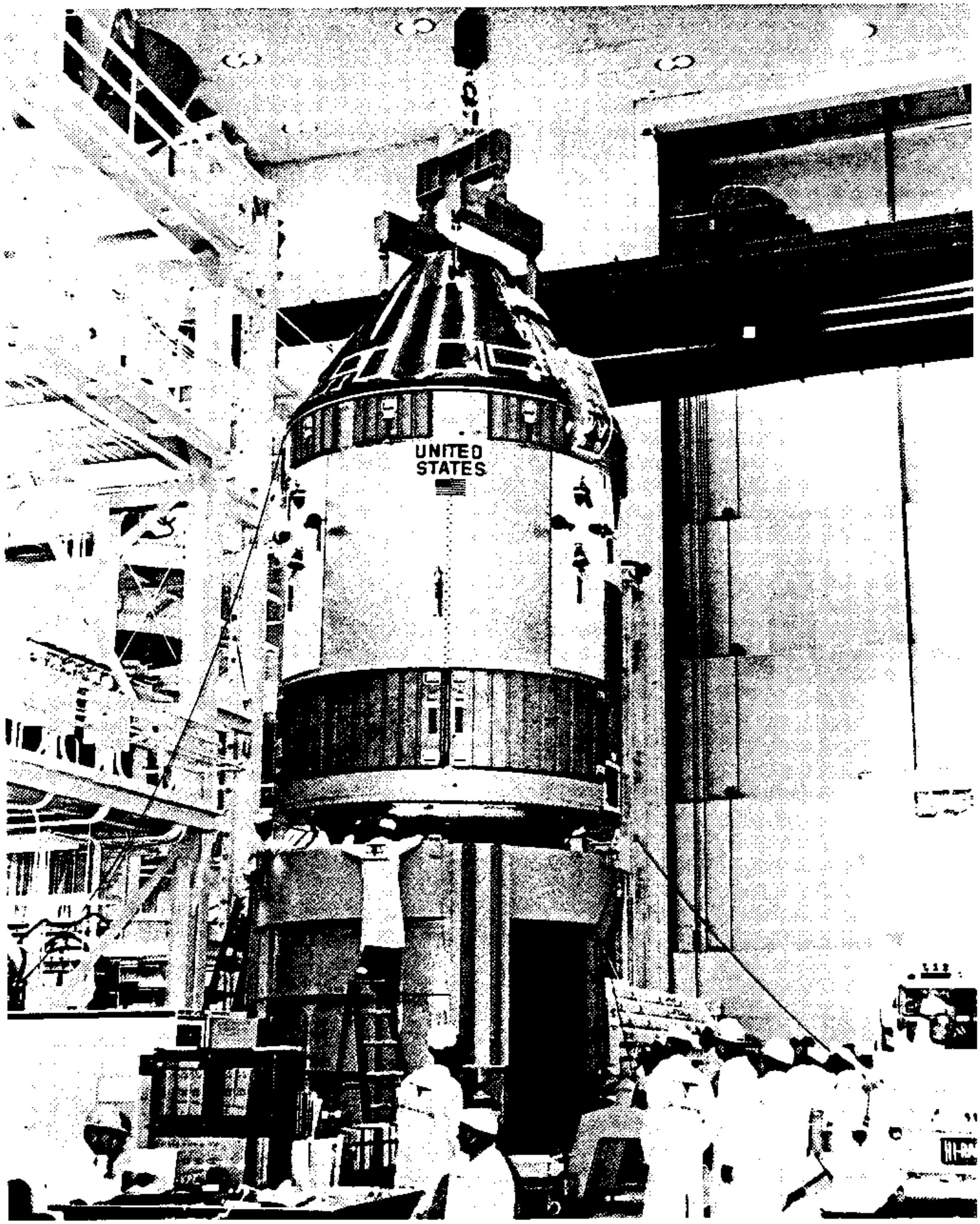


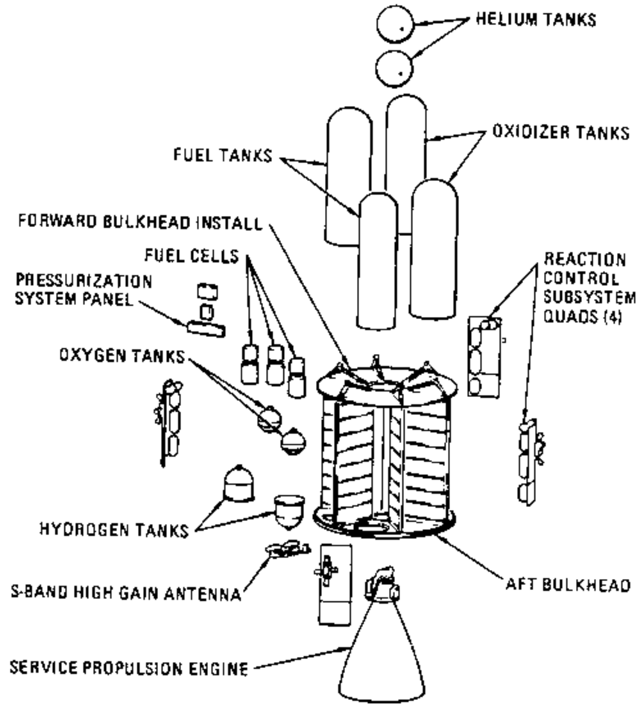
P-65 *Service module mated to command module at Kennedy Space Center*

The service module is a cylindrical structure which serves as a storehouse of critical subsystems and supplies for almost the entire lunar mission. It is attached to the command module from launch until just before earth atmosphere entry.

The service module contains the spacecraft's main propulsion engine, which is used to brake the spacecraft and put it into orbit around the moon and to send it on the homeward journey from the moon. The engine also is used to correct the spacecraft's course on both the trips to and from the moon.

Besides the service propulsion engine and its propellant and helium tanks, the service module contains a major portion of the electrical power, environmental control, and reaction control subsystems, and a small portion of the communications subsystem.

It is strictly a servicing unit of the spacecraft, but it is more than twice as long and more than four times as heavy as the manned command module. About 75 percent of the service module's weight is in propellant for the service propulsion engine.



Main components of SM

STRUCTURE

The service module is a relatively simple structure consisting of a center section or tunnel surrounded by six pie-shaped sectors.

The basic structural components are forward and aft (upper and lower) bulkheads, six radial beams, four sector honeycomb panels, four reaction control system honeycomb panels, an aft heat shield, and a fairing.

The radial beams are made of solid aluminum alloy which has been machined and chem-milled (metal removed by chemical action) to thicknesses varying between 2 inches and 0.018 inch, thus making a lightweight, efficient structure.

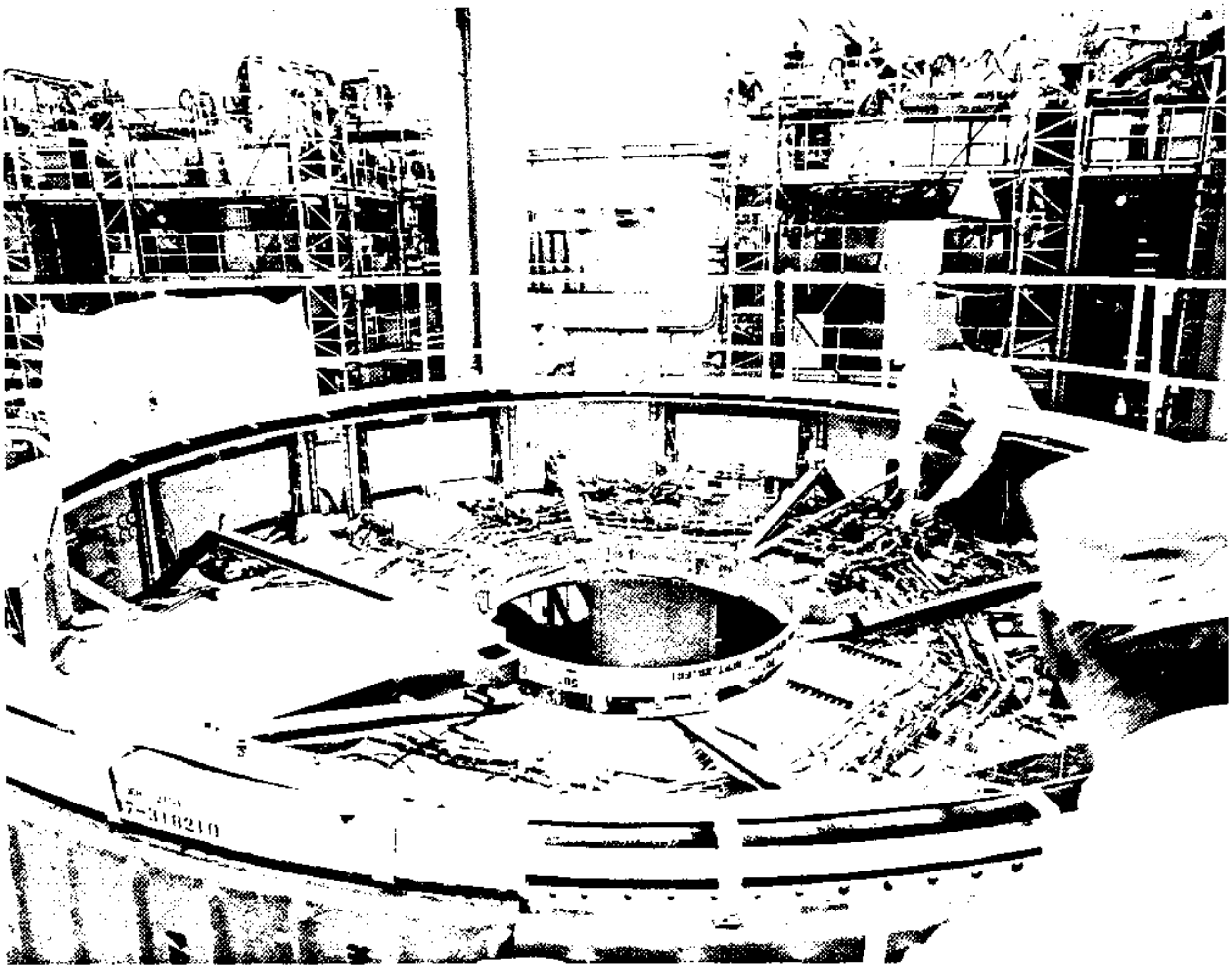
The forward and aft bulkheads cover the top and bottom of the module. Radial beam trusses extending above the forward bulkhead support and secure the command module. Three of these beams have compression pads and the other three have shear-compression pads and tension ties. Explosive charges in the center sections of these tension ties are used to separate the two modules.

