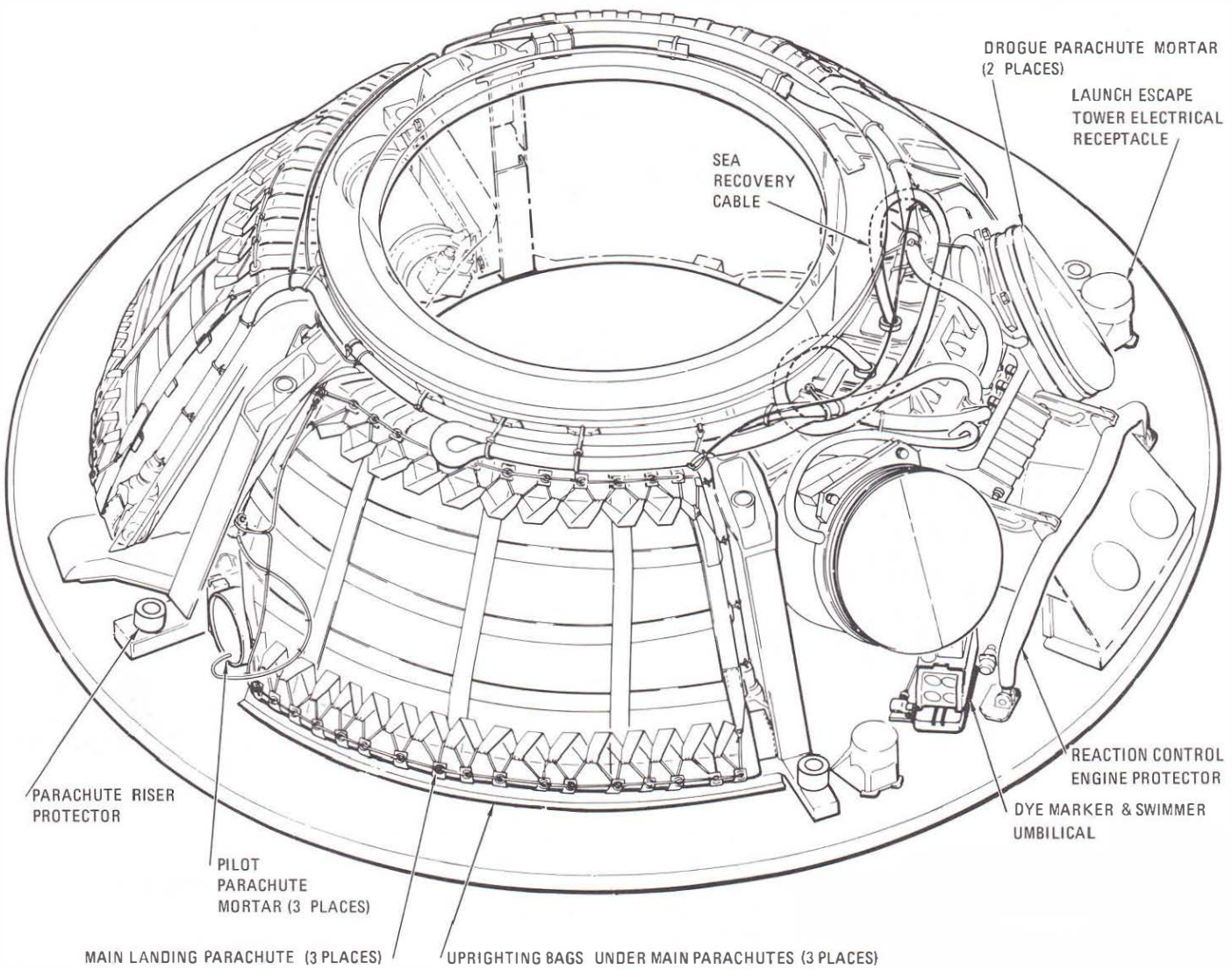
EARTH LANDING



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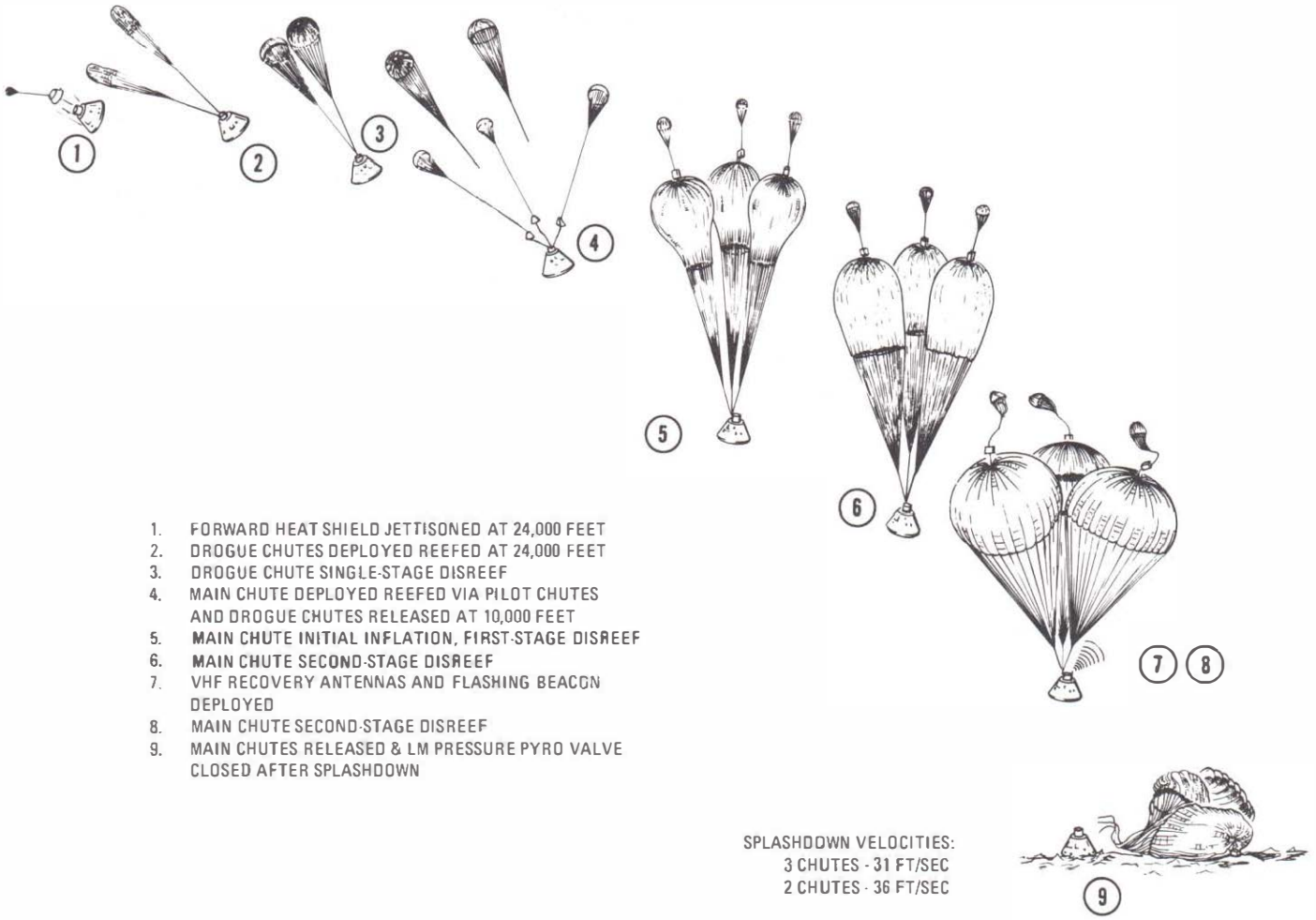
Location of main components of earth landing subsystem

The earth landing subsystem provides a safe landing for the astronauts and the command module. Several recovery aids which are activated after splashdown are part of the subsystem. Operation of the subsystem normally is automatic, timed and activated by the sequential control system. There are, however, backup manual controls for astronaut operation.

For normal entry, the subsystem operation begins with jettison of the forward heat shield when the CM descends to about 24,000 feet. About 1-1/2 seconds later the two drogue parachutes are deployed to orient the module properly and to provide initial deceleration. At about 10,000 feet, the drogue parachutes are released and the three pilot parachutes are deployed; these pull the main parachutes from the forward section of the CM. The main parachutes hold the CM at an angle of 27-1/2 degrees so the module will hit the water on its "toe," which will produce water penetration at the least impact load. If one of the main parachutes fails to open, the remaining two will be able to land the CM safely.

