DOCKING

The docking subsystem provides the means to connect and disconnect the lunar module and the command module. It is used twice during a normal lunar mission: at the beginning of the translunar flight when the CM docks with the LM, and in lunar orbit when the ascent stage of the lunar module docks with the CM.

Docking is achieved by maneuvering one of the modules close enough to the other so that a probe on the CM engages a drogue on the LM. In the first docking, the CM is the maneuvering vehicle and the LM the passive one; in the second docking the LM ascent stage is active and the CM passive.

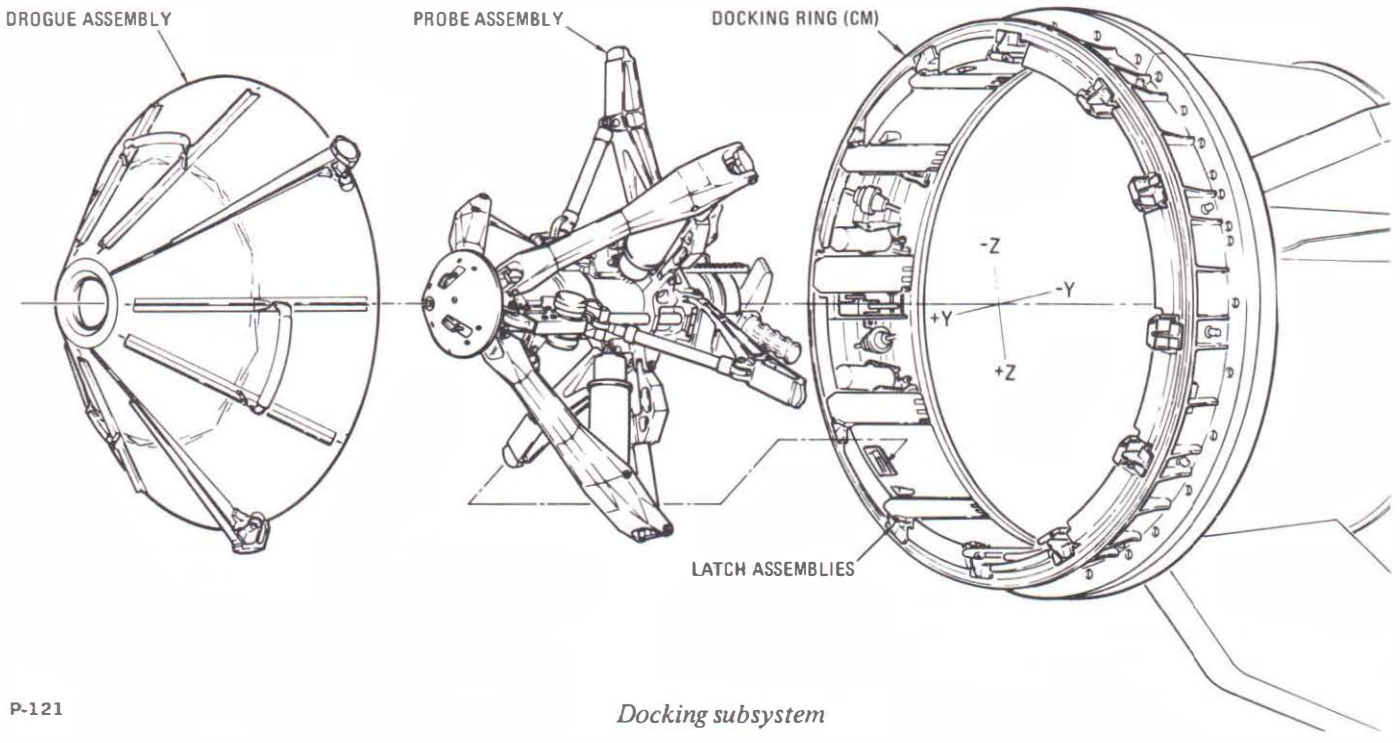
The probe, drogue, tension tie, and a docking ring are the principal components of the docking subsystem. Each module also contains a docking pressure hatch and a tunnel through which the astronauts will transfer from one vehicle to the other.