An aft heat shield surrounds the service propulsion engine to protect the service module from the engine's heat during thrusting. The gap between the command module and the forward bulkhead of the service module is closed off with a fairing which is ½-inch thick and 22 inches high. The fairing is composed of 16 pieces; eight electrical power subsystem radiators alternated with eight aluminum honeycomb panels.

The center section is circular and is 44 inches in diameter.

Maintenance doors around the exterior of the module provide access to equipment within each sector. These doors are designed for installation and checkout operations and are not used during space operations.

The sector and reaction control system panels are 1-inch thick and are made of aluminum honeycomb core between two aluminum face sheets. The sector panels are bolted to the radial beams. Radiators used to dissipate heat from the environmental control subsystem are bonded to the sector panels on opposite sides of the module. These radiators are each about 30 square feet in area.



P-67

Technicians work on wiring and plumbing on "top deck" of service module

SECTORS

The service module's six sectors are of three sizes, with two sectors each of the same size. The 360 degrees around the center section is divided among two 50-degree (Sectors 1 and 4), two 60-degree (Sectors 3 and 6), and two 70-degree (Sectors 2 and 5) compartments.

SECTOR 1

It is not currently planned to install any equipment in this sector. The space is thus available if any additional equipment needs to be added to the spacecraft for the lunar mission or if equipment is added for scientific experiments. Ballast may be stowed in the sector to maintain the service module's center of gravity if no equipment is added.

SECTOR 2

One of the two 70-degree sectors, contains part of a space radiator and a reaction control subsystem engine quad on its exterior panel, and the oxidizer sump tank, its plumbing, and the reaction control engine tanks and plumbing within the sector.

The oxidizer sump tank is the larger of the two tanks that hold the oxidizer (nitrogen tetroxide) for the service propulsion engine. A cylindrical tank made of titanium, it is 153.8 inches high (about 12 feet 9-¾ inches) and has a diameter of 51 inches (4 feet 3 inches). It holds 13,923 pounds of oxidizer. It is the tank from which oxidizer is fed to the engine. Feed lines connect the sump tank to the service propulsion engine and to the oxidizer storage tank.

SECTOR 3

Sector 3 is one of the 60-degree sectors, and contains the rest of the space radiator and a reaction control engine quad on its exterior panel, and the oxidizer storage tank and its plumbing within the sector.

The oxidizer storage tank is similar to the sump tank but not quite as large. It is 154.47 inches high (about 12 feet 10-½ inches) and has a diameter of 45 inches. It holds 11,284 pounds of oxidizer. Oxidizer is fed from it to the oxidizer sump tank in Sector 2.

SECTOR 4

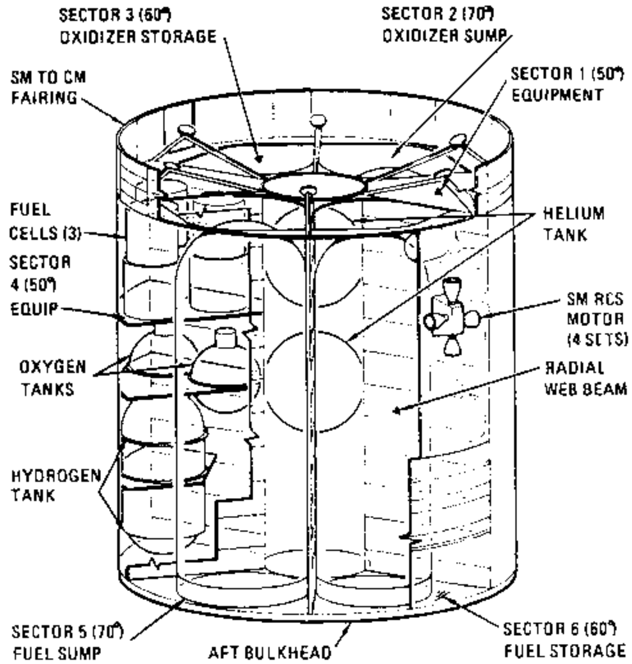
Sector 4 is one of the 50-degree sectors and contains most of the electrical power subsystem equipment in the service module, including three fuel cell powerplants, two cryogenic oxygen and two cryogenic hydrogen tanks, and a power control relay box. A helium servicing panel also is located in this sector.

The three fuel cell powerplants are mounted on a shelf in the upper third of the sector. Each powerplant is 44 inches high, 22 inches in diameter, and weighs about 245 pounds. They supply most of the electrical power for the spacecraft as well as some of the drinking water.

The cryogenic (ultra low temperature) tanks supply oxygen to the environmental control subsystem and oxygen and hydrogen to the fuel cell powerplants. The tanks are spheres, with the oxygen tanks mounted side by side in the center of the sector and the hydrogen tanks mounted below them one on top of the other.

The oxygen tanks are made of Inconel (a nickel-steel alloy) and are a little over 26 inches in diameter. Each holds 326 pounds of oxygen in a semi-liquid, semi-gas state. Operating temperature of the tanks ranges from 300 degrees below zero to 80 above. Oxygen must be maintained at 297 degrees below zero to remain liquid.

The hydrogen tanks are made of titanium and are about 31-¾ inches in diameter. Each holds a little over 29 pounds of hydrogen. (Hydrogen is much lighter than oxygen, so that in vessels of the same volume the weight of the oxygen would be far greater.) The hydrogen also is in a semi-gas, semi-



SM general arrangement

liquid stage, and its operating temperature ranges from 425 degrees below zero to 80 above. To remain liquid, hydrogen must be maintained at 423 degrees below zero.

The power control relay box operates in conjunction with the fuel cell powerplants to control the generation and distribution of electrical power.

SECTOR 5

This is the other 70-degree sector; it contains part of an environmental control radiator and a reaction control engine quad on the exterior panel, and the fuel sump tank within the sector.

The fuel sump tank occupies almost all of the space with the sector. It is a cylindrical titanium tank the same size as the oxidizer sump tank: 153.8 inches high (12 feet 9-¾ inches) and 51 inches in diameter. It holds 8,708 pounds of propellant (a 50-50 mixture of hydrazine and unsymmetrical dimethylhydrazine) for the service propulsion engine. It is the tank from which the fuel is fed to the engine; feed lines also connect it to the fuel storage tank.

SECTOR 6

The other 60-degree sector contains the rest of the space radiator and a reaction control engine

P-69

Technician finishes installation of cryogenic oxygen tank

quad on its exterior, and the fuel storage tank within the sector.

The fuel storage tank is the same size as the oxidizer storage tank: 154.47 inches high (about 12 feet 10-½ inches) and 45 inches in diameter. It holds 7,058 pounds of fuel. Fuel is fed from it to the fuel sump tank in Sector 5.

The sump tanks and the storage tanks for fuel and oxidizer are the same size; the difference in weight each contains is that the oxidizer is more than 50-percent heavier than the fuel.

CENTER SECTION

The center section or tunnel contains two helium tanks and the service propulsion engine.

The helium tanks are spherical vessels about 40 inches in diameter located one on top of the other in the upper half of the center section. Each contains 19.6 cubic feet of helium gas under a pressure of 3600 psi. This gas is used to pressurize the oxidizer and fuel tanks of the service propulsion subsystem. The pressure forces the propellant from one tank to another and through the feed lines to the engine.

The service propulsion engine is located in the lower half of the center section, with its nozzle extension skirt protruding more than 9 feet below the aft bulkhead of the module. The length of the engine including the skirt is 152.82 inches (about 12 feet 8 inches) and its weight is 650 pounds. This engine is used as a retrorocket to brake the spacecraft and put it into orbit around the moon, to supply the thrust for the return to earth from the moon, and for course corrections on the trips to and from the moon.

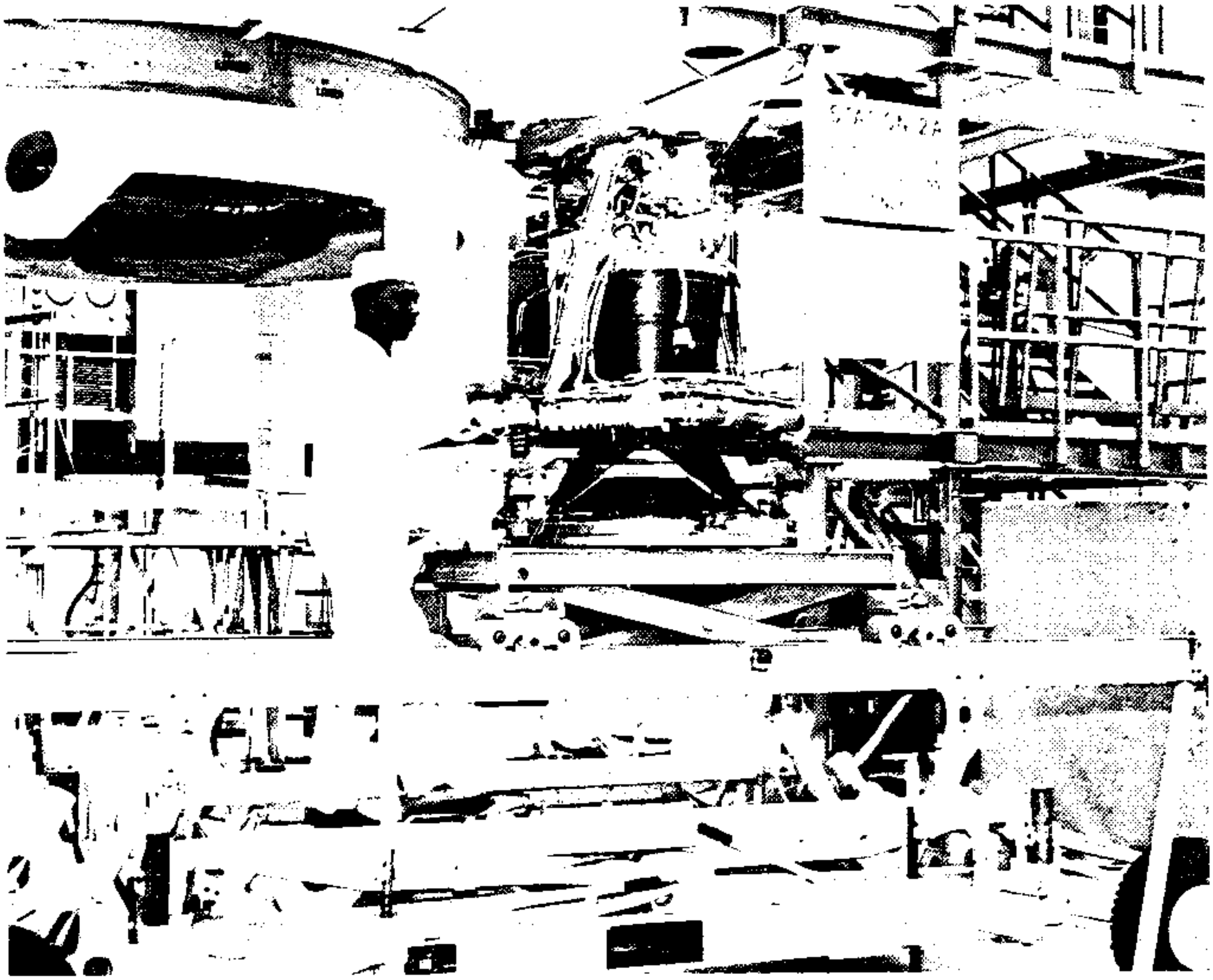
EXTERIOR

Located on the exterior of the service module are space radiators for both the environmental control and electrical power subsystems, reaction control subsystem engines, three antennas, umbilical connections, and several lights.

