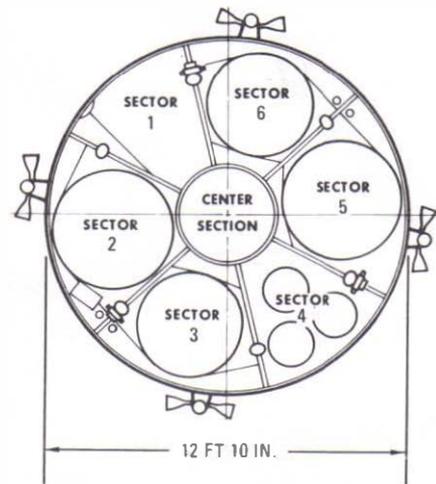
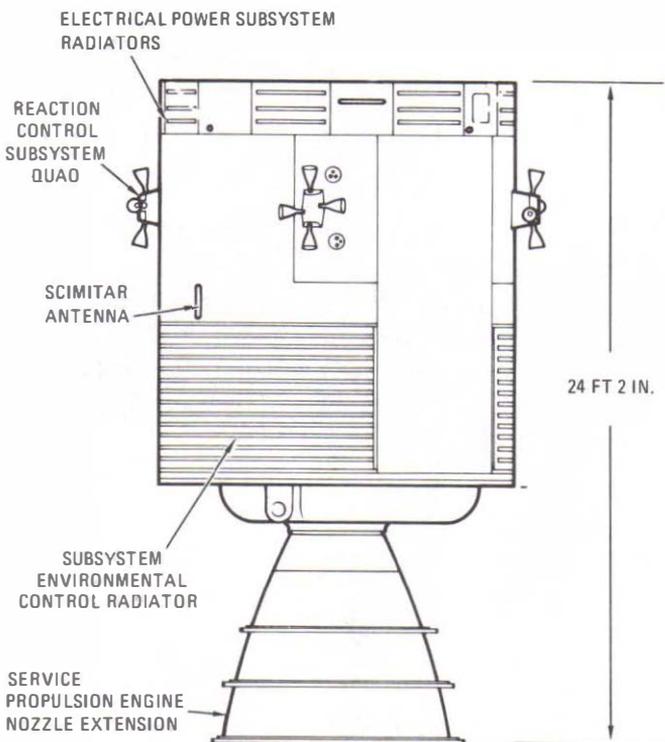


SERVICE MODULE



- SECTOR 2 } SERVICE PROPULSION AND SYSTEM
 - SECTOR 3 } OXIDIZER TANKS
 - SECTOR 4 } OXYGEN TANKS, HYDROGEN TANKS, FUEL CELLS
 - SECTOR 5 } SERVICE PROPULSION SUBSYSTEM
 - SECTOR 6 } FUEL TANKS
- CENTER SECTION - SERVICE PROPULSION ENGINE AND HELIUM TANKS

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Dimensions

Height	24 ft. 2 in.
Diameter	12 ft. 10 in.
Weight (loaded)	55,000 lb.
Weight (dry)	11,500 lb.