The docking maneuvers are controlled by the commander through short bursts of the reaction control engines on the active vehicle. He is aided in maneuvering his craft by the crewman alignment sight, an optical device something like the range finder of a camera which is mounted at a rendezvous window.

Before the docking maneuvers begin a crewman in the CM activates a switch which extends the probe. When the probe comes into contact with the drogue, it is guided into the socket at the bottom of the drogue. Three capture latches in the probe head then hold the two modules together.

A crewman then activates the probe retraction device (a nitrogen pressure system located in the probe) which automatically pulls the LM and CM together. At contact 12 latches mounted on the CM docking ring are automatically activated to form a pressure-tight seal between the two modules.

A CM crewman then equalizes the pressure between the LM and CM tunnels through a valve provided for the purpose and removes the CM's docking hatch. After removing the hatch, he first checks all the docking ring latches to make sure they are engaged (locking of any 3 of the 12 latches is sufficient to assure a pressure-tight seal and allow entry into tunnel), and manually locks those that aren't. He then connects the two electrical umbilicals (stowed in the LM) to the CM ring connectors, providing power from the CM to the LM. The probe and drogue are then removed and passed down into the CM along with the hatch. Finally, he operates the valve in the LM docking hatch to equalize the



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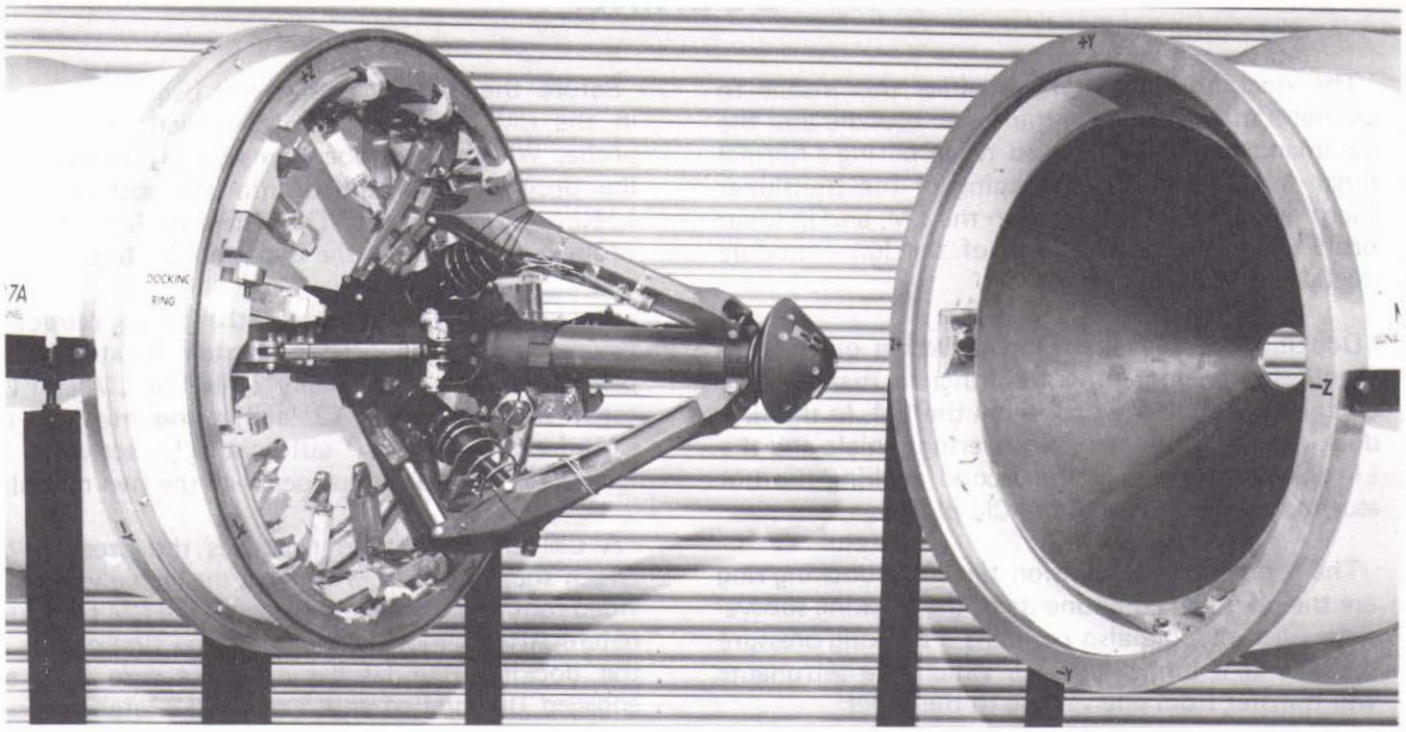
Docking subsystem