The environmental control subsystem space radiators are the larger ones and are located on the lower half of the service module on opposite sides. One is part of the panel covers for Sectors 2 and 3 and the other is part of the panel covers for Sectors 5 and 6. The radiators, each about 30 square feet, consist of five parallel primary tubes and four secondary tubes mounted horizontally and one series tube mounted vertically. The water-glycol coolant flows through these tubes to radiate to the cold of space the heat it has absorbed from the command module cabin and from operating electronic equipment.

The electrical power subsystem space radiators are located on the fairing at the top of the service module. Each of the eight radiator panels (which are alternated with eight aluminum honeycomb panels) contains three tubes which are used to radiate to space excess heat produced by the fuel cell powerplants. A separate radiation loop is used for each powerplant; that is, one of the tubes on each panel is connected to a specific powerplant.

The reaction control subsystem engines are located in four clusters of 90 degrees apart around the upper portion of service module. The clusters or quads are arranged in such a manner that the engines are on the outside of the panels and all the other

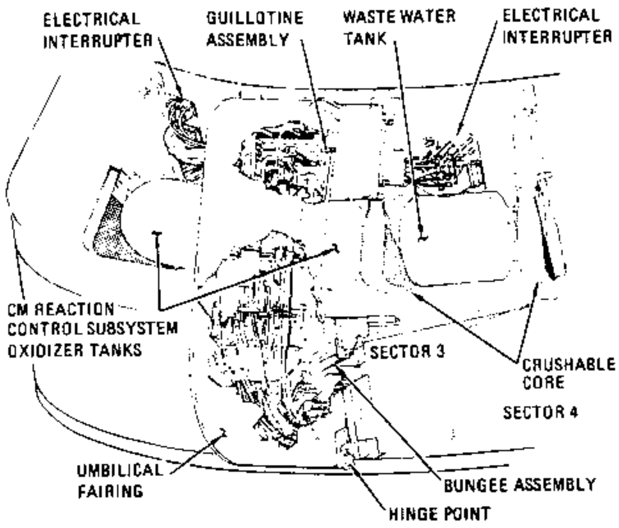


P-70

Technician prepares service propulsion engine for installation in service module

components are on the inside. The engines are mounted with two pointed up and down and two pointed to the sides in opposite directions. Components of the quad panels on the inside of the sectors include two oxidizer and two fuel tanks, a helium tank, and associated valves, regulators, and plumbing. Each quad package is eight feet long and nearly three feet wide.

The four antennas on the outside of the service module are the S-band high-gain antenna, mounted on the aft bulkhead; two VHF omni-directional antennas, mounted on opposite sides of the module near the top; and the rendezvous radar transponder antenna, mounted in the SM fairing. The S-band high-gain antenna, used for deep space communications, is composed of four 31-inch diameter reflectors surrounding an 11-inch square reflector. At launch it is folded down parallel to the service propulsion engine nozzle so that it fits within the spacecraft-LM adapter. After the CSM separates from the adapter the antenna is deployed at a right angle to the service module. The omnidirectional antennas, called scimitars because of their shape, are made of stainless steel and are approximately 13-½ inches long and only a hundredth of an inch thick.



P-71 *CM-SM umbilical assembly*

The umbilicals consist of the main plumbing and wiring connections between the command module and service module, which are enclosed in a fairing (aluminum covering), and a "flyaway" umbilical which is connected to the launch tower. The latter supplies oxygen and nitrogen for cabin pressurization, water-glycol, electrical power from ground equipment, and purge gas.

Seven lights are mounted in the aluminum panels of the fairing. Four (one red, one green, and two amber) are used to aid the astronauts in docking, one is a floodlight which can be turned on to give astronauts visibility during extravehicular activities, one is a flashing beacon used to aid in rendezvous, and one is a spotlight used in rendezvous from 500 feet to docking with the lunar module.

SM-CM SEPARATION

Separation of the SM from the CM occurs shortly before entry. The sequence of events during separation is controlled automatically by two redundant service module jettison controllers, located on the forward bulkhead of the SM.

A number of events must occur in rapid sequence or at the same time for proper separation. These include physical separation of all the connections between the modules, transfer of electrical control, and firing of the service module's reaction control engines to increase the distance between the modules.

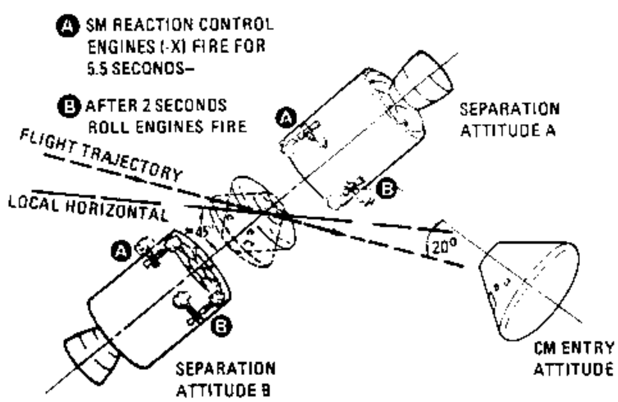
Before separation, the crewmen in the CM transfer electrical control to the CM reaction control subsystem (the SM reaction control subsystem is used for attitude maneuvers throughout the mission up to entry) so that they can pressurize it and check it out for the entry maneuvers.

Electrical control is then transferred back to the SM subsystem. Separation is started manually, by activation of either of two redundant switches on the main display console. These switches send signals to the SM jettison controllers. The controllers first send a signal to fire ordnance devices which activate the CM-SM electrical circuit interrupters; these interrupters deadface (cut off all power to) the electrical wires in the CM-SM umbilical.

A tenth of a second after the wires are deadfaced, the controllers send signals which fire ordnance devices to sever the physical connections between the modules. These connections are three tension ties and the umbilical. The tension ties are straps which hold the CM on three of the compression pads on the SM. Linear-shaped charges in each tension-tie assembly sever the tension ties to separate the modules. At the same time, explosive charges drive guillotines through the wiring and tubing in the umbilical.

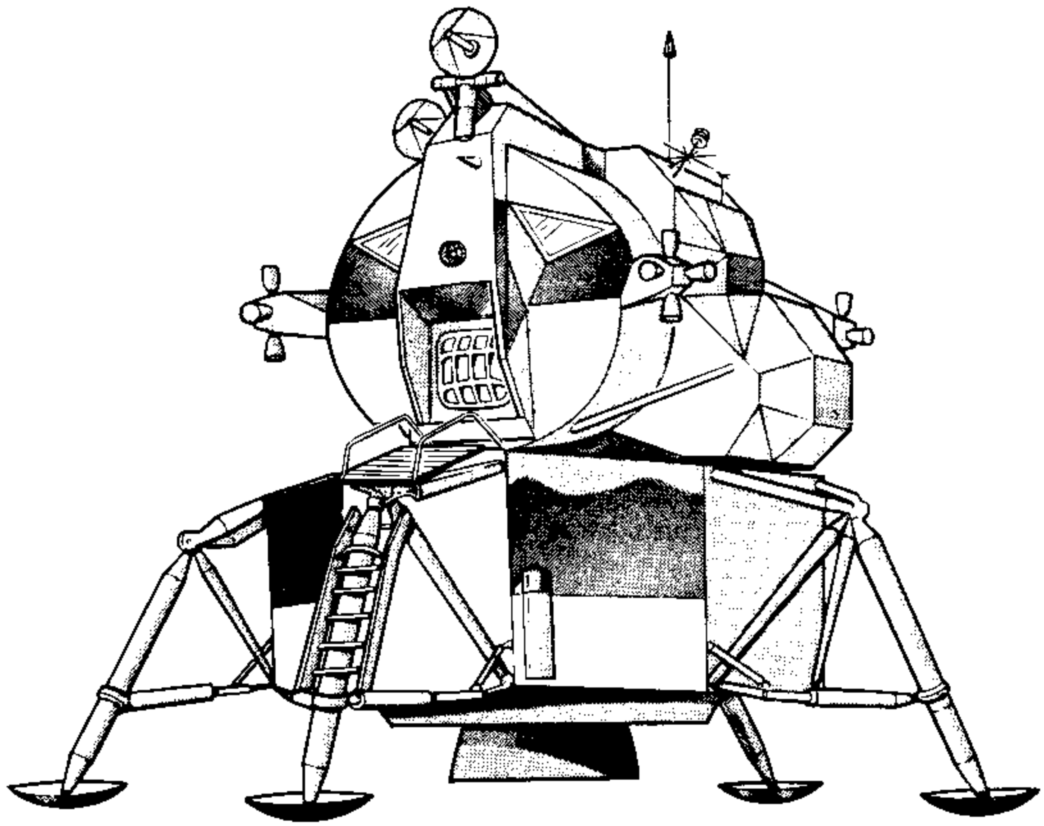
Simultaneously with the firing of the ordnance devices, the controllers send signals which fire the SM reaction control engines. Roll engines are fired for 5 seconds to alter the SM's course from that of the CM, and the translation (thrust) engines are fired continuously until the propellant is depleted or fuel cell power is expended. These maneuvers carry the SM well away from the entry path of the CM.

The service module will enter the earth's atmosphere after separation and burn up.



P-72 *Attitude of SM and CM during separation*

LUNAR MODULE



P-73

Dimensions

Height	22 ft 11 in. (with legs extended)
Diameter	31 ft (diagonally across landing gear)
Weight (with propellant and crew)	32,500 lb (approx.)
Weight (dry)	9,000 lb (approx.)
Pressurized volume	235 cu ft
Habitable volume	160 cu ft
Ascent stage	
Height	12 ft 4 in.
Diameter	14 ft 1 in.
Weight (dry)	4,850 lb (approx.)
Descent stage	
Height	10 ft 7 in.
Diameter	14 ft 1 in.
Weight (dry)	4,300 lb (approx.)
Propellant	
Ascent stage	5,170 lb tanked
Descent stage	17,880 lb tanked
RCS	605 lb tanked

Function

The lunar module carries two astronauts from lunar orbit to the surface of the moon; serves as living quarters and a base of operations on the moon, and returns the two men to the CSM in lunar orbit. The descent stage is left on the moon; the ascent stage is left in orbit around the moon.