This sequence of operations differs slightly for an abort. In that case, the forward heat shield is jettisoned 0.4 second after jettisoning of the launch escape tower. The drogue chutes are then deployed 1.6 seconds later. For low-altitude aborts the main



Normal sequence of operation for earth landing subsystem

parachutes are automatically deployed 12 seconds later, or between zero and 12 seconds by the astronauts. For high-altitude aborts, the main parachutes are deployed in the same manner as normal entry.

After splashdown, the main parachutes are released and the recovery aid subsystem is set in operation by the crew. The subsystem consists of an uprighting system, swimmer's umbilical cable, a sea dye marker, a flashing beacon, and a VHF beacon transmitter. A sea recovery sling of steel cable also is provided to lift the CM aboard a recovery ship.

The two VHF recovery antennas are located in the forward compartment with the parachutes. They are deployed automatically 8 seconds after the main parachutes. One of them is connected to the beacon transmitter, which emits a 2-second signal every 5 seconds to aid recovery forces in locating the CM. The other is connected to the VHF/AM transmitter and receiver to provide voice communications between the crew and recovery forces.

Automatic operation of the earth landing subsystem is provided by the event sequencing system located in the right-hand equipment bay of the command module. The system contains the barometric pressure switches, time delays, and relays necessary to control automatically the jettisoning of the heat shield and the deployment of the parachutes.

The parachute subsystem is produced by the Northrop Corporation, Ventura Division, Newbury Park, Calif.

EQUIPMENT

Drogue Parachutes (Northrop-Ventura, Newbury Park, Calif.) – Two white nylon conical-ribbon parachutes with canopy diameters of 16.5 feet. They are deployed at 23,000 feet to orient and

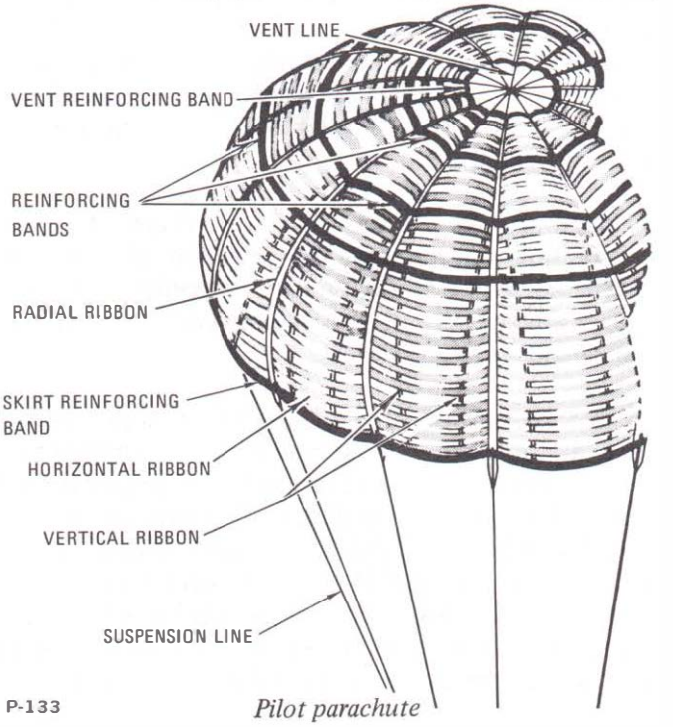
slow the spacecraft from 300 miles an hour to 175 miles an hour so that the main parachutes can be safely deployed. They are 65 feet above the command module.

Pilot Parachutes (Northrop-Ventura) – Three white nylon ring-slot parachutes with canopy diameters of 7.2 feet. They deploy the main parachutes and are 58 feet above the main parachutes.