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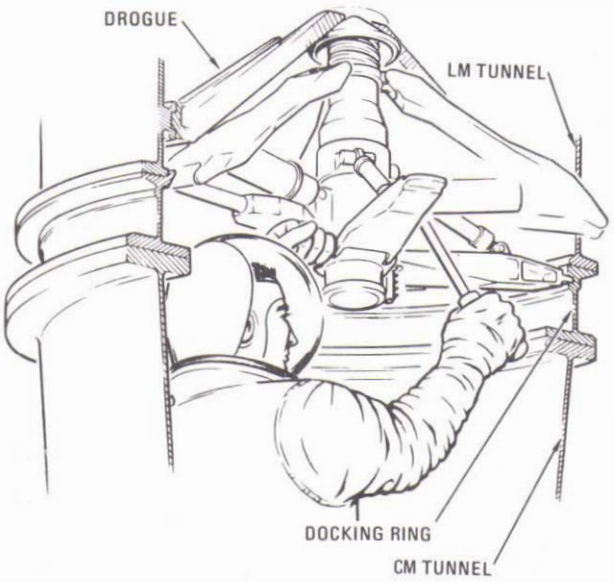
Mockup of docking subsystem

pressure in the LM. The LM hatch can then be opened; this is hinged to swing inward into the LM crew compartment.

In the first docking, the probe and drogue will not be removed, nor will the LM hatch be opened. The CM crewman will remove the CM hatch, check the locking latches, connect the umbilicals, and replace the CM hatch.

Once in orbit around the moon, the passage between the two modules is opened, the hatch, probe and drogue are removed, and two astronauts transfer into the LM. The remaining CM crewman then passes the drogue back to an LM crewman and it is re-installed in the tunnel. The CM crewman re-installs the probe and disconnects the LM/CM umbilicals for stowage in the tunnel area, manually cocks all the 12 ring latches, and then closes and seals both hatches. The two vehicles are separated for lunar descent through remote electrical release of latches on the probe assembly.

In the second docking, the LM is the maneuvering or active vehicle, but the operations are otherwise similar. The CM crewman must remove the CM hatch, check the latches, and remove the probe into the CM. An LM crewman opens the LM hatch and removes the drogue to open the tunnel.