The LM, built by Grumman Aircraft Engineering Corp:, Bethpage, N.Y., is designed to operate for 48 hours while separated from the CM, with a maximum stay time of 35 hours on the moon. It consists of two main parts: a descent stage and an ascent stage. The former provides the means of landing on the moon, carries extra supplies, and serves as a launching platform for the liftoff from the moon. The latter contains the crew compartment in which the two astronauts will spend their time while not on the moon's surface, and the engines which will return the astronauts to the CM.

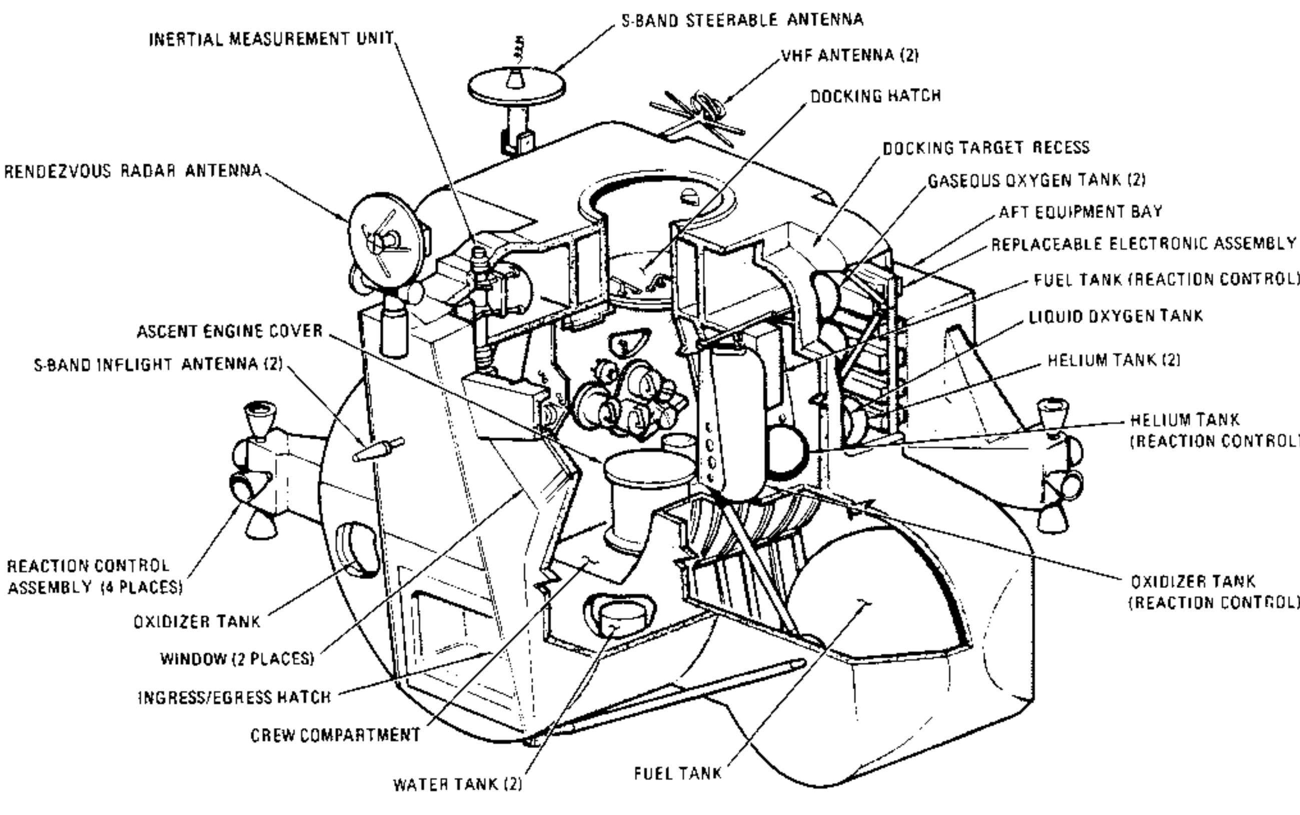
Information in this section was provided by Grumman Aircraft Engineering Corp. Complete details on the lunar module are contained in Grumman's Lunar Module News Reference.

ASCENT STAGE

The ascent stage houses the crew compartment, the ascent engine and its propellant tanks, and all the crew controls. It has essentially the same kind of subsystems found in the command and service modules, including propulsion, environmental control, communications, reaction control, and guidance and control. Overall height of the stage is 12 feet, 4 inches; overall width, with tankage, is 14 feet, 1 inch. Its weight, without propellant, is 4,850 pounds.

The ascent stage provides shelter and a base of operations for the two LM crewmen during their lunar stay. The crewmen use it to return to lunar orbit and rendezvous with the orbiting CSM. After the crewmen have transferred to the CM, the ascent stage is jettisoned and remains in orbit around the moon.

The primary structural components of the ascent stage are the crew compartment, the midsection, the aft equipment bay, and tank sections.



Ascent stage

P-74

The cabin is 92 inches in diameter and is made of welded aluminum alloy which is surrounded by a 3-inch-thick layer of insulating material. A thin outer skin of aluminum covers the insulation. The cabin is a pressurized shell in which the two astronauts will spend about two-thirds of their time during the lunar stay. The crew compartment is pressurized to 5 psi, its temperature is controlled at about 75 degrees F, and it has a 100-percent oxygen atmosphere. It contains the displays and controls that enable the astronauts to maneuver the module during descent, landing, lunar launch and ascent, and rendezvous and docking with the CSM. It also contains crew equipment, storage bays, and provisions for sleeping, eating, and waste management.

Astronaut stations are 44 inches apart and each man has a set of controllers and armrests but no seats. Total volume of the pressurized portion of the lunar module is 235 cubic feet; the habitable volume is about 160 cubic feet.

There are two hatches in the crew compartment, the docking hatch and the forward hatch. Both open inward. The round docking hatch (32 inches in diameter) is at the upper end of the docking tunnel and is used for the transfer of crewmen back and forth from the command module. The drogue portion of the docking subsystem is located outside the hatch. The forward hatch tunnel is beneath the center instrument console. The forward hatch is rectangular and is the one through which the astronauts will go to reach the lunar surface. Outside the forward hatch is a platform and a ladder mounted to the forward landing gear strut.

The crew compartment has three windows. The two triangular forward windows are approximately two square feet and canted down to the side to permit sideward and downward visibility. The third window, used for docking, is located on the left side of the cabin directly over the commander's position. It is about 5 inches wide and 12 inches long.

The midsection of the ascent stage is a smaller compartment directly behind the cabin; its floor is 18 inches above the crew compartment deck. Part of the midsection is pressurized. Ascent engine plumbing and valving extends above the deck. The midsection also contains the overhead docking tunnel (32 inches in diameter and 18 inches long), docking hatch, environmental control subsystem equipment, and stowage for equipment that must be accessible to the astronauts.

The aft equipment bay is unpressurized and is behind the midsection pressure-tight bulkhead. It contains an equipment rack with coldplates on which replaceable electronic assemblies are mounted. It also includes two oxygen tanks for the environmental control system, two helium tanks for ascent stage main propellant pressurization, and inverters and batteries for the electrical power subsystem.

The propellant tank sections are on either side of the midsection, outside the pressurized area. The tank sections contain ascent engine fuel and oxidizer tanks, and fuel, oxidizer, and helium tanks for the reaction control subsystem.

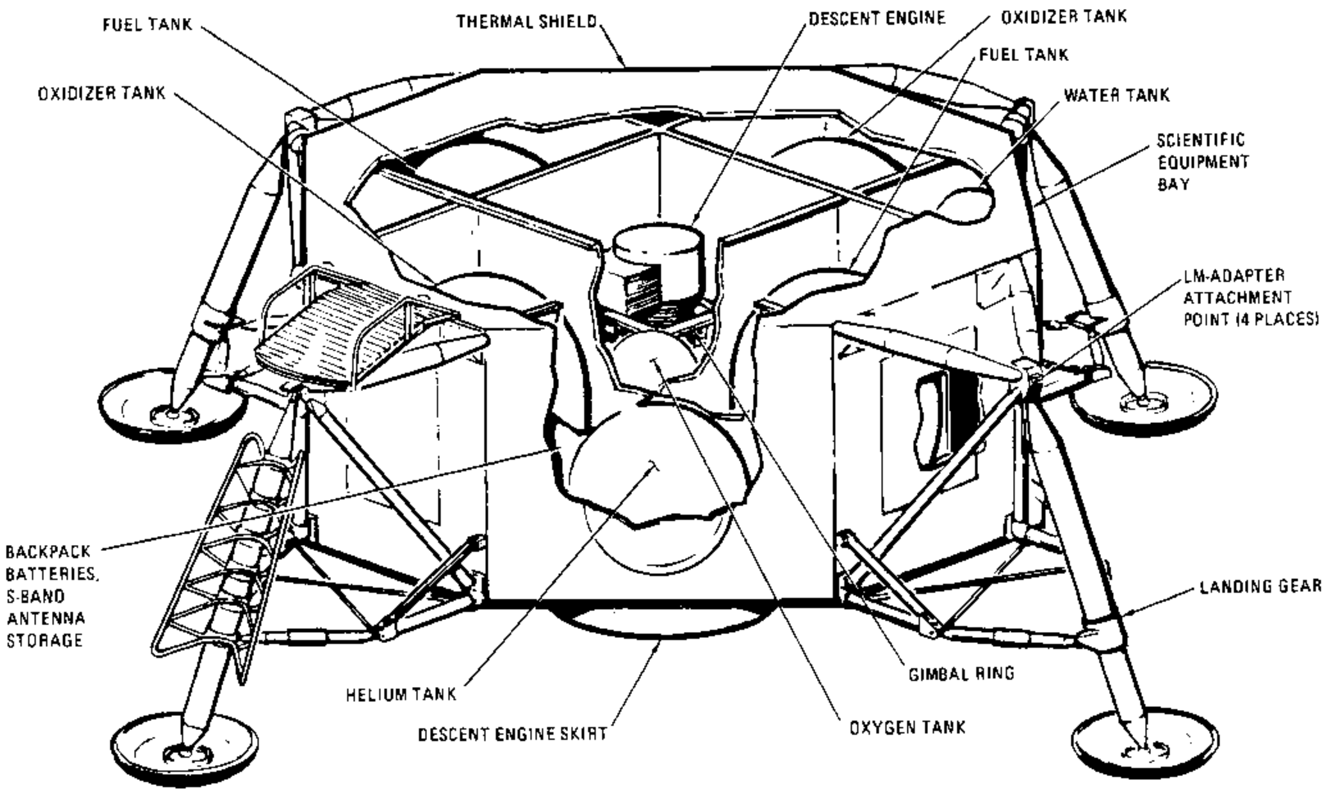
DESCENT STAGE

The descent stage is a modified octagonal shape. It is 10 feet, 7 inches high (with gear extended), 14 feet, 1 inch at its widest point, and has a diameter of 31 feet diagonally across the landing gear. It consists primarily of the descent engine and its propellant tanks, the landing gear assembly, batteries, a section to house scientific equipment for use on the moon, and extra oxygen, water, and helium tanks. The stage serves as a launching platform for the ascent stage and will remain on the moon. It is constructed of aluminum alloy chem-milled to reduce weight. (Chem-milling is a process of removing metal by chemical action.)