Propellant

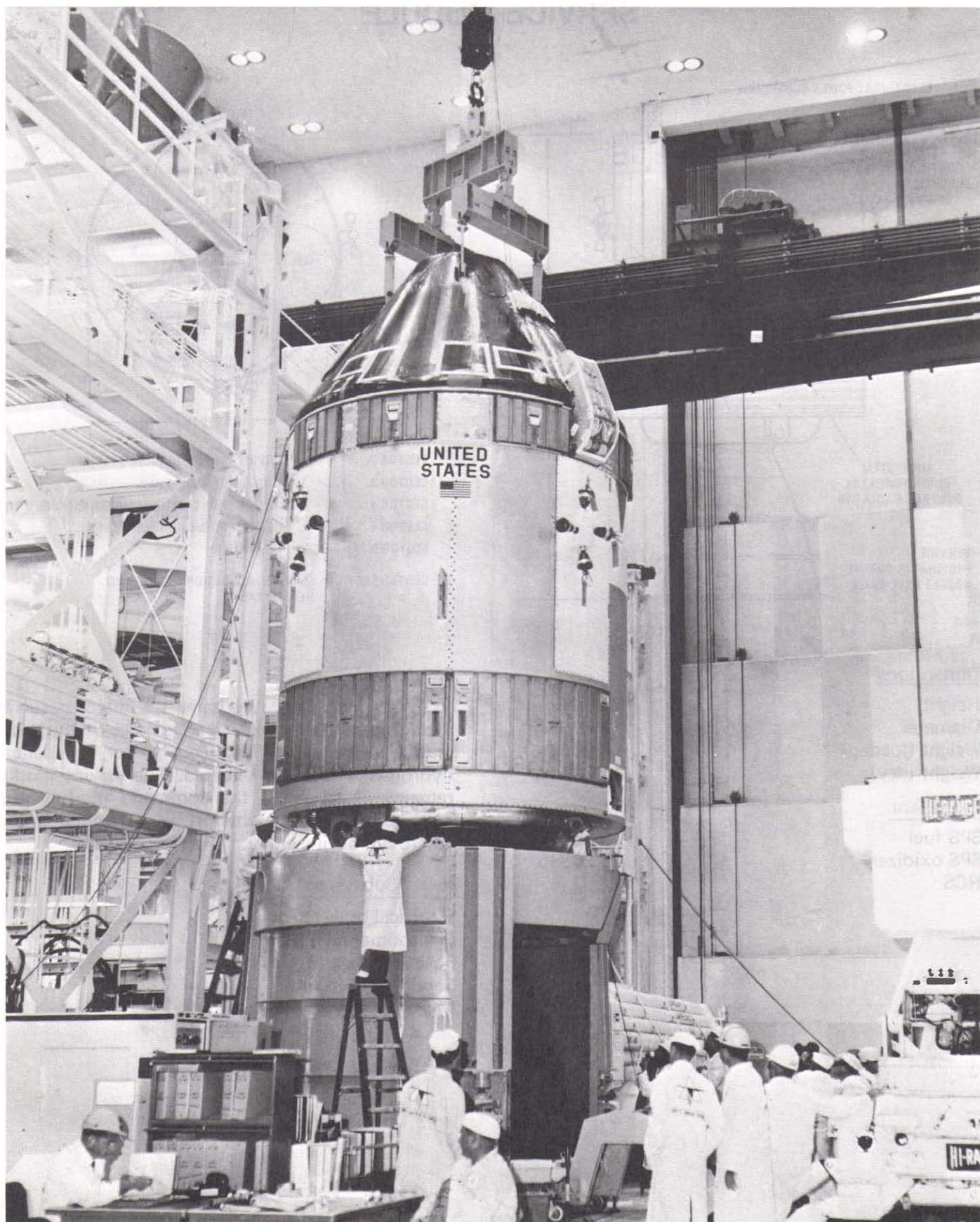
SPS fuel	15,766 lb.
SPS oxidizer	25,208 lb.
RCS	1,362 lb.

Function

The service module contains the main spacecraft propulsion system and supplies most of the spacecraft's consumables (oxygen, water, propellant, hydrogen). It is not manned. The service module remains attached to the command module until just before entry, when it is jettisoned and is destroyed during entry.

Major Subsystems

- Electrical power
- Environmental control
- Reaction control
- Service propulsion
- Telecommunications



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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.