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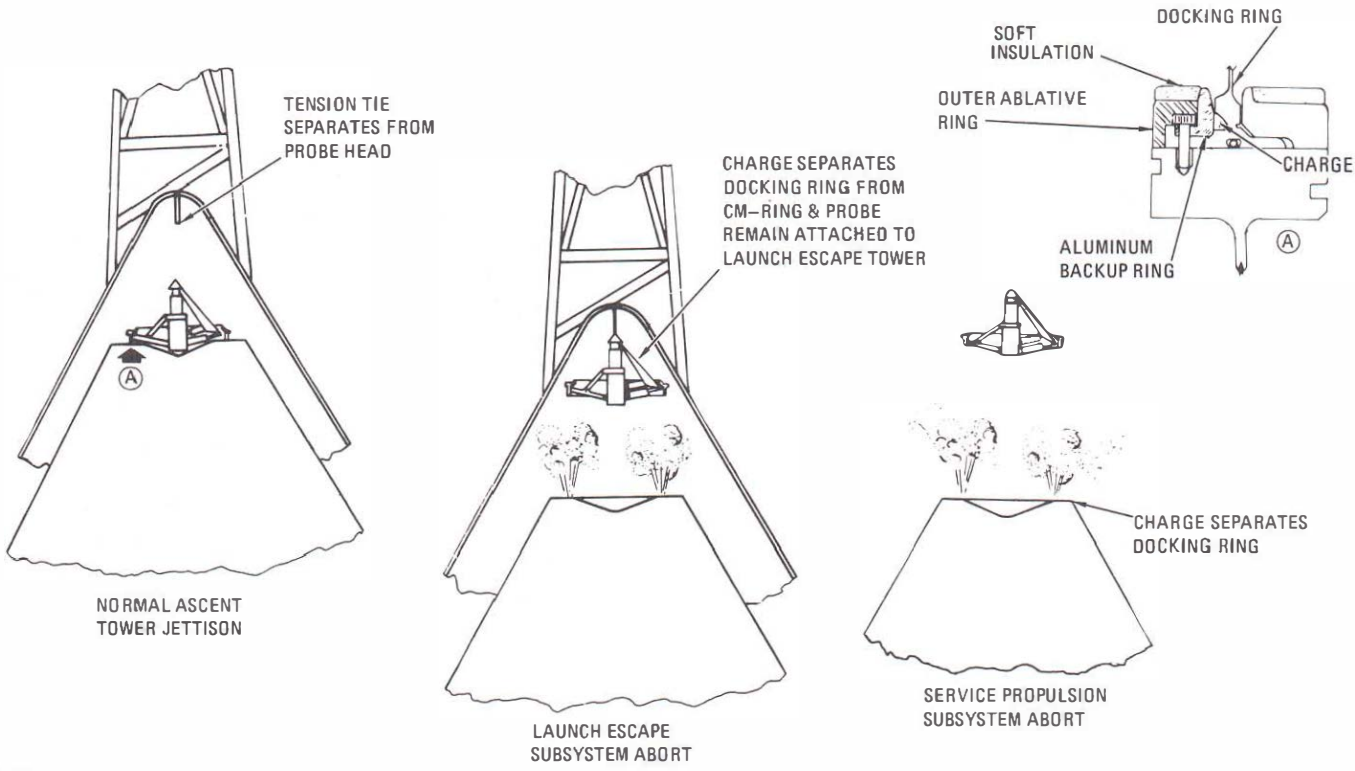
Operation of ratchet assembly

After all equipment has been transferred from the LM to the CM, the probe and drogue are stowed in the LM, since they are no longer needed. Both hatches are then replaced and sealed and the modules are ready for separation.

In this case, separation is accomplished by firing an explosive train located around the circumference



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Modes of separating probe

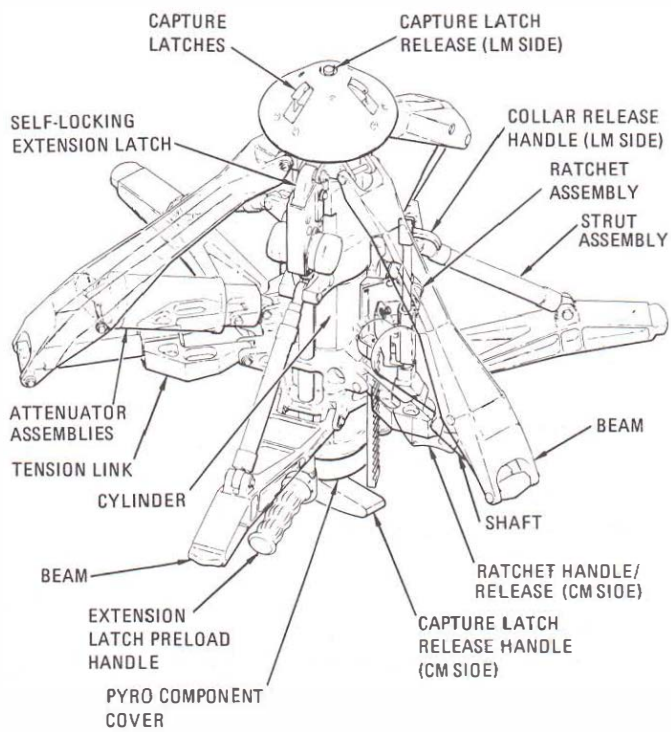
of the docking ring. This separates the entire docking ring from the CM and provides enough impetus to separate the modules. The docking ring remains attached to the LM ascent stage, which remains in orbit around the moon.