The descent engine provides the power for the complex maneuvers required to take the lunar module from orbit down to a soft landing on the moon. It is a throttleable, gimballed engine which provides from 1,050 to 9,710 pounds of thrust.

Four main propellant tanks (two oxidizer and two fuel) surround the engine. Such items as scientific equipment, the lunar surface antennas, four electrical power subsystem batteries, six portable life support system batteries, and tanks for helium, oxygen, and water are in bays adjacent to the propellant tanks.

The landing gear is of the cantilever type and consists of four legs connected to the outriggers. The legs extend from the front, rear, and sides of the LM. Each landing gear leg consists of a primary strut and footpad, a drive-out mechanism, two secondary struts, two downlock mechanisms, and a truss. Each strut has a shock-absorbing insert of crushable aluminum honeycomb material to soften the landing impact. The forward landing gear has a boarding ladder on the primary strut



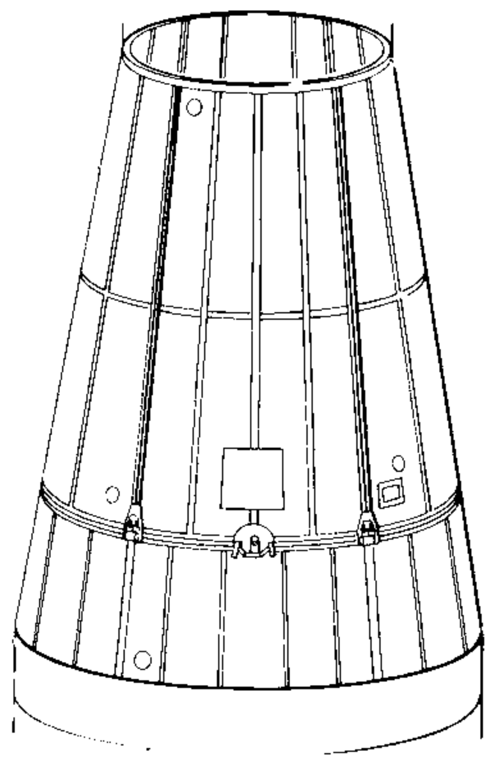
P-75

Descent stage

which the astronauts will climb to and from the forward hatch.

The landing gear is retracted until shortly after the astronauts enter the LM during lunar orbit. Extension is activated by a switch in the LM. The landing gear locks are then released by a mild explosive charge and springs in each drive-out mechanism extend the landing gear. The footpads, about 37 inches in diameter, are made of two layers of spun aluminum bonded to an aluminum honeycomb core.

SPACECRAFT-LM ADAPTER



P-76

Dimensions

Height	28 ft
Diameter	12 ft 10 in. (top)
	21 ft 8 in. (bottom)
Weight	4050 lb (approx)
Volume	6700 cu ft (5000 cu ft usable)

Function

The spacecraft-LM adapter is an aluminum structure which protects the LM during launch and provides the structural attachment of the spacecraft to the launch vehicle.

The spacecraft-LM adapter (SLA) is constructed of eight 1.7-inch thick aluminum honeycomb panels which are arranged in two sets of four of equal size: the upper or forward panels, about 21 feet long, and the lower or aft panels, about 7 feet long. The exterior surface of the SLA is covered completely by a layer of cork 30/1000 of an inch thick. The cork helps insulate the LM from the heat generated by the spacecraft pushing through the atmosphere during boost.

The lunar module is attached to the SLA at four places around the joint between the upper and lower SLA panels. Besides the lunar module, the SLA encloses the nozzle of the service module's service propulsion engine (which extends down to the top of the LM) and an umbilical which houses connecting circuits between the launch vehicle and the spacecraft.

SLA-SM SEPARATION

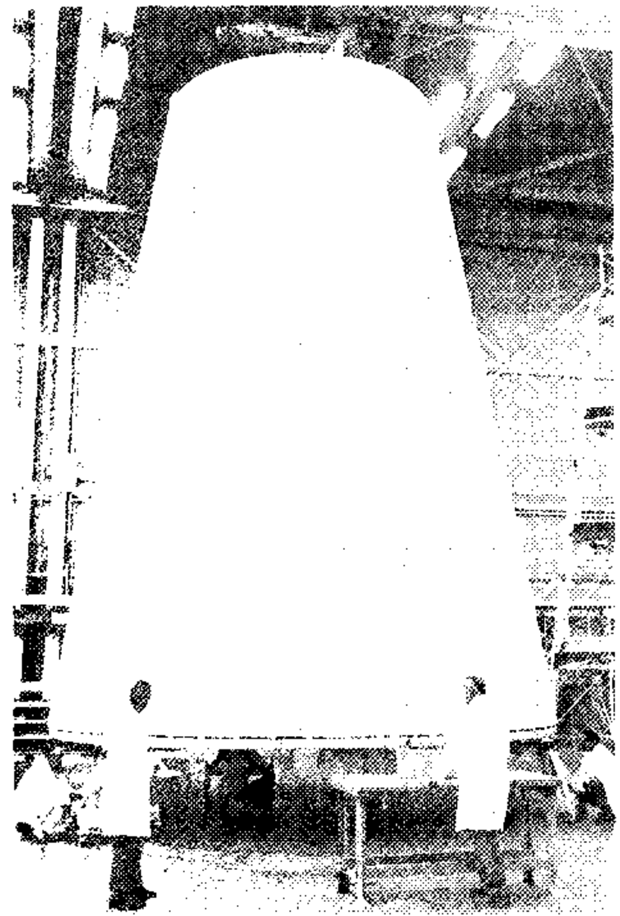
The SLA and SM are joined by bolts through a flange that extends around the circumference of the two structures. The only other connection is an umbilical cable through which electrical power is supplied to the SLA. This power is used to trigger the separation devices.

Redundancy is provided in three areas to assure separation. The signals that initiate the ordinance are redundant; the detonators and cord trains are redundant, and the charges are "sympathetic"—that is, detonation on one charge will set off another.

The SLA and SM and the four upper panels of the SLA are separated by an explosive train which cuts through the metal connecting the structures.

The explosive train consists of 28 charge holders, each of which contains two strands of detonating cord, either one of which will sever the joint. The charge holders (aluminum strips to which the detonating cord is bonded) are mounted on the flange connecting the SM and SLA and on the splice plates (metal strips) which join the forward panels. Boosters (larger charges) are used at the ends of each charge holder and at crossover points to assure that the entire explosive train fires.

Although the explosive train fires like a fuse—that is, it travels from one point to another—it travels so fast that for practical purposes the entire train can be said to explode simultaneously.



P-77

Completed SLA in Tulsa before shipment

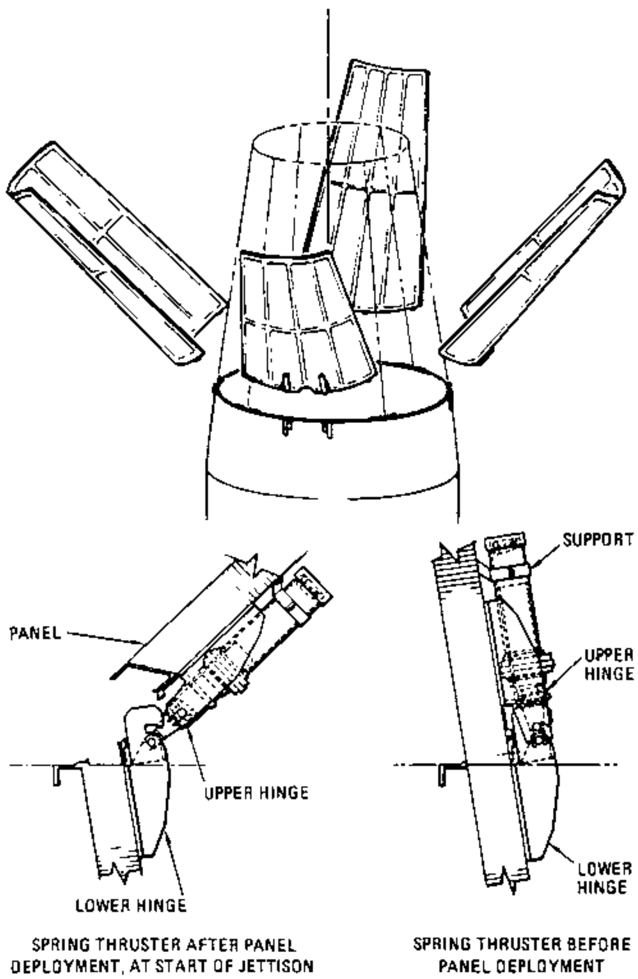
Two sets of thrusters—one pyrotechnic and one spring—are used in deploying and jettisoning the SLA's upper panels.

The four pyrotechnic thrusters are located at the top of the lower panels at the upper panel joints and are used to rotate the panels backwards. Each of these thrusters has two pistons, one acting on each panel, so that each panel has two pistons thrusting against it, one on each end.