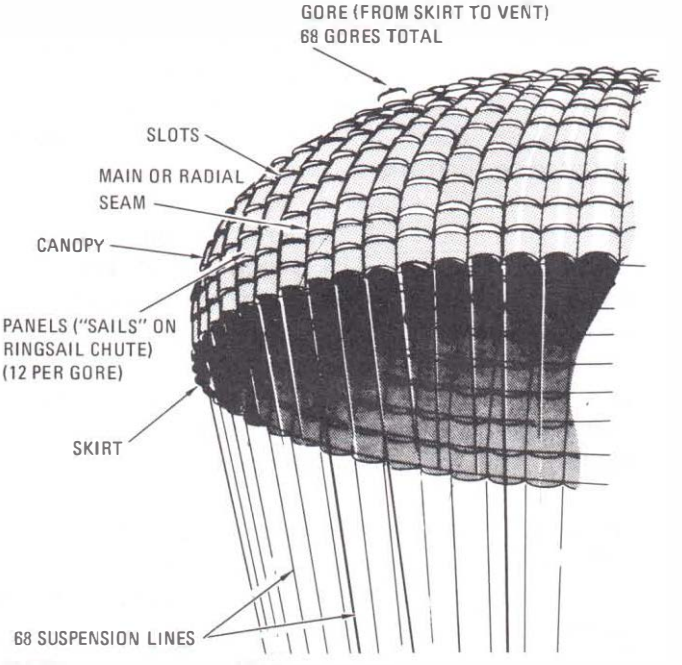
Main Parachutes (Northrop-Ventura) – Three orange-and-white-striped ringsail parachutes with canopy diameters of 83.5 feet. Each weighs 127 pounds counting canopy, risers, and deployment bag. They are deployed at 10,000 feet to reduce the speed of the spacecraft from 175 miles an hour to 22 miles an hour when it enters the water. The parachutes are 120 feet above the command module.

Reefing Line Cutters (Northrop-Ventura) – Each assembly is about the size of a fountain pen and consists of slow-burning powder, small explosive charge, blade, and hole through which the reefing line passes. Burning powder sets off a charge, which drives the blade into the reefing line, severing it and allowing full inflation of the parachutes.

Sequence Controller – Two 3 by 3 by 6-inch boxes each containing four barometric pressure switches, four time delays, and four relays to sequence and



P-133 *Pilot parachute*

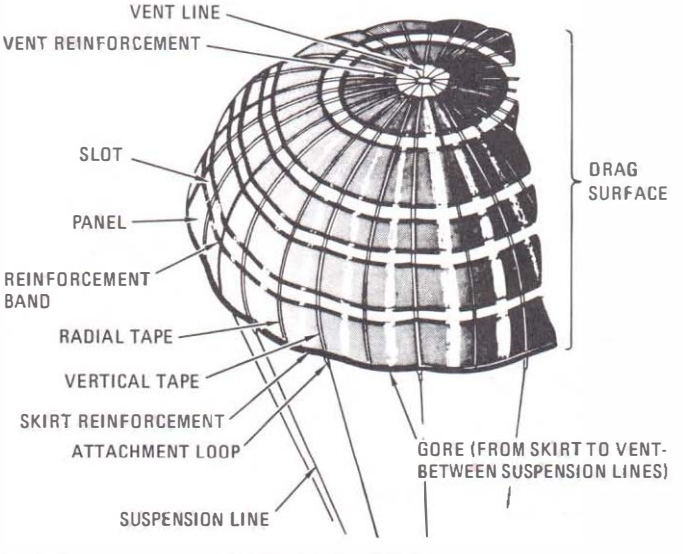


P-134 *Main parachute*

control the deployment and release of parachutes automatically. Each box weighs less than four pounds. They are in the forward compartment of the command module.

Pyro Continuity Verification Box – A 2-1/2 by 8 by 10-inch box containing relays and fusistors located in the forward compartment of the command module. It provides an accessible point within the command module to verify the continuity of the pyrotechnic device firing circuits.

Uprighting System – Three inflatable bags in the forward compartment of the command module



P-135 *Drogue parachute*

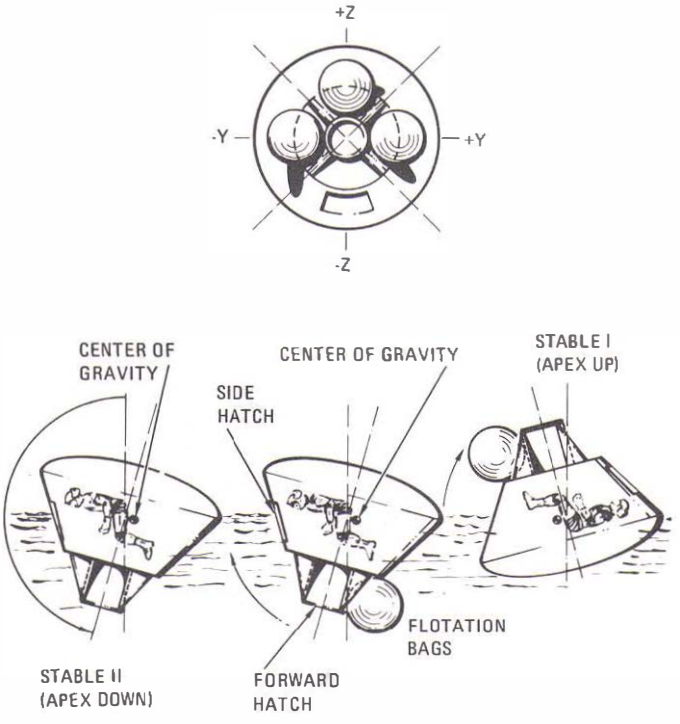
and two air compressors in the aft compartment. The compressors are manually initiated to provide air to the bags through tubes. Each bag has a volume of 22 cubic feet. If the command module turns apex down after landing, the air bags are inflated to right the spacecraft.