STRUCTURE

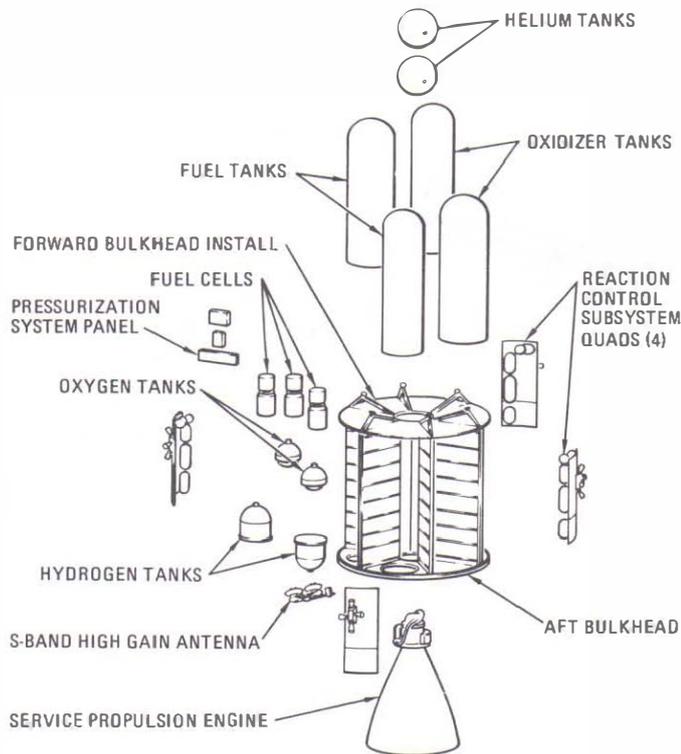
The service module is a relatively simple structure consisting of a center section or tunnel surrounded by six pie-shaped sectors.

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



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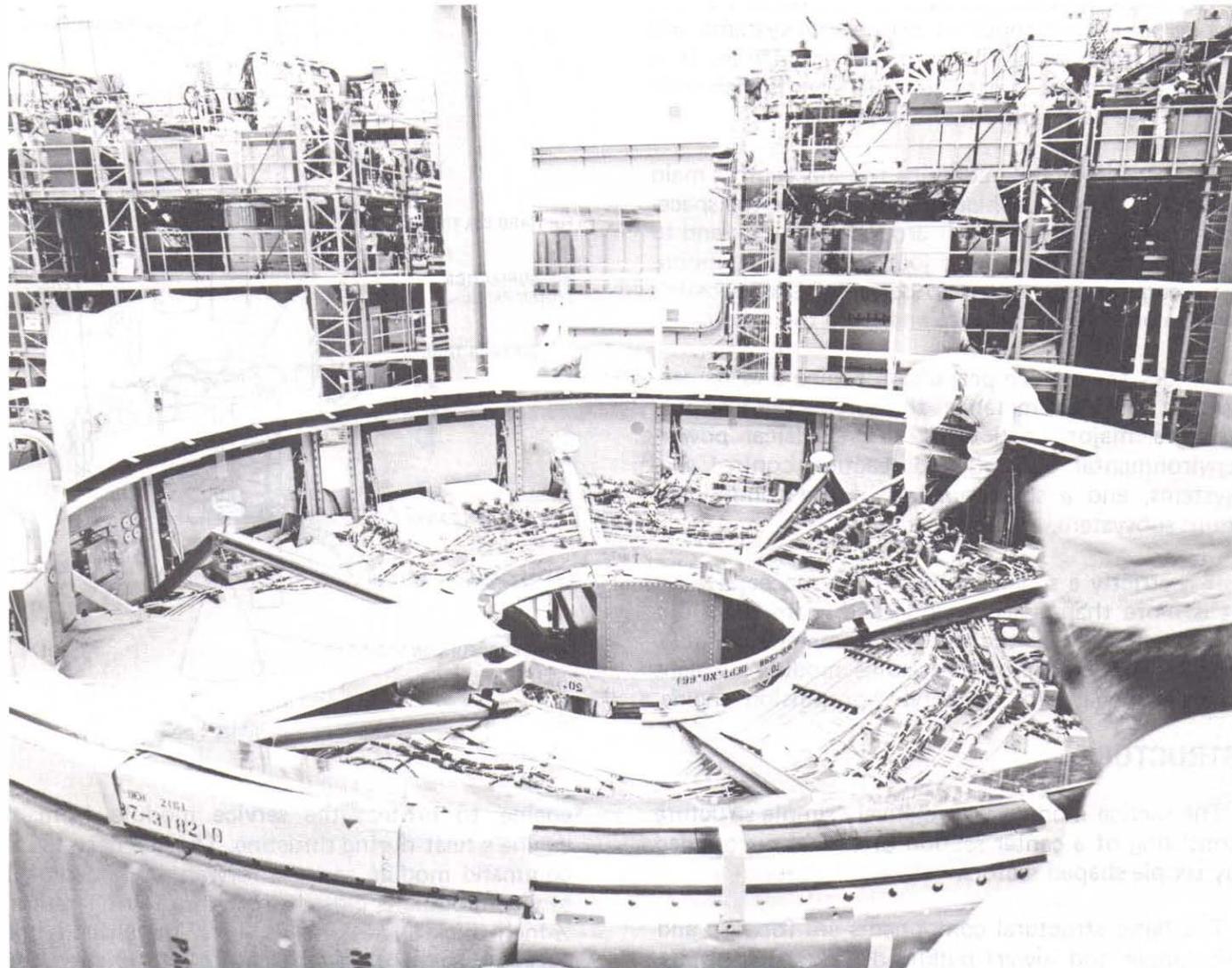
Main components of SM