EQUIPMENT

Probe—Consists of aluminum inner and outer cylinders sized to allow a maximum of 10 inches of travel of the inner cylinder, and a probe head gimbal-mounted on the inner cylinder. The probe head is self-centering and houses the three capture latches. The probe is mounted at three points to the docking ring by a support structure attached to the outer cylinder and is designed to fold so that it can be removed from either LM or CM side. Its components include pitch arms and tension linkages, shock attenuators, extension latch assembly, capture latches, ratchet assembly, a retraction system, and probe umbilicals.

Pitch Arms and Tension Linkages—These make contact with the drogue surface for CM/LM alignment and shock attenuation; the contacting surfaces of the pitch arms are contoured to match the curvature of the drogue. The tension links transmit loads to the shock attenuators.

Shock Attenuators—These are piston, variable orifice, fluid displacement units hermetically sealed with a metal bellows. They absorb the shock of impact during docking.



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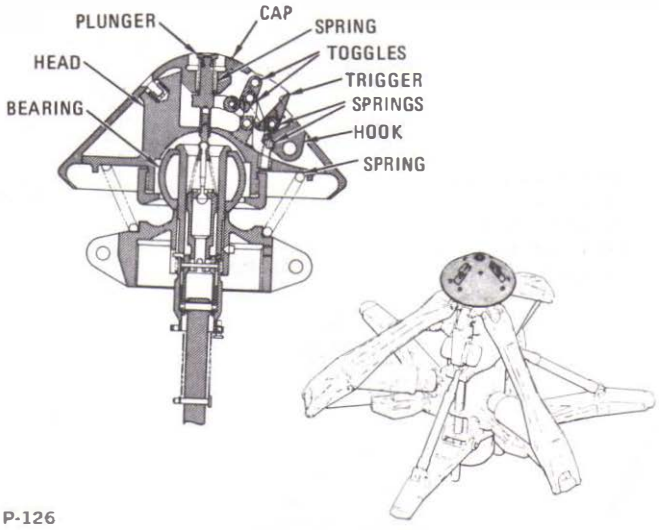
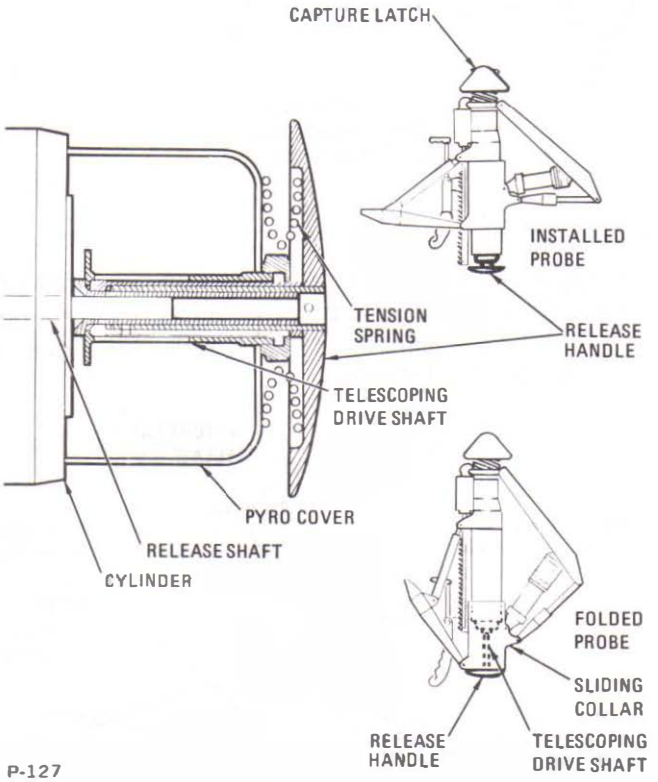
Probe assembly



Capture latch assembly



Capture latch release

Extension Latch Assembly—This engages and retains the probe in a fully retracted position after docking. It is released remotely from the CM to allow probe extension.