Sea Dye Marker – Powdered fluorescein dye packed in a 3 by 3 by 6-inch metal container. When the marker is deployed, dye colors the sea yellow-green around the command module. The marker is in the forward compartment of the command module. It is released manually and is connected to the command module by a 12-foot tether. The dye lasts approximately 12 hours.

Flashing Beacon – Flashing self-powered strobe light to aid in recovery of crew and command module. Eight seconds after main parachutes are deployed, the beacon is automatically extended from the forward compartment of the command module. The light is turned on manually. The arm is one-foot long.

Swimmer's Umbilical – This is the 12-foot dye marker tether. A recovery frogman can connect his communications equipment to the end of the tether to talk to the command module crew.

Automatic and manual control circuits for jettisoning the forward heat shield are included in the



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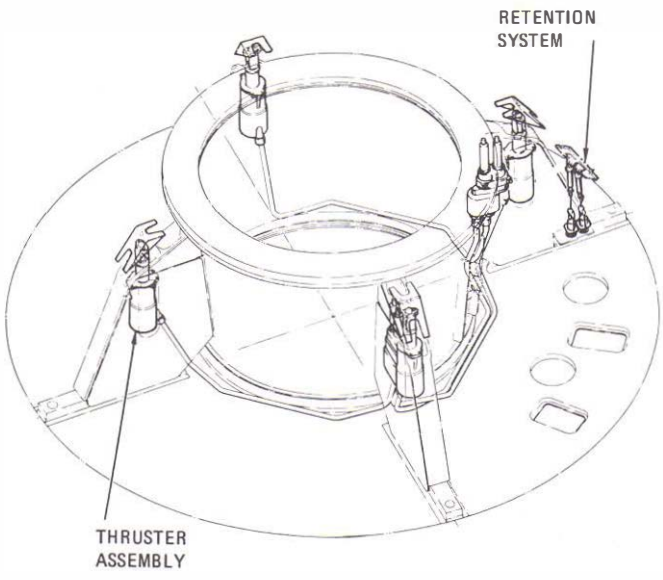
CM uprighting system



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Forward heat shield retention and thruster system

integrated master events sequence controllers, the earth landing sequence controllers, and the lunar docking events controllers.

The shield is jettisoned by the use of a thruster mechanism and a drag parachute. When gas pressure is generated by the pressure cartridges, two pistons are forced apart, breaking a tension tie which connects the shield to the forward compartment structure. The lower piston is forced against a stop and the upper piston is forced out of its cylinder. The piston rod ends are fastened to fittings on the shield, which is thrusted away from the CM. Two of the thruster assemblies have breeches and pressure cartridges; plumbing connects the breeches to thrusters mounted on diametrically opposite CM structural members.

The mortar-deployed parachute drags the heat shield out of the area of negative air pressure following the CM and prevents recontact with the CM. Lanyard-actuated switches are used to fire mortar pressure cartridges.

The forward heat shield must be jettisoned before earth landing equipment may be used. Drogue and pilot parachutes are mortar-deployed to assure that they are ejected beyond the turbulent air around and following the CM. An engine protector bar prevents damage to CM reaction control engines by the drogue cables. The drogue cables (risers) are protected from damage by spring-loaded covers over the launch escape tower attachment studs.

The sea recovery cable loop will spring into position after the parachutes have been deployed. Three uprighting bags are installed under the main parachutes. A switch is provided for the crew to deploy the sea dye marker and swimmer umbilical any time after landing.

Eight parachutes are used in the earth landing subsystem: two drogue, three pilot, and three main. The drogue parachutes are the conical ribbon type and are 16.5 feet in diameter. The pilot parachutes are the ring slot type and are 7.2 feet in diameter. The main parachutes are the ring sail type and are 83.5 feet in diameter.

