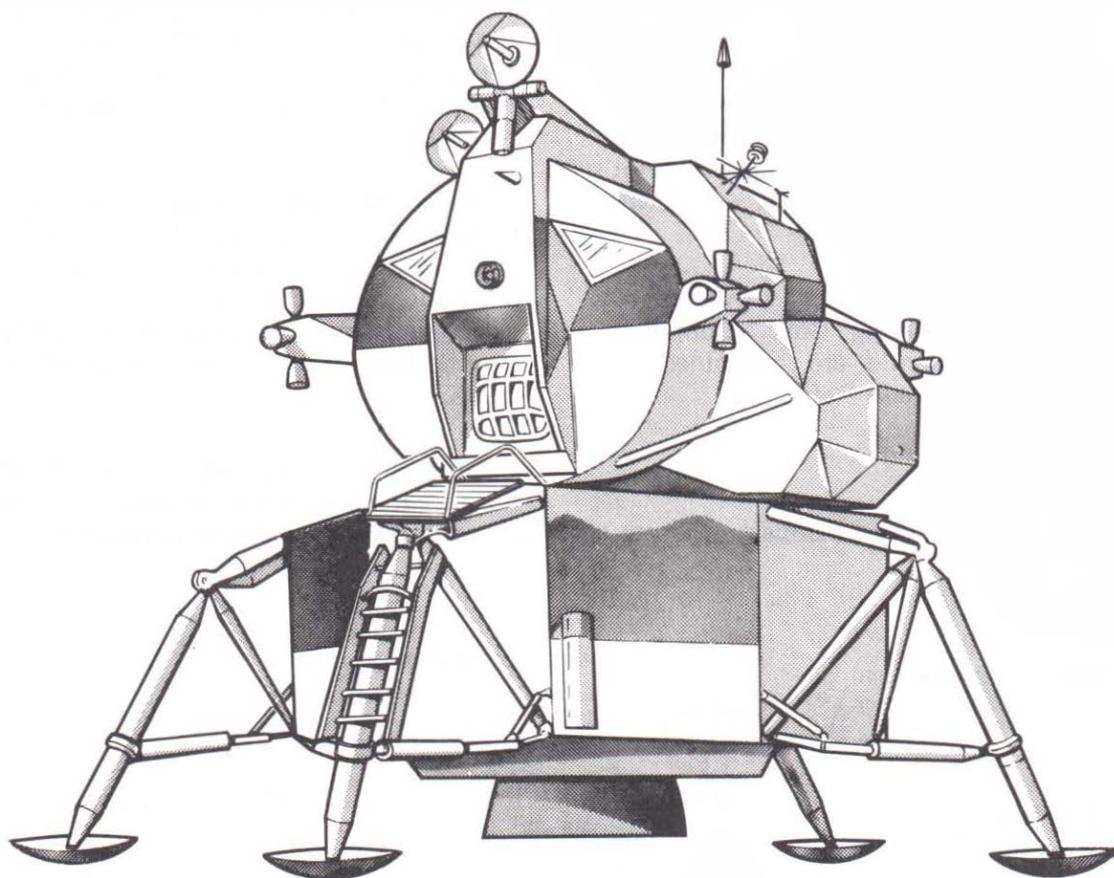


# LUNAR MODULE



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.