Capture Latches—These are mounted in the probe head and engage automatically when the probe head centers and bottoms in the drogue. Engagement of these latches operates a switch on the probe which initiates automatic operation of the retraction mechanism. The capture latches can be released remotely from the CM or by a manual release handle from the CM side. They can also be released from the LM side by depressing the center button in the probe head.

Ratchet Assembly—This mechanism provides a hold for handling the probe, and performs the ratcheting operation to install the probe support arms. A handle is provided from either the CM or LM side to unlock the ratchet sliding collar for folding and removing the probe.

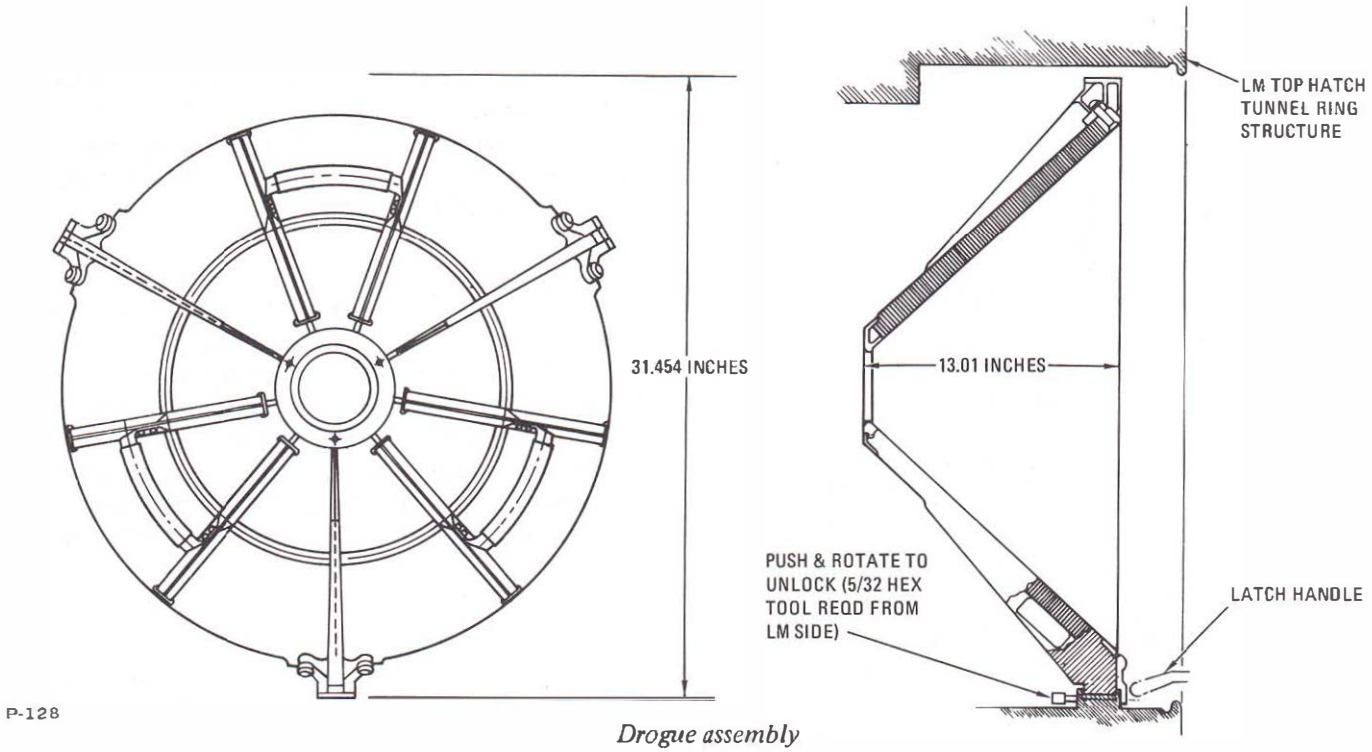
Retraction System—This is a cold gas system pressurized from four hermetically sealed nitrogen bottles located inside the probe body. When the gas pressure is released it compresses a piston with sufficient force to draw the LM to the CM, compress the interface seal, and engage the locking latches. The retraction system is activated automatically by capture latch engagement into the drogue opening or manually by a CM crewman.