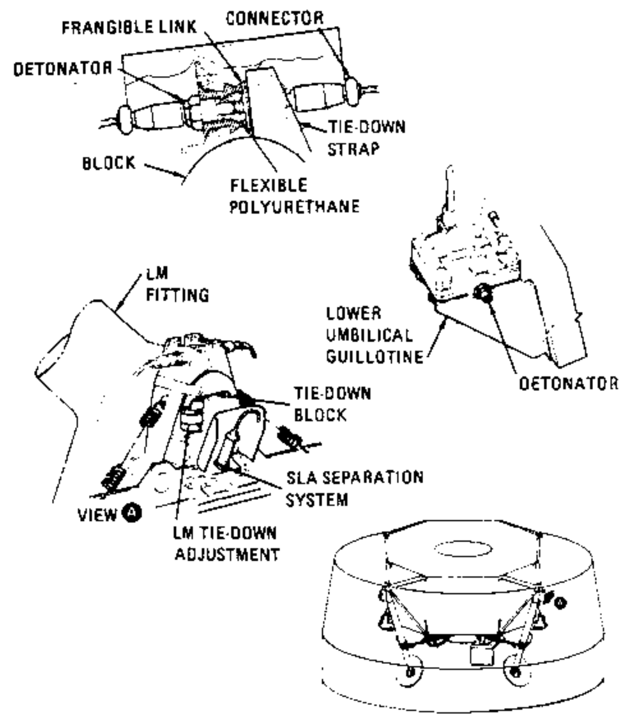
The explosive train which separates the panels is routed through two pressure cartridges in each thruster assembly. Ignition of the pressure cartridges drives the pistons against the panels to begin deployment. Redundancy is provided because ignition of one pressure cartridge normally will sympathetically ignite the other.

The pyrotechnic thrusters apply only a small amount of impulse to the panels (for only 2 degrees of rotation), but this is enough to assure deployment. The speed (33 to 60 degrees per second of angular velocity) imparted by this thrust remains essentially constant. The panels are connected to the lower panels by two hinges. When the panels have rotated about 45 degrees, the hinges disengage and free the panels from the aft section of the SLA.

The spring thrusters are mounted on the outside of the upper panels. When the panel hinges disengage, the springs in the thruster push against the lower panels to propel the panels away from the vehicle. The opening speed and the spring thruster force are such that the panels will be pushed away from the vehicle at an angle of 110 degrees to the vehicle centerline and a speed of about 5-1/2 miles an hour. This assures that the panels will be headed away from the spacecraft.



P-78 *How SLA panels are jettisoned*

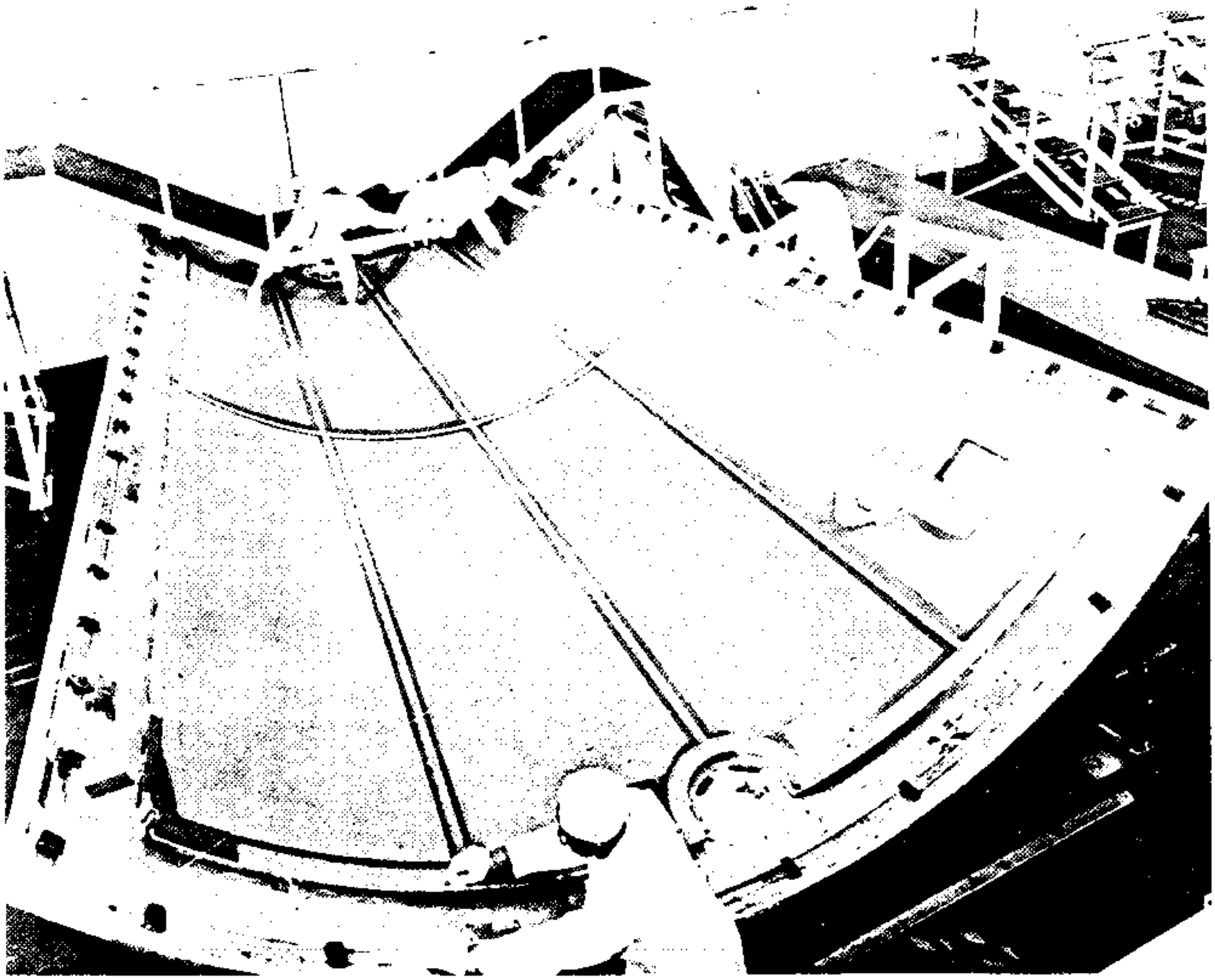


P-79 *SLA-LM separation system*

SLA-LM SEPARATION

Spring thrusters also are used to separate the LM from the SLA. After the CSM has docked with the LM, mild charges are fired to release the four connections which hold the LM to the SLA. Simultaneously, four spring thrusters mounted on the lower SLA panels push against the LM to separate the two vehicles.

The separation is controlled by two lunar module separation sequence controllers located inside the SLA near the attachment point to the instrument unit. The redundant controllers send signals which fire the charges that sever the connections and also fire a detonator to cut the LM-instrument unit umbilical. The detonator impels a guillotine blade which severs the umbilical wires.



P-80

Technicians at Tulsa put the finishing touches on SLA forward panel

CREW

Crew equipment includes all that provided for the protection, comfort, and assistance of the crew, as well as that for routine functions such as eating, sleeping, and cleansing. This section includes seven subsections: clothing, food and water, couches and restraints, hygiene equipment, operational aids, medical supplies, and survival equipment.

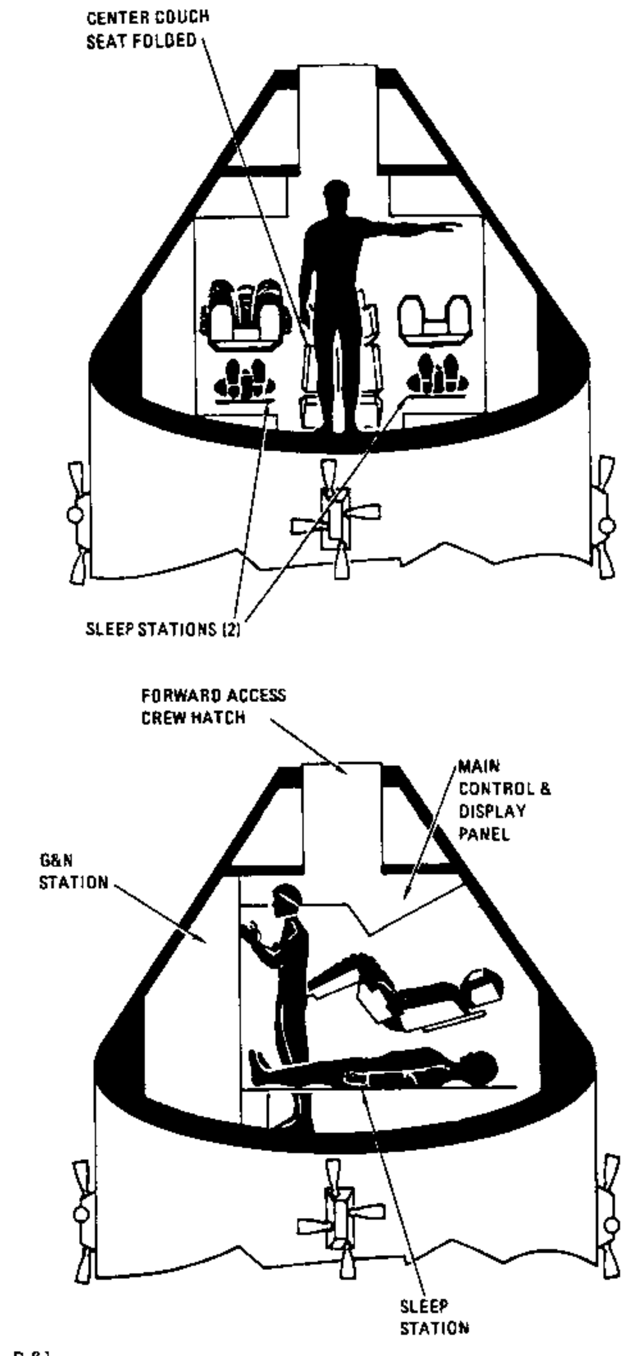
CLOTHING

The number of items a crewman wears varies during a mission. There are three basic conditions: unsuited, suited, and extravehicular. Unsuited, the crewman breathes the cabin oxygen and wears a bioinstrumentation harness, a communication soft hat, a constant wear garment, flight coveralls, and booties.

Under the space suit, the astronaut wears the bioinstrumentation harness, communications soft hat, and constant-wear garment. The extravehicular outfit, designed primarily for wear during lunar exploration, includes the bioinstrumentation harness, a fecal containment system, a liquid-cooled garment, the communication soft hat, the space suit, a portable life support system (backpack), an oxygen purge system, a thermal meteoroid garment, and an extravehicular visor. The space suit and the extravehicular equipment are described in the Space Suit section.

The bioinstrumentation harness has sensors, signal conditioners, a belt, and wire signal carriers. These monitor the crewman's physical condition and relay the information to the spacecraft's communications subsystem. This information is telemetered to the ground throughout the lunar mission. The sensors are attached to the crewman's skin and routed to signal conditioners in the biomedical belt. The belt is cloth, with four pockets, and snaps onto the constant wear garment. The sensors, which monitor heart beat and respiration, are silver chloride electrodes applied with paste and tape; at least four are worn by each astronaut.