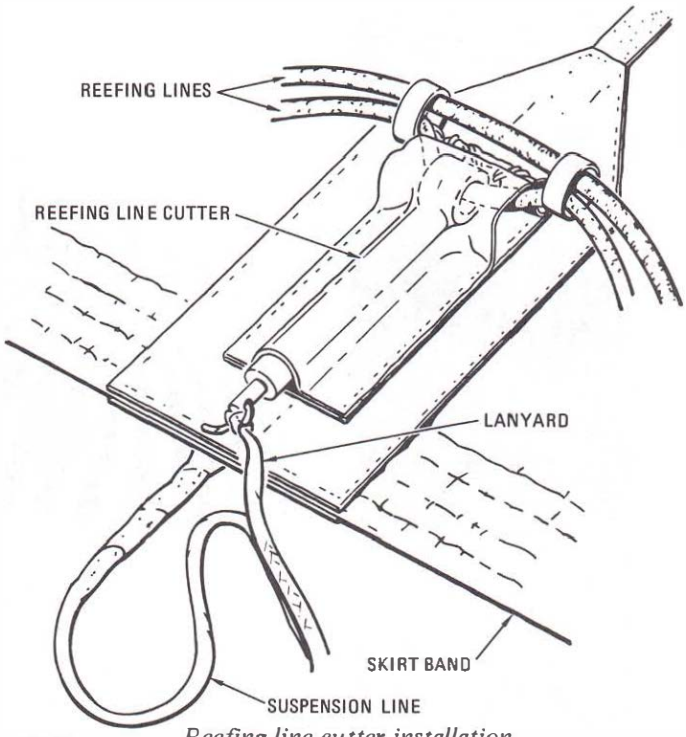
The drogue and main parachutes are deployed reefed for 10 seconds. The reefing lines run through rings which are sewn to the inside of the parachute skirts and reefing line cutters. When the suspension lines pull taut, a lanyard pulls the sear release from the reefing line cutter and a pyrotechnic time-delay is started. When the delay train has burned through, a propellant is ignited, driving a cutter through the reefing line.

Each of the drogue parachutes has two reefing lines with two cutters per line to prevent disreefing in case one reefing line cutter fires prematurely. Each of the three main parachutes has three reefing lines with two cutters per line. Two of the three reefing lines are severed after 6 seconds, allowing the main parachutes to open slightly wider than when deployed. The remaining reefing line is cut 4 seconds later, or 10 seconds after deployment. At this time the parachutes inflate fully.

Reefing line cutters also are used in the deployment of the two VHF antennas and the flashing beacon light during descent. These recovery devices are retained by spring-loaded devices which are secured with parachute rigging cord. The cord is passed through reefing line cutters which are activated by action of the main parachute risers.

Redundant channels in the sequential events system command the sequence of operations of the subsystem.

Activation of the earth landing subsystem switch ("ELS Logic") on the main display console closes logic power circuits to redundant transistorized switches in the master events sequence controllers. Each of these solid-state switches requires two conditions to close; one is closure of the logic



