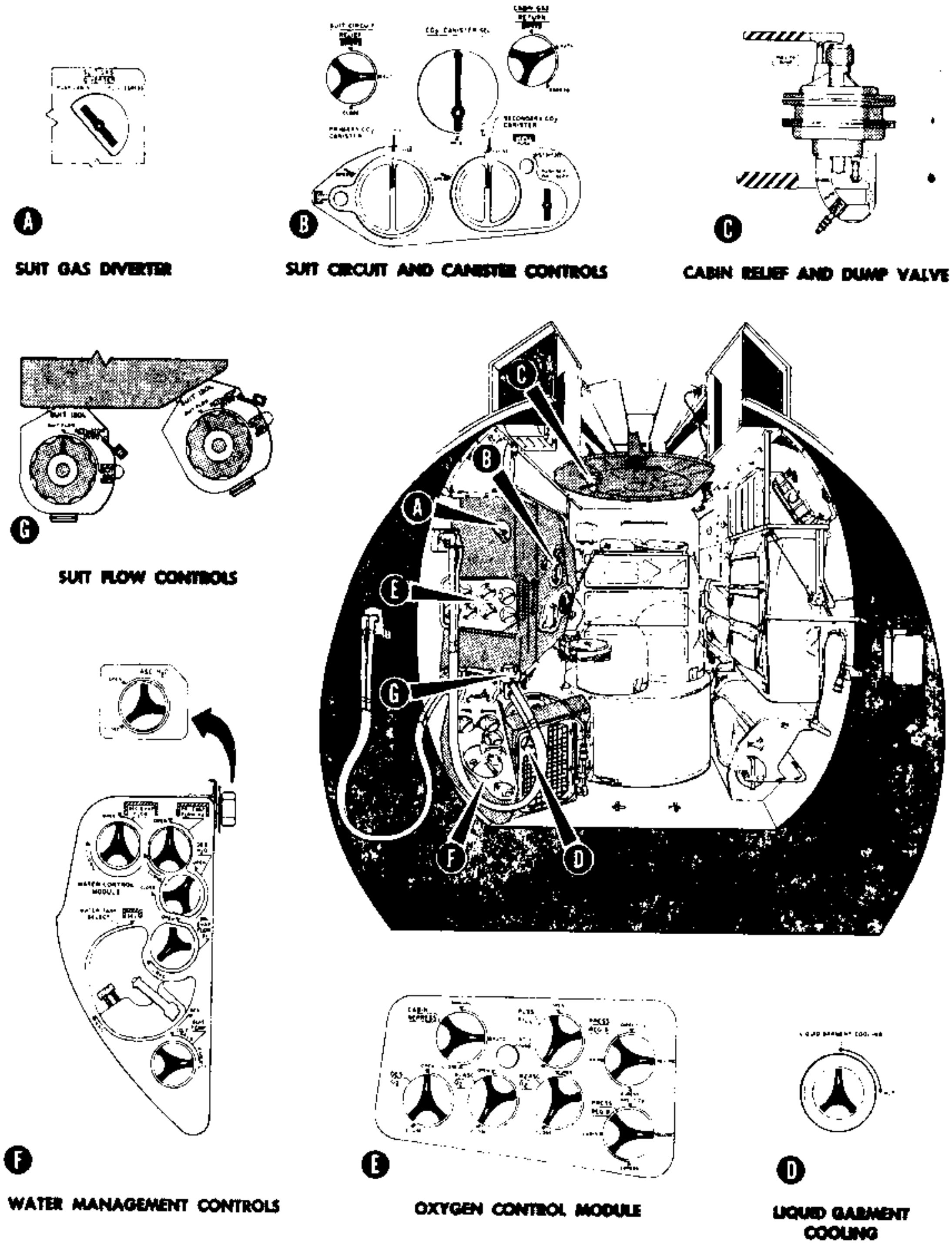

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Environmental Control Subsystem, Component Location (Sheet 2)

ATMOSPHERE REVITALIZATION SECTION

The ARS is a recirculation system that conditions oxygen by cooling or heating, dehumidifying, and deodorizing it for use within the space suits and cabin, and circulates water through the liquid cooling garment to provide cooling during peak heat loads. The major portion of the ARS is contained within the suit circuit assembly.

In normal operation, conditioned oxygen flows to the space suits and is discharged through the return umbilical to the suit circuit. Suit circuit pressure, sensed at a point downstream of the suits, is referenced to the oxygen regulators that control pressure by supplying makeup oxygen to the suit circuit. The suit circuit relief valve protects the suit circuit against overpressurization, by venting the cabin.