Probe Umbilicals— The microdot connectors and harness assemblies are provided for probe instrumentation and power. The connectors are installed on the side of the docking ring and can be mated and demated from either the CM or LM side. During probe removal and stowing, the umbilical connectors are attached to receptacles on the probe support beams.

Drogue Assembly—The drogue consists of an internal conical surface facing the CM, a support structure and mounting provisions, and a locking mechanism that prevents it from turning during the docking maneuvers. It is made of aluminum honeycomb with aluminum support beams. The drogue may be unlocked and removed from either side.

Docking Ring—This is an aluminum structure bolted to the CM tunnel just forward of the top hatch. It contains seals and the shaped charge for final separation. It also serves as the mounting point for the probe and docking latches. The docking ring must withstand all loads from docking and from course corrections, and must maintain proper alignment of the docked vehicles. The ring also contains a covered passageway for the electrical harnesses and connections for attaching the umbilicals between the modules.

Docking Latches—The 12 docking latches are spaced an equal distance around the inner peri-



Drogue assembly

phery of the docking ring. The latches automatically seek and engage the back surface of the LM docking flange. The latch trigger mechanism is activated by contact with the flange. The latch will retract its hook, seat it on the back of the flange, and compress the docking seals. The latches are released manually by a crewman pulling the handle two times. This relieves the load from the hook and cocks the mechanism for the next docking engagement.

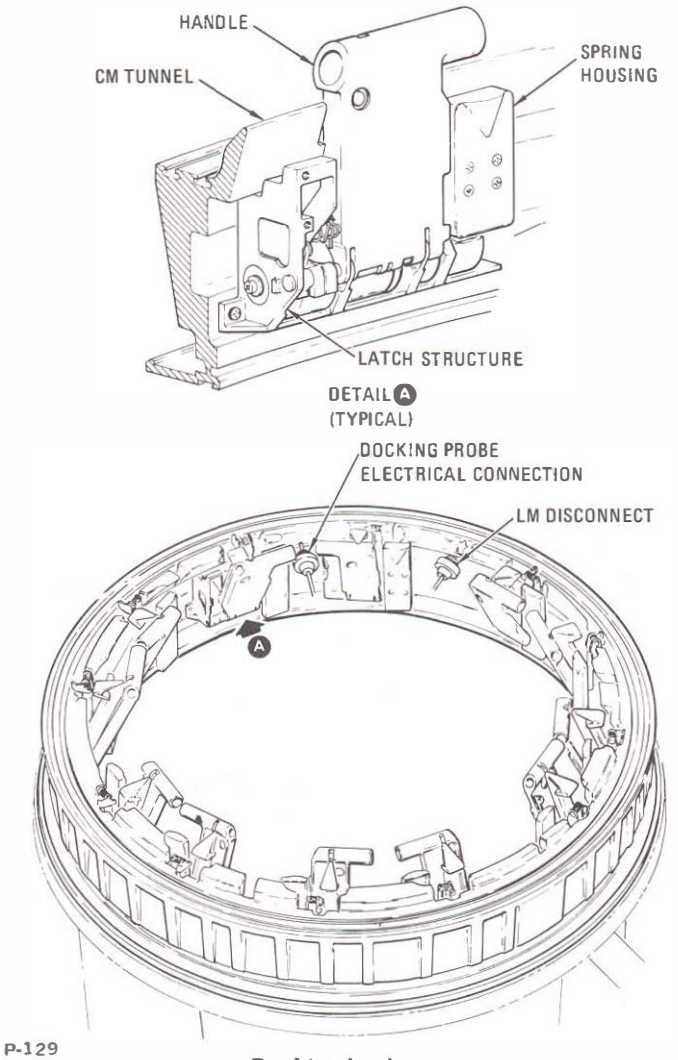
Docking Seals—These seals are round and hollow and made of a silicon material; they compress when the two modules come together to form a pressure-tight seal.

Umbilicals—Two electrical umbilicals are attached to stowage connectors on the LM tunnel wall so that they are clear of the probe and drogue supports during docking. The umbilicals can be reached from the CM tunnel and are connected to the receptacles on the CM docking ring before LM withdrawal.