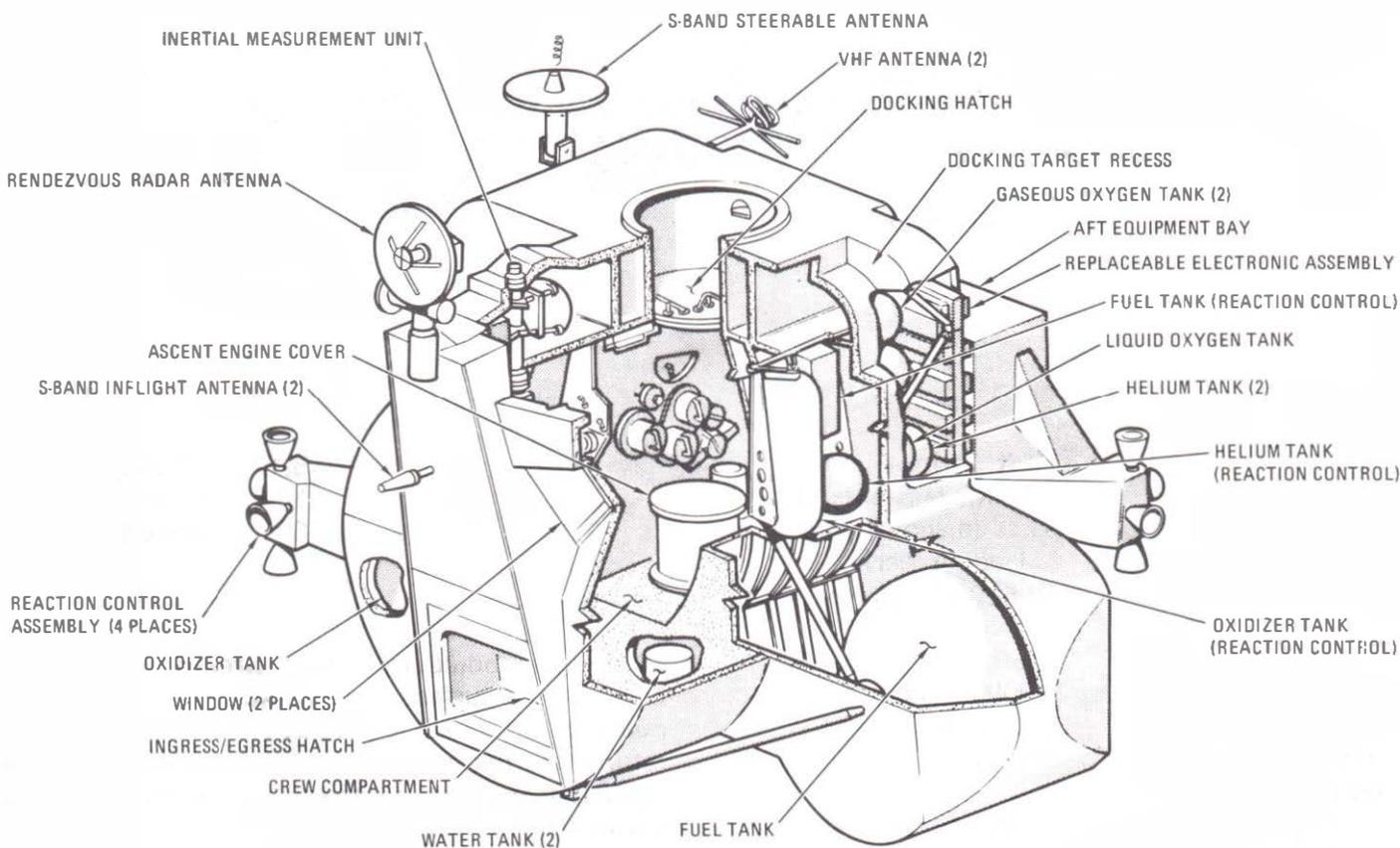
## ASCENT STAGE

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*

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.