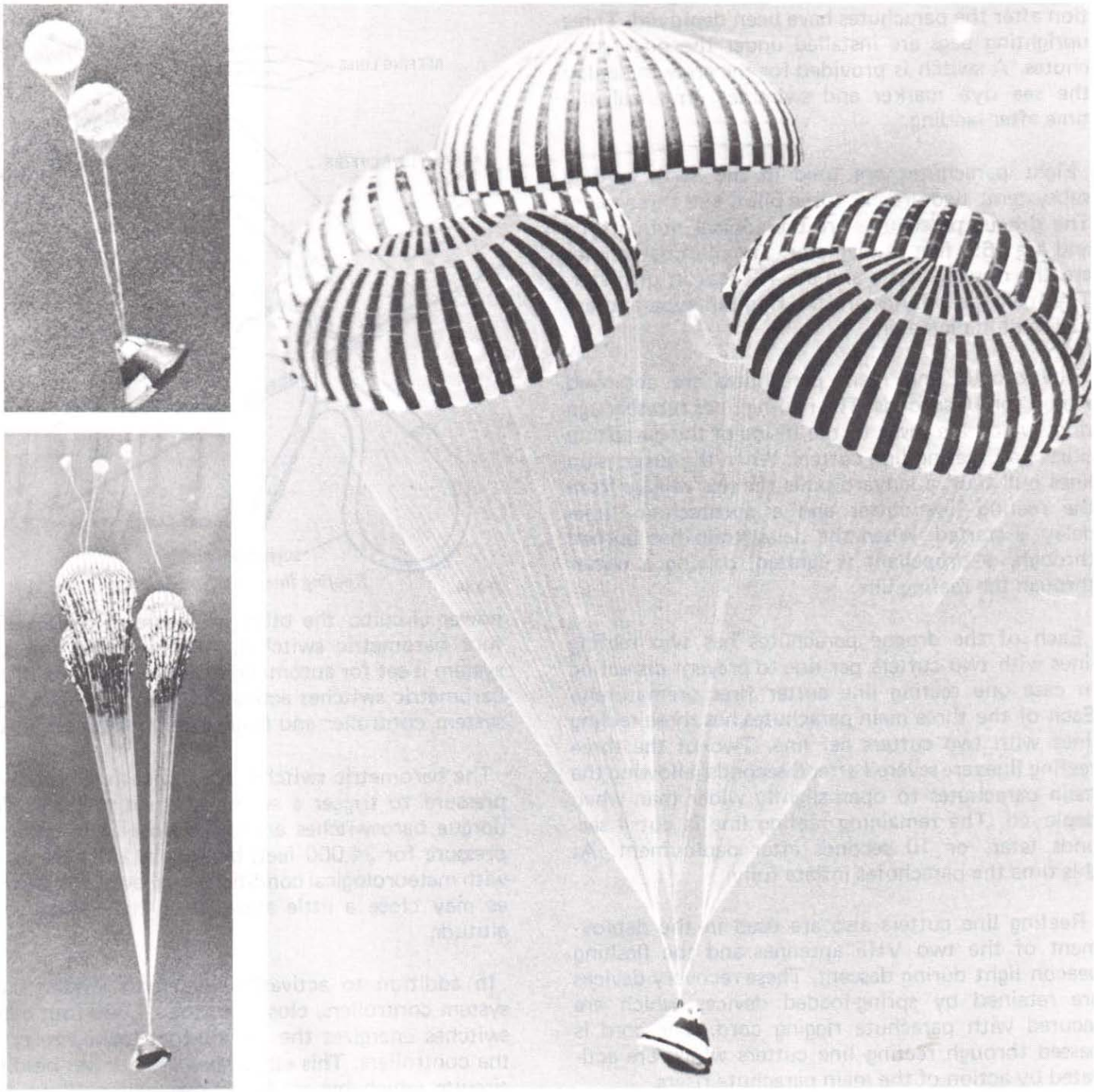
Reefing line cutter installation

power circuits, the other is closure of the 24,000-foot barometric switches. Assuming that the subsystem is set for automatic operation, closure of the barometric switches activates the earth landing subsystem controller and begins the landing sequence.

The barometric switches are devices which use air pressure to trigger a switch at a set altitude. The dorgue baroswitches are set to close at the normal pressure for 24,000 feet; because air pressure varies with meteorological conditions, however, the switches may close a little above or a little below that altitude.

In addition to activating the earth landing subsystem controllers, closure of the 24,000-foot baroswitches energizes the 24,000-foot lockup relay in the controllers. This establishes logic power holding circuits which bypass the baroswitches. When the controllers are activated a signal is relayed to the unlatching coils of the reaction jet engine control to disable the automatic firing of the reaction control engines.

The first function of the earth landing subsystem controllers is to jettison the forward heat shield. After a delay of 0.4 second, the shield thrusters are fired and the lanyard-actuated switches used to deploy the drag parachute are armed. The lanyard, which is attached to the forward heat shield, pulls



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Parachute sequence: drogues (top left) open at 24,000 feet, pilots pull out main chutes (bottom left), and main chutes open fully

holding pins from the switches which, because of spring loading, close circuits to energize relays to fire the drag parachute mortar.

Two seconds after the forward heat shield is jettisoned, relays close to send signals that fire the drogue mortars and deploy the drogue parachutes. When the CM has descended to 10,000 feet, another set of baroswitches closes to energize relays which fire the mortars to deploy the pilot parachutes. The main parachutes are deployed by the pilot chutes.

After splashdown, a crewman activates a switch on the main display console which fires ordnance devices to drive a chisel-type cutter through the main parachute risers, releasing the chutes.