Tunnel Hatches—The hatch at the forward end of the CM can be opened from either side (by a handle on the CM side and with a tool from the LM side), but can be removed only into the CM. The hatch contains a pressure equalization valve which can be operated from either side to equalize the pressure in the tunnel and LM before removing the hatch. The LM docking hatch is located at the lower end of the LM tunnel and is not removable; it swings down into the LM crew compartment. It also can be opened from either side, and has a pressure dump valve. Although the valve's primary function is to release pressure from the LM cabin, it can also be used to equalize pressure in the tunnel.

Passive Tension Tie—A tension-type bolt arrangement connecting the probe and the boost protective cover. During normal flight, the attaching pins are sheared in the probe head, leaving the probe intact for docking. During an abort, a pyrotechnic charge separates the docking ring, allowing the launch escape tower to take the ring and probe with it.

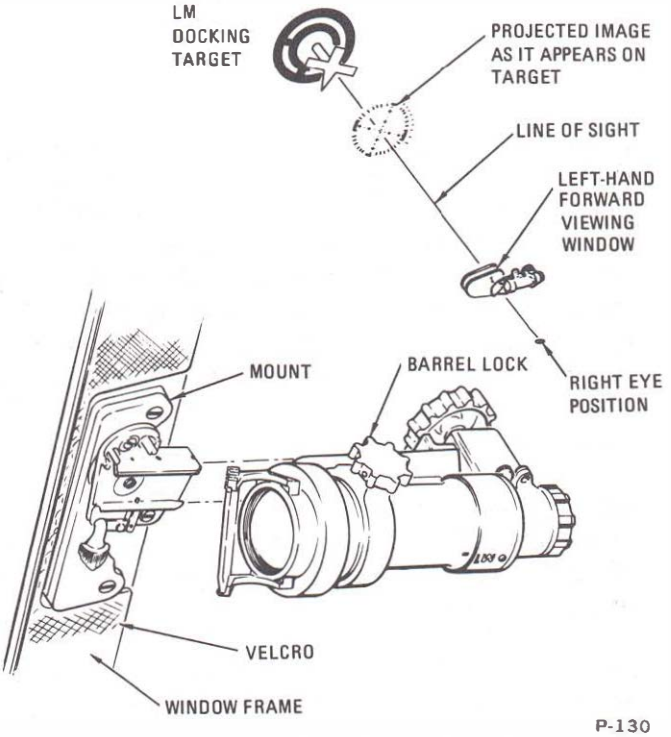
Pyrotechnic Charge—This is a mild detonating fuse located around the periphery of the docking ring. When fired, the charge separates the ring structure between the forward heat shield and the probe mounting, leaving all docking hardware with the LM. The charge is initiated by a signal from the CM. The charge normally is fired for final separation of the LM ascent stage, just before the CSM is injected on the transearth flight. It also would be fired during an abort, and the docking hardware would be carried away by the launch escape subsystem.



Docking latches

Crewman Optical Alignment Sight—This is used to help astronauts align the maneuvering module with the passive one. It is a collimator-type device that provides the astronaut with a fixed line-of-sight reference image. When viewed through the rendezvous window, the image appears to be the same distance away as the target. It is about 8 inches long, can be mounted near either rendezvous window, and has a control to permit adjustment for proper brightness against any background lighting conditions. The operator controls firing of the reaction control engines so as to keep the projected image superimposed on the passive module target. Range and rate of closure are determined by the size relationship between the image and the target. The adjustable light source projects the image from within its housing to the crewman's right eye by means of a beam splitter or combining glass. Though the image is projected to the right eye only, the crewman sights with both eyes open. Single-eye projection keeps the system small and eliminates apparent parallax of the projected image caused by focusing and by convergence when sighting during the final docking phase. Sideward motion of the astronaut's head during sighting will not affect the system.

Docking Targets—These are mounted in a window of the CM and LM to aid in docking maneuvers. The LM active docking target is mounted in the right rendezvous window of the CM. Its base is 8 inches in diameter and contains green electroluminescent lamps and a black stripe pattern on the first. An upright support at a right angle to base contains a red incandescent lamp. The docking target in the LM is similar but about twice the size.



Crewman optical alignment sight