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.



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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- $\frac{3}{4}$ 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

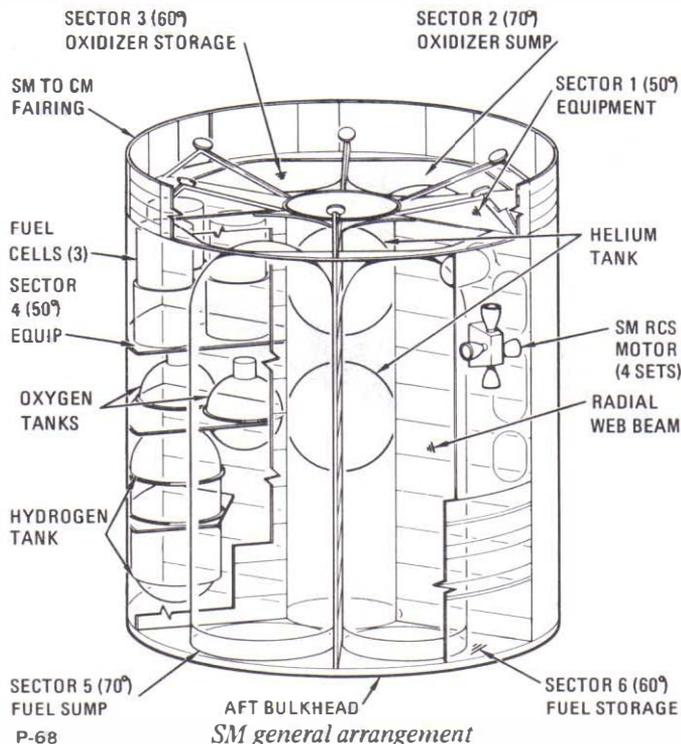
Sector 4 is one of the 50-degree sectors and contains most of the electrical power subsystem equipment in the service module, including three fuel cell powerplants, two cryogenic oxygen and two cryogenic hydrogen tanks, and a power control relay box. A helium servicing panel also is located in this sector.

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-



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.