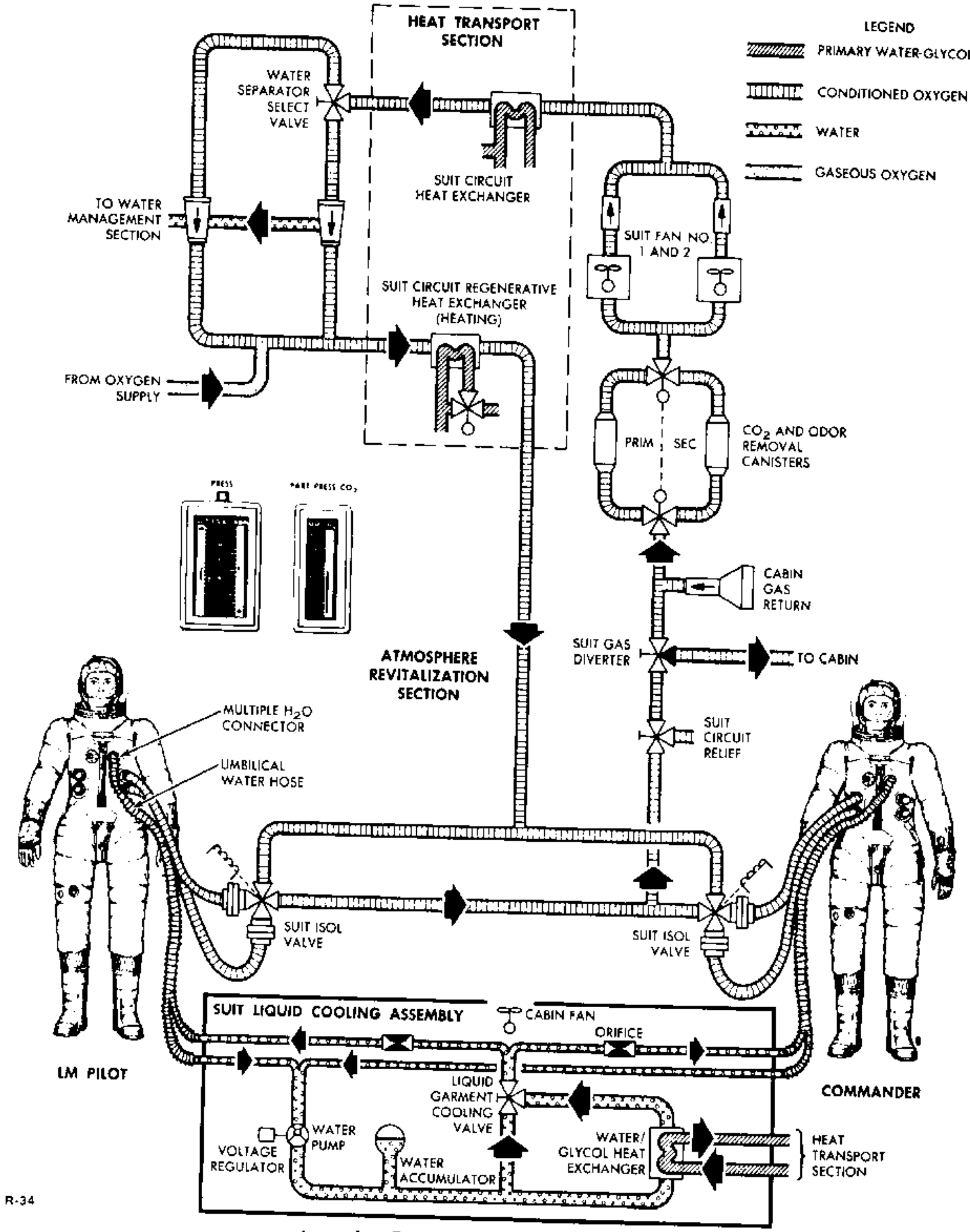
The cabin position of the suit gas diverter valve is used during pressurized-cabin operation, to direct sufficient conditioned oxygen to the cabin to control carbon dioxide and humidity levels. Pulling the valve handle selects the egress position to isolate the suit circuit from the cabin. The egress position is used for all unpressurized-cabin operations, as well as closed suit mode with pressurized cabin. An electrical solenoid override automatically repositions the valve from cabin to egress when cabin pressure drops below the normal level or when the egress position is selected on the pressure regulators.

With the suit gas diverter valve set to the cabin position, cabin discharge oxygen is returned to the suit circuit through the cabin gas return valve. Setting the cabin gas return valve to automatic position enables cabin pressure to open the valve. When the cabin is depressurized, differential pressure closes the valve, preventing suit pressure loss.

A small amount of oxygen is tapped from the suit circuit upstream of the PGA inlets and fed to the carbon dioxide partial pressure sensor, which provides a voltage to the CO_2 partial pressure indicator.

The primary and secondary carbon dioxide and odor removal canisters are connected to form a parallel loop. The primary canister contains a LM cartridge with a capacity of 41 man hours; the secondary canister, a PLSS cartridge with a capacity of 14 man hours. A debris trap in the primary canister cover prevents particulate matter from entering the cartridge. A relief valve in the primary canister permits flow to bypass the debris trap if it becomes clogged. Oxygen is routed to the CO_2 and odor removal canisters through the canister selector valve. The carbon dioxide level is controlled by passing the flow across a bed of lithium hydroxide (LiOH); odors are removed by absorption in activated charcoal. When carbon dioxide partial pressure reaches or exceeds 7.6 mm Hg, as indicated on the partial pressure CO_2 indicator, the CO_2 component caution light and ECS caution light go on. (The CO_2 component caution light also goes on when the CO_2 canister selector valve is in the secondary position.) The CO_2 canister selector valve is then set to the secondary position, placing the secondary canister onstream. The primary cartridge is replaced and the CO_2 canister selector valve is set to the primary position, placing the primary canister back onstream.

From the canisters, conditioned oxygen flows to the suit fan assembly, which maintains circulation in the suit circuit. Only one fan operates at a time. The ECS suit fan 1 circuit breaker is closed and the SUIT FAN selector switch is set to 1 to initiate suit fan operation. At startup, a fan differential pressure sensor is in the low position (low Δ P), which, through the fan condition signal control, energizes the ECS caution light and suit fan component caution light. The lights remain on until the differential pressure across the operating fan increases sufficiently to cause the differential pressure sensor to move to the normal position. If the differential pressure drops to 6.0 inches of water or less, the lights go on and switchover to fan No. 2 is required. The ECS caution light goes off when fan No. 2 is selected and the suit fan warning light goes on. The suit fan component caution light goes off when fan No. 2 comes up to speed and builds up normal differential pressure. The suit fan warning light and suit fan component caution light go off if fan No. 2 differential pressure reaches 9.0 inches of water. The fan check valve permits air to pass from the operating fan without backflow through the inoperative fan.



Atmosphere Revitalization Section, Flow Diagram