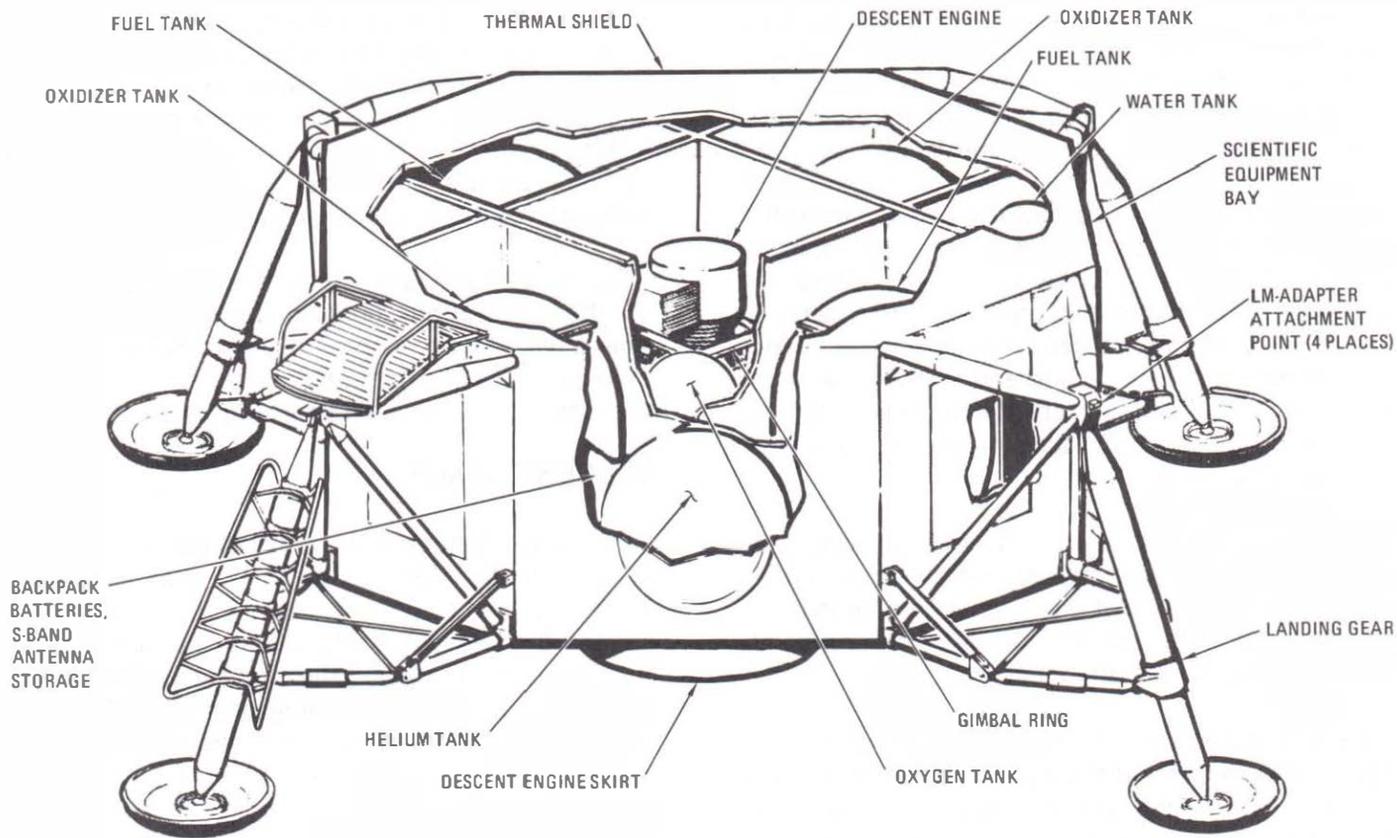
## DESCENT STAGE

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



*Descent stage*

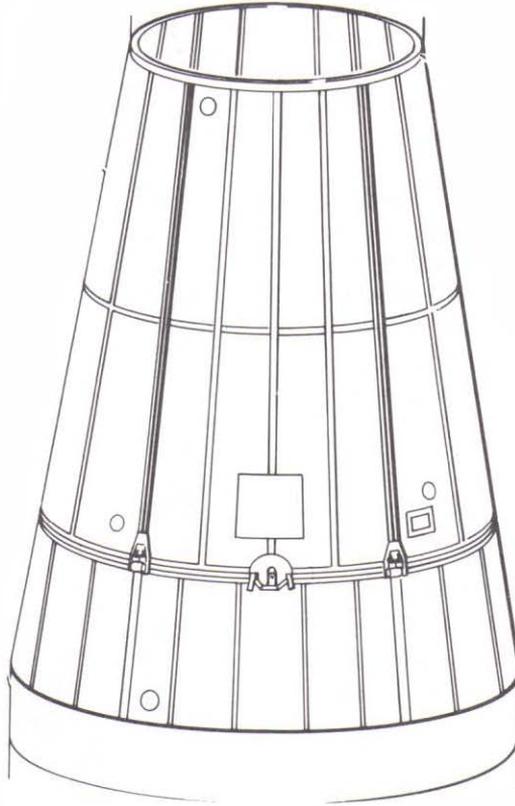
P-75

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

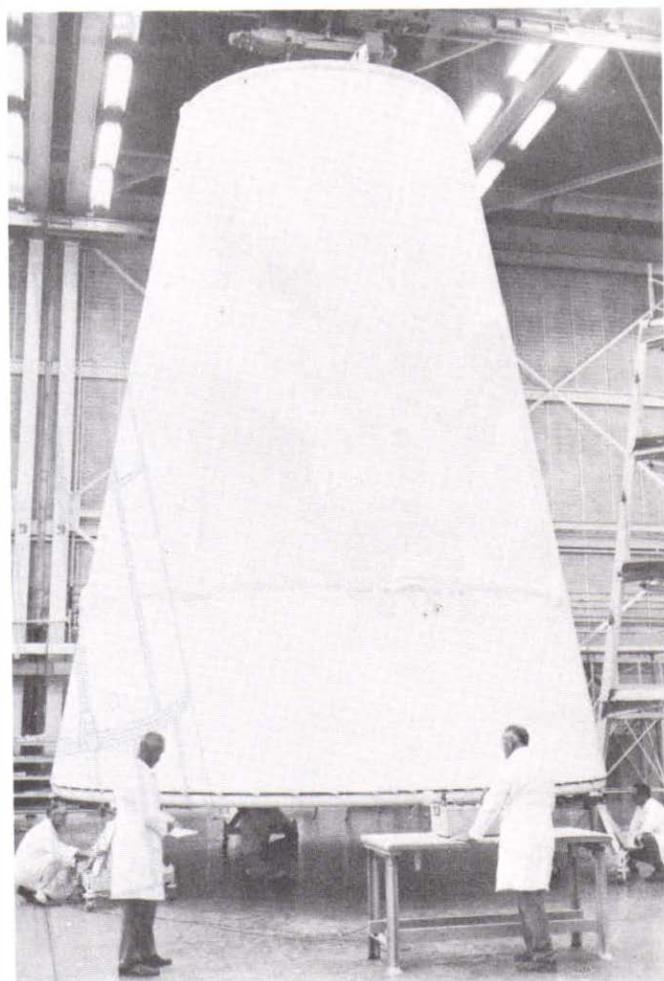
The SLA and SM are joined by bolts through a flange that extends around the circumference of the two structures. The only other connection is an umbilical cable through which electrical power is supplied to the SLA. This power is used to trigger the separation devices.

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.