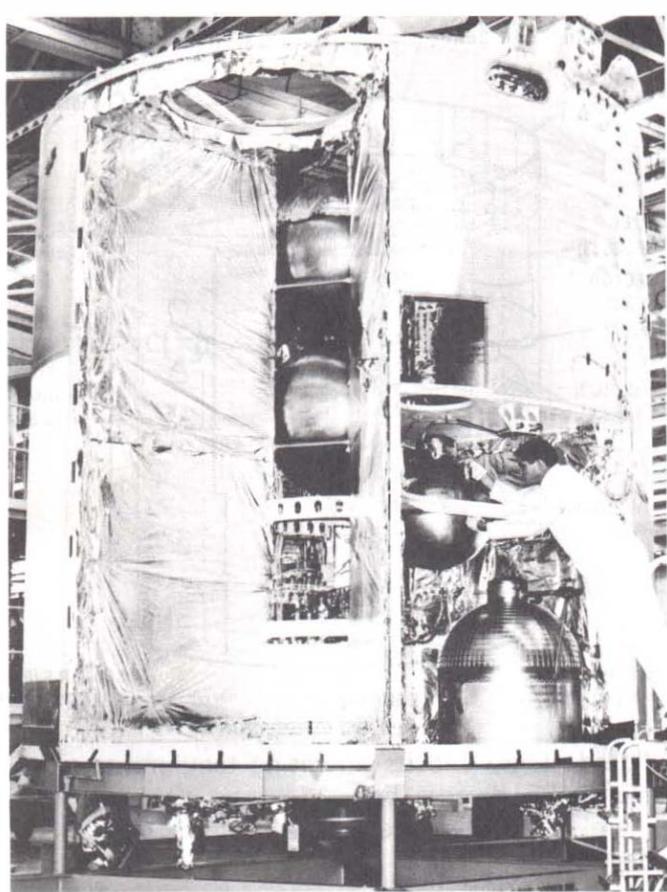
SECTOR 5

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



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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 oxi-

dizer 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.