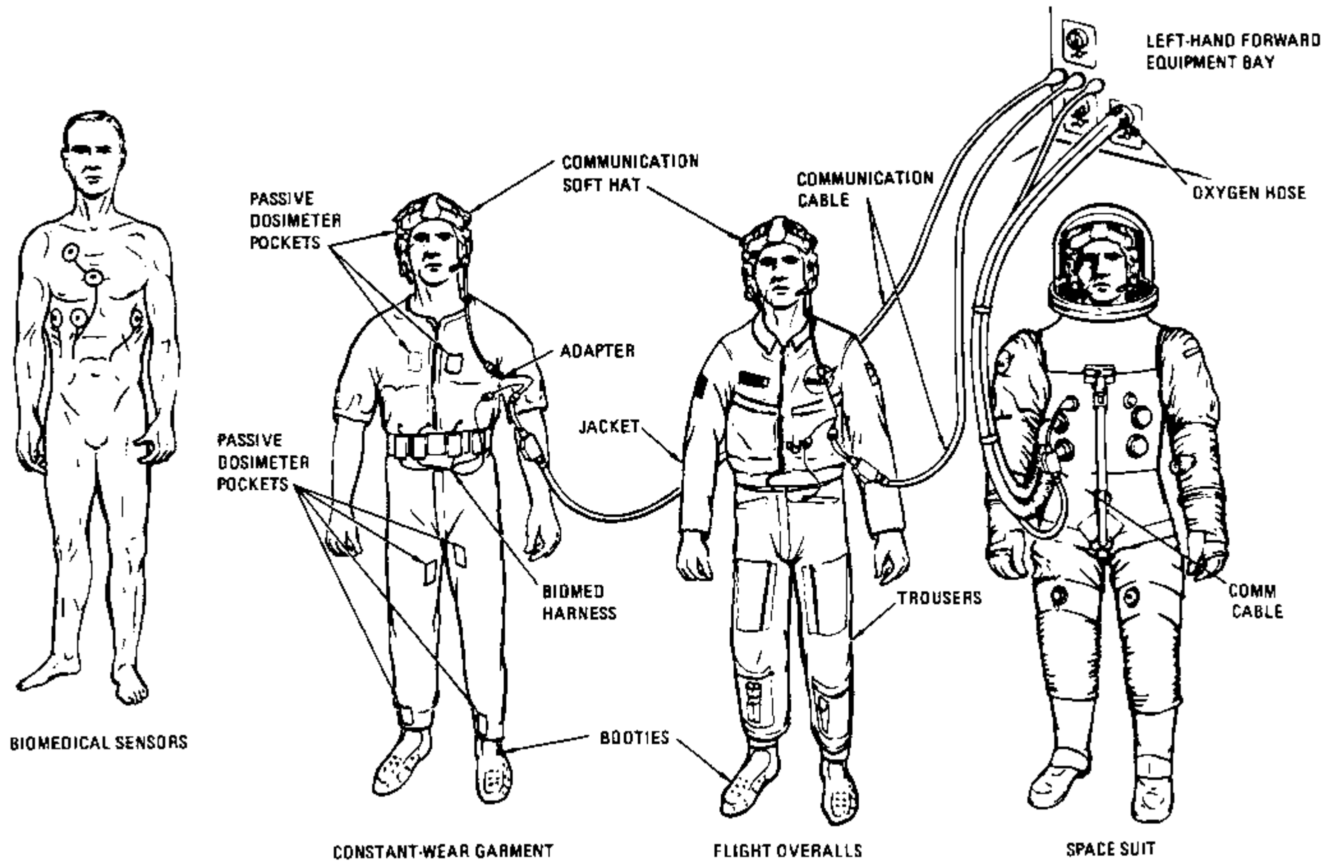
The constant-wear garment is an undergarment for the suit and flight coveralls. Made of porous cloth, it is a one-piece short-sleeved garment with feet similar to long underwear. It is zippered from waist to neck and has openings front and rear.



Crew stations

for personal hygiene. Pockets at the ankles, thighs, and chest hold passive radiation dosimeters. Spare garments are stowed on the aft bulkhead.

The flight coverall is the basic outer garment for



Basic articles of clothing

unsuited operations. It is a two-piece Beta cloth garment with pockets on the shins and thighs for personal equipment.

The communication soft hat is worn when suited. It has two earphones and two microphones, with voice tubes on two mounts that fit over the ears. Three straps adjust the hat for a snug fit and a chin strap is used to hold it on. A small pocket near the right temple holds a passive radiation dosimeter. An electrical cable runs from the hat to the communications cable. The lightweight headset is worn when crewmen are not in their suits.

Booties worn with the flight coveralls are made of Beta cloth with Velcro hook material bonded to the soles. During weightlessness, the Velcro hook engages Velcro pile patches attached to the floor to hold the crewmen in place.

FOOD AND WATER

Food supplies, furnished by NASA, are designed to supply each astronaut with a balanced diet of approximately 2800 calories a day. The food is either freeze-dried or concentrated and is carried in vacuum-packaged plastic bags. Each bag of freeze-dried food has a one-way valve through which water is inserted and a second valve through which the food passes. Concentrated food is packaged in bite-size units and needs no reconstitution. Several bags are packaged together to make one meal bag. The meal bags have red, white, and blue dots to identify them for each crewman, as well as labels to identify them by day and meal.

The food is reconstituted by adding hot or cold water through the one-way valve. The astronaut kneads the bag for about 3 minutes. He then cuts the neck of the bag and squeezes the food into his mouth. After use, a germicide tablet attached to the bag is dropped through the mouthpiece; this prevents fermentation and gas. Empty bags are rolled as small as possible, banded, and returned to the food stowage drawer.

The two food stowage compartments (in the left-hand and lower equipment bays) have 5072 cubic inches of space, enough to store food for about 14 days. The food is prepared by the

Pillsbury Co. and packaged by the Whirlpool Corp.

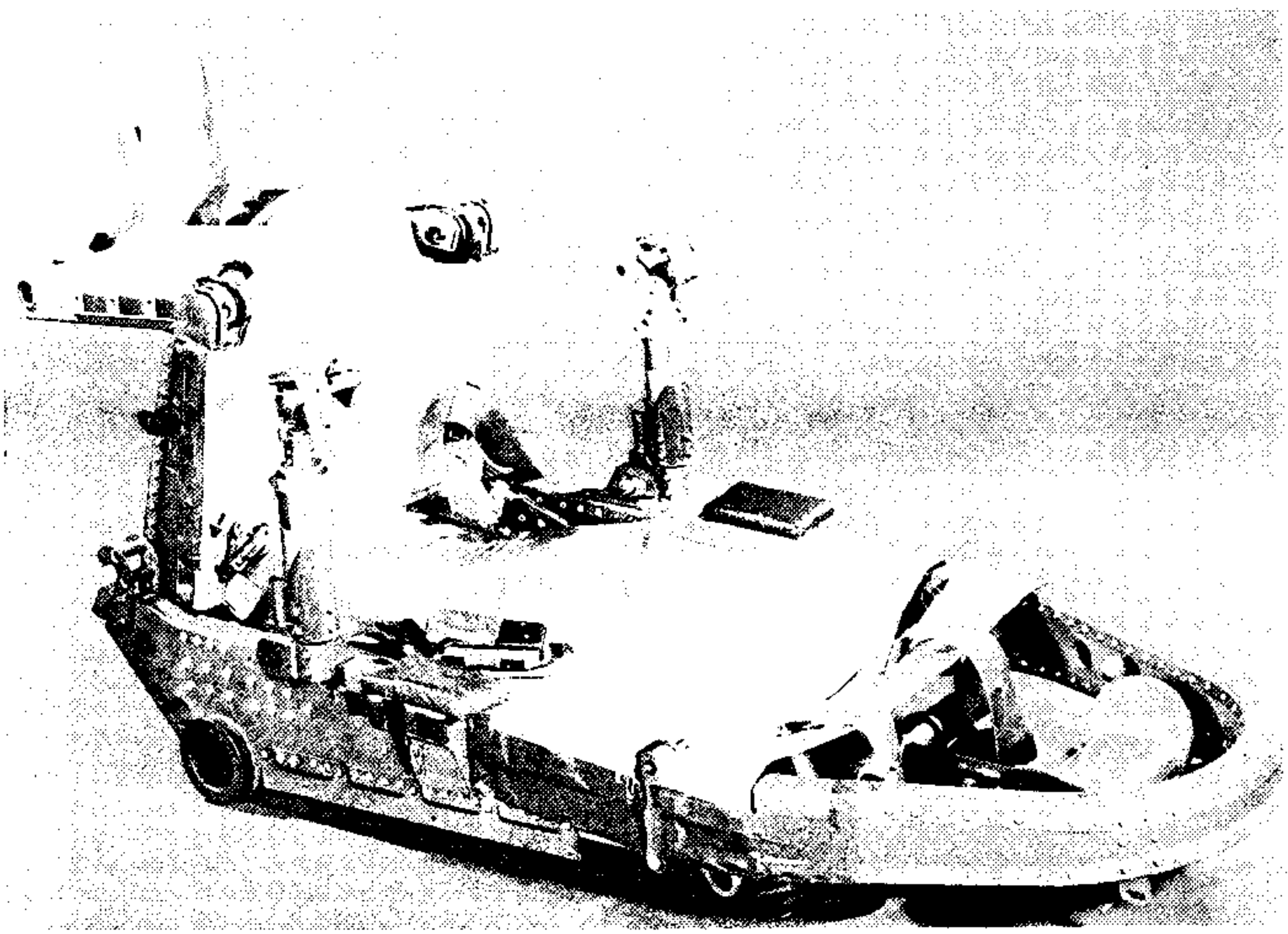
Drinking water comes from the water chiller to two outlets: the water meter dispenser and the food preparation unit. The dispenser has an aluminum mounting bracket, a 72-inch coiled hose, and a dispensing valve unit in the form of a button-actuated pistol. The pistol barrel is placed in the mouth and the button pushed for each half-ounce of water. The meter records the amount of water drunk. A valve is provided to shut off the system in case the dispenser develops a leak or malfunction.

Food preparation water is dispensed from a unit which has hot (150°F) and cold (50°F) water. The water is dispensed in 1-ounce amounts by two syringe-like valves and a nozzle. The nozzle cover is removed and the food bag valve pushed over the nozzle. The syringe valve (either hot or cold) then is pulled as many times as needed.

Cold water comes directly to the unit from the water chiller. Hot water is accumulated in a 38-ounce tank which contains three heaters that keep the water at 150°.