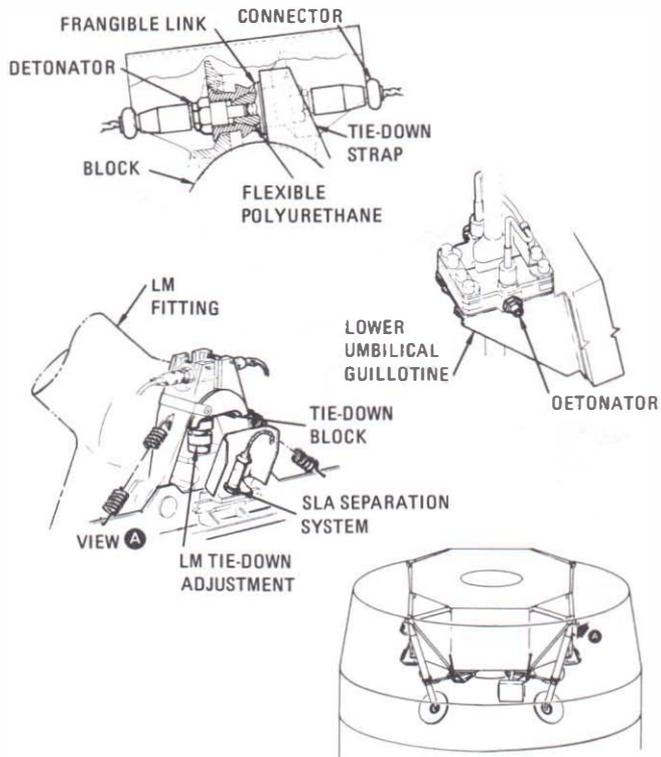
The four pyrotechnic thrusters are located at the top of the lower panels at the upper panel joints and are used to rotate the panels backwards. Each of these thrusters has two pistons, one acting on each panel, so that each panel has two pistons thrusting against it, one on each end.

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.