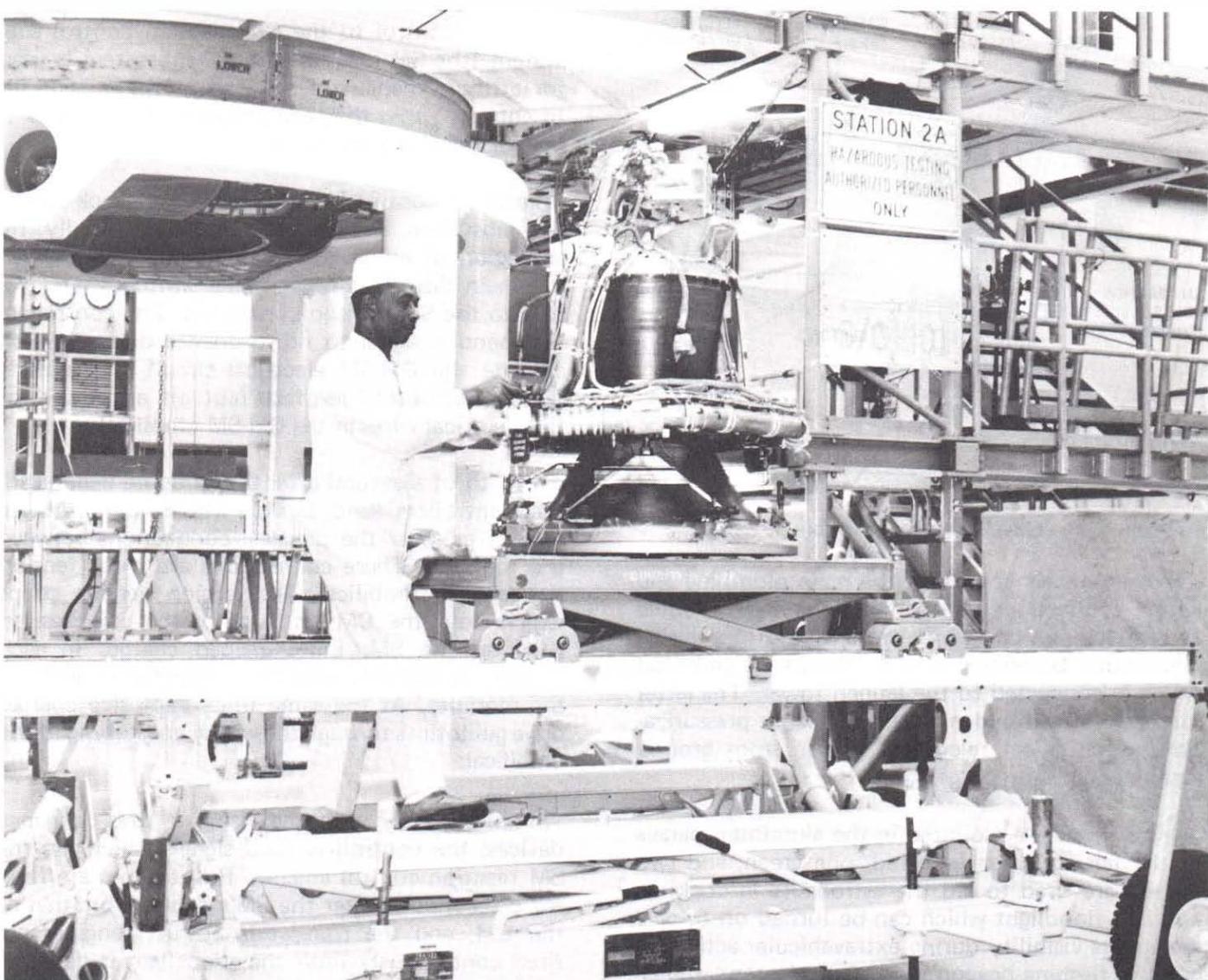
EXTERIOR

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



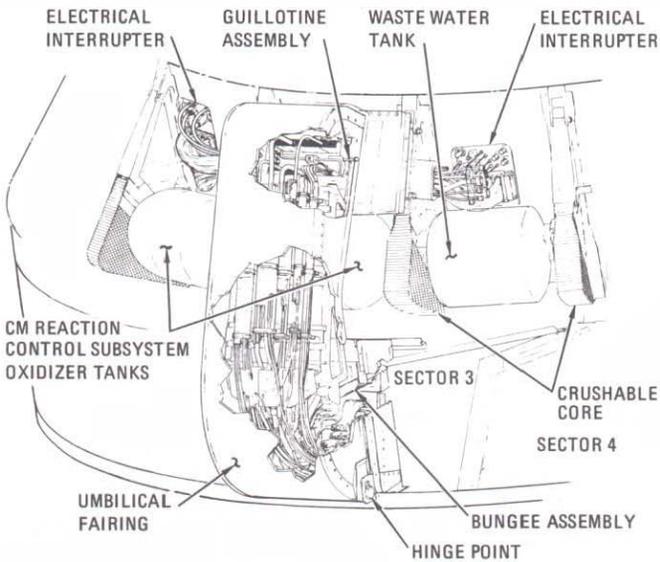
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Technician prepares service propulsion engine for installation in service module

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 omni-directional antennas, called scimitars because of their shape, are made of stainless steel and are approximately 13½ inches long and only a hundredth of an inch thick.



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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

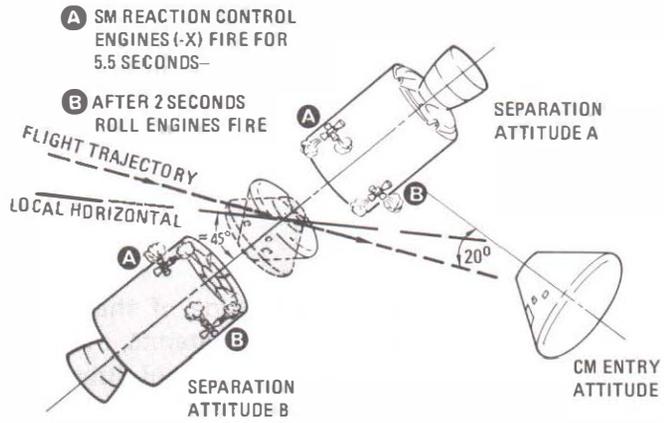
electrical control to the CM reaction control subsystem (the SM reaction control subsystem is used for attitude maneuvers throughout the mission up to entry) so that they can pressurize it and check it out for the entry maneuvers.

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.



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Attitude of SM and CM during separation