COUCHES AND RESTRAINTS

The astronauts spend much of their time in their couches. These are individually adjustable units made of hollow steel tubing and covered with a heavy, fireproof fiberglass cloth (Armalon). The couches (produced by Weber Aircraft Division of Walter Kidde and Co., Burbank, Calif.) rest on a head beam and two side stabilizer beams supported by eight attenuator struts (two each for the Y and Z axes and four for the X axis) which absorb the impact of landing.



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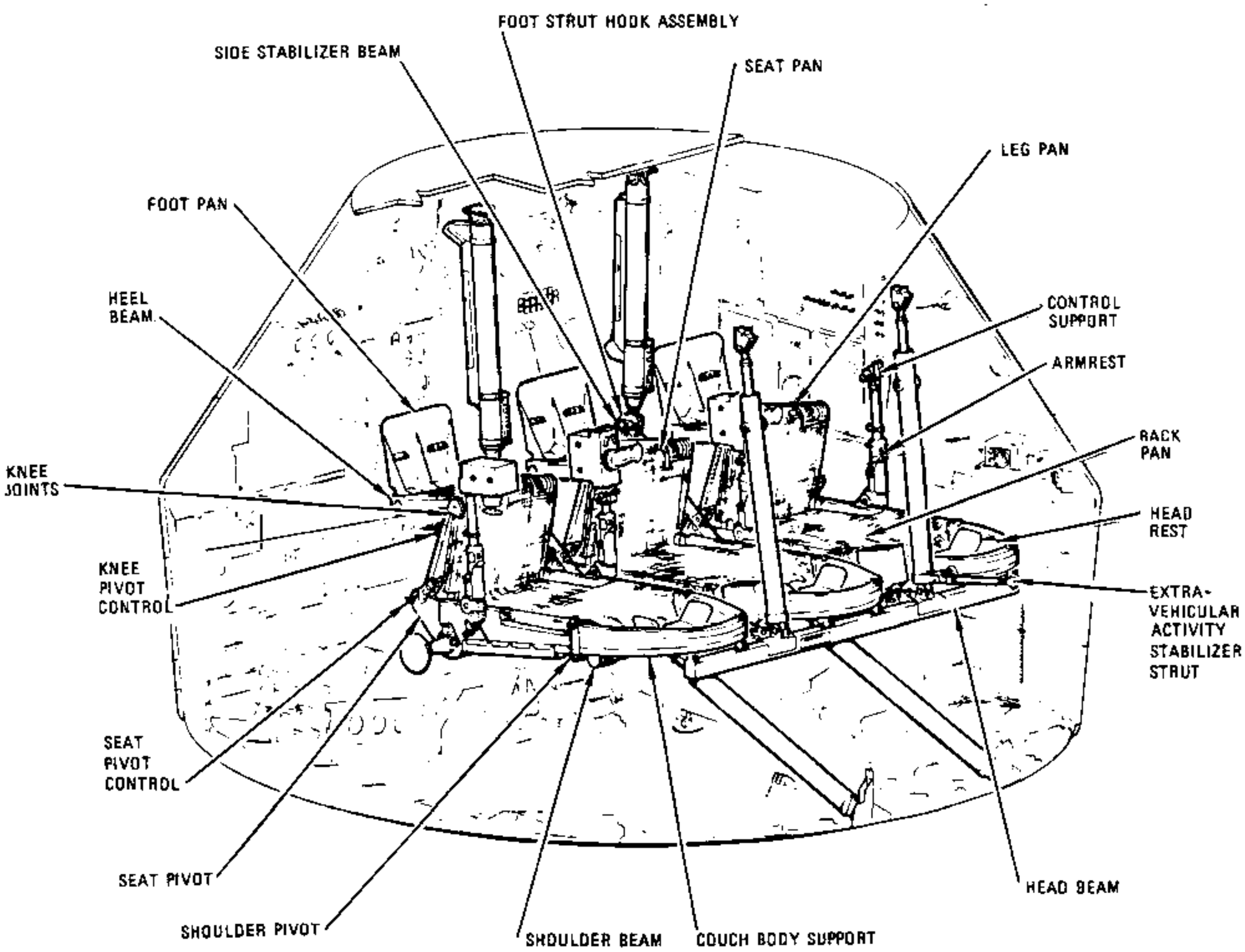
Couch

The couches — called foldable — support the crewmen during acceleration and deceleration, position the crewmen at their duty stations, and provide support for translation and rotation hand controls, lights, and other equipment. A lap belt and sholder straps are attached to the couches.

The couches can be folded or adjusted into a number of seat positions. The one used most is the 85-degree position assumed for launch, orbit entry, and landing. The 170-degree (flat-out) position is used primarily for the center couch, so that crewmen can move into the lower equipment bay. The armrests on either side of the center couch can be folded footward so the astronauts from the two outside couches can slide over easily. The hip pan of the center couch can be disconnected and the couch pivoted around the head beam and laid on the aft bulkhead (floor) of the CM. This provides room for the astronauts to stand and easier access to the side hatch for extra-vehicular activity.

The three couches are basically the same. The head rest can be moved 6-1/2 inches up and down to adjust for crewman height. Two armrests are attached to the back pan of the left couch and two armrests to the right couch. The center couch has no armrests. The translation and rotation controls can be mounted to any of the four armrests. A support at the end of each armrest rotates 100 degrees to provide proper tilt for the controls. The couch seat pan and leg pan are formed of framing and cloth, and the foot pan is all steel. The foot pan contains a boot restraint device which engages the boot heel and holds it in place.

The couch restraint harness consists of a lap belt



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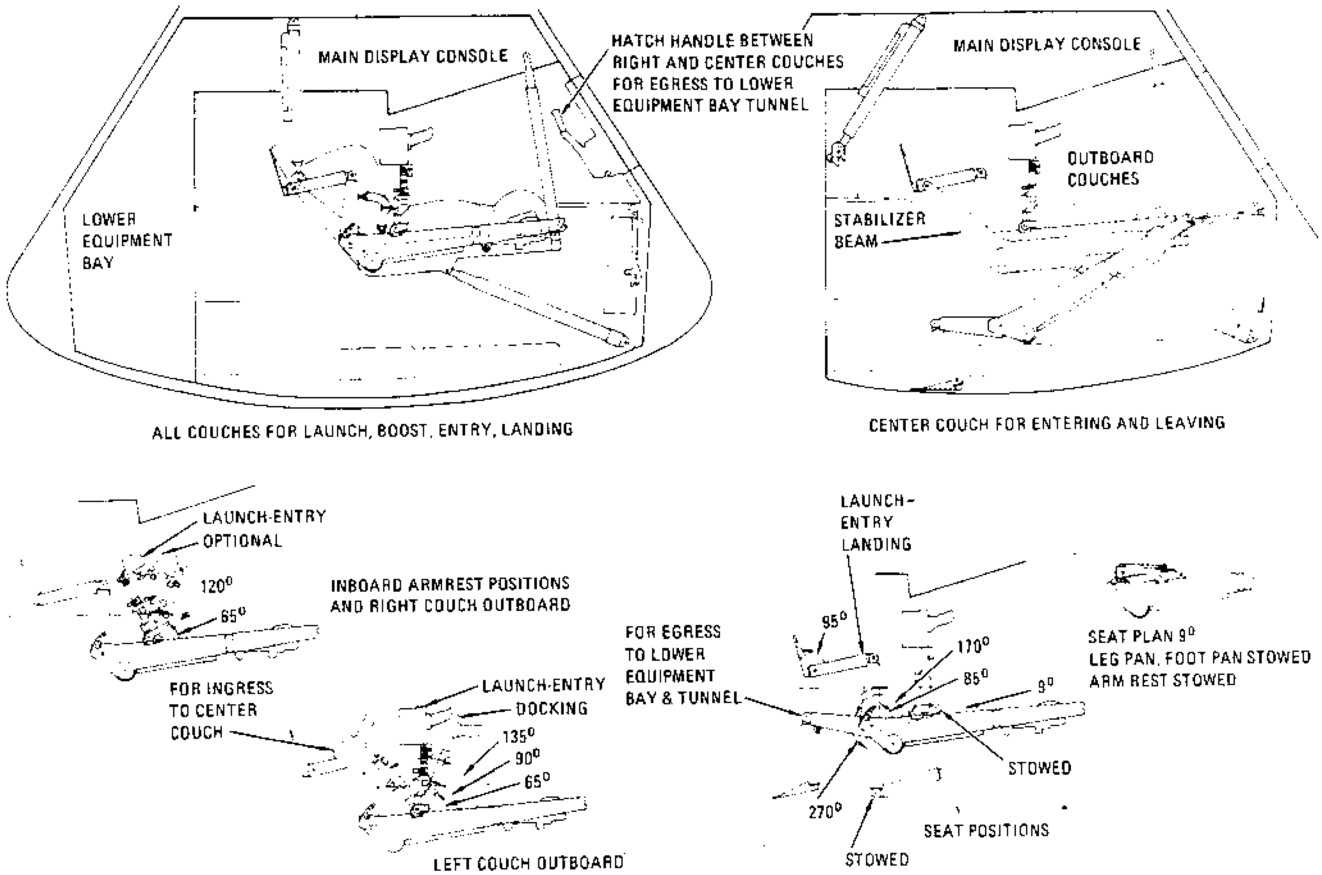
Foldable couch



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Couch positions

and two shoulder straps which connect to the lap belt at the buckle. The shoulder straps connect to the shoulder beam of the couch. The lap belt buckle is a lever-operated, three-point release mechanism. By pulling a lever, the shoulder straps and right-lap belt strap will be released. The strap ends and buckle have button snaps which are fastened to mating snaps on the controllers and struts to prevent them from floating during zero gravity.

Other restraints in the CM include handholds, a hand bar, hand straps and patches of Velcro which hold crewmen when they wear sandals.

Two aluminum handholds are by the side windows close to the main display console. The hand bar on the main display console near the side hatch helps crewmen move through the hatch and move couches to the locking position. The hand bar can be stowed or extended.

The hand straps, made of Fluorel attached by brackets at each end, serve as a maneuvering aid during weightlessness. There are five hand straps behind the main display console and one on the left-hand equipment bay.

The astronauts sleep in bags under the left and right couches with the head toward the hatch. The two sleeping bags are lightweight Beta fabric 64 inches long, with zipper openings for the torso and 7-inch-diameter neck openings. They are supported by two longitudinal straps that attach to storage boxes in the lower equipment bay and to the CM inner structure. The astronauts sleep in the bags when unsuited and on top of the bags when they have the space suit on.

HYGIENE EQUIPMENT

Hygiene equipment includes wet and dry cloths for cleaning, towels, a toothbrush, and the waste management system. The cloths are 4 inches square and come in sealed plastic bags packaged with the food. The wet cloths are saturated with a germicide and water. Twelve-inch square towels similar to a washcloth are stowed under the left couch.