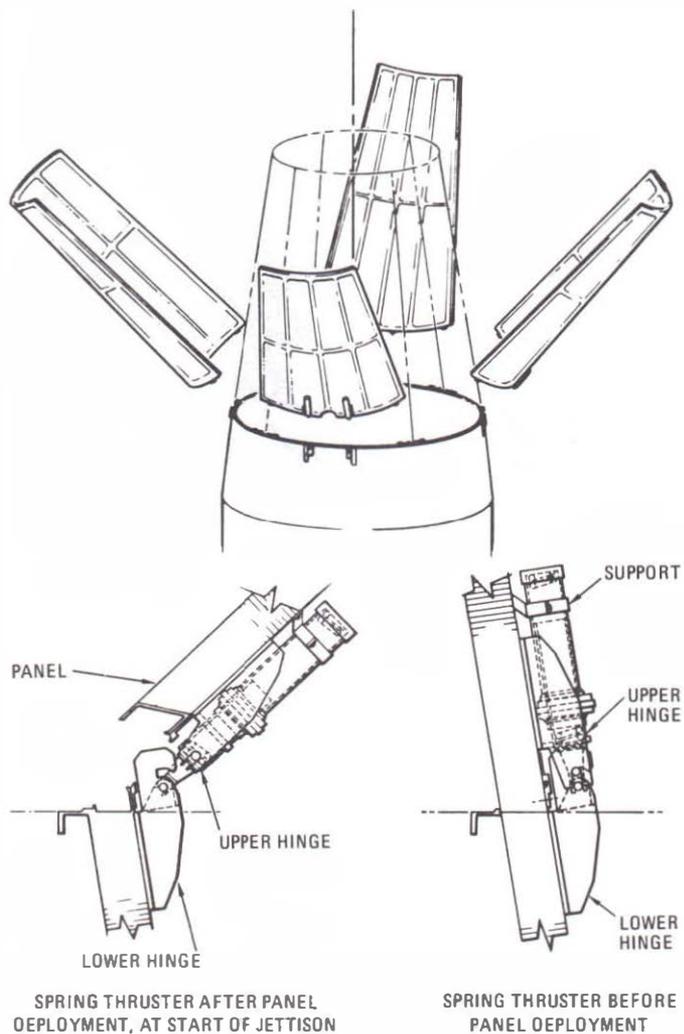
P-79

*SLA-LM separation system*

## SLA-LM SEPARATION

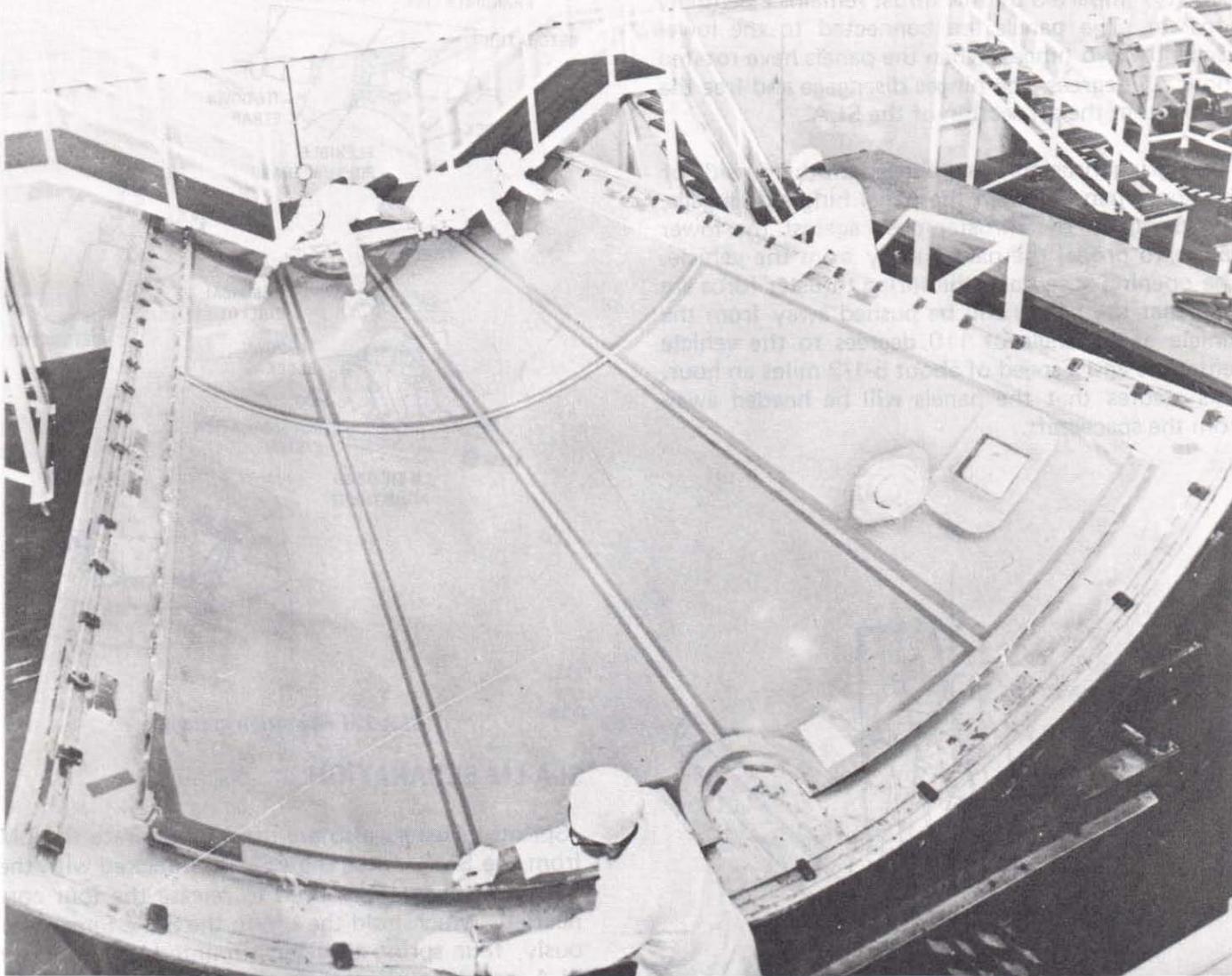
Spring thrusters also are used to separate the LM from the SLA. After the CSM has docked with the LM, mild charges are fired to release the four connections which hold the LM to the SLA. Simultaneously, four spring thrusters mounted on the lower SLA panels push against the LM to separate the two vehicles.

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-78

*How SLA panels are jettisoned*



P-80

*Technicians at Tulsa put the finishing touches on SLA